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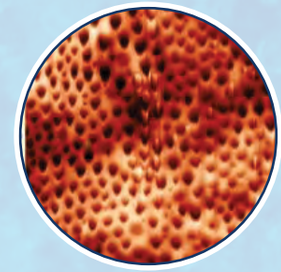
BIENNIAL REPORT
2012-2014

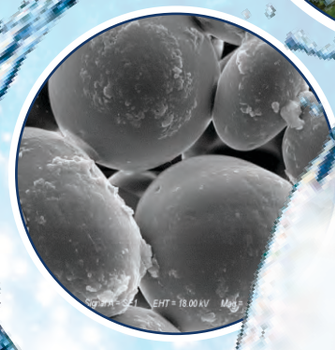


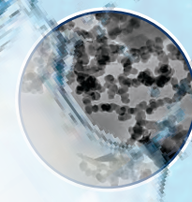














वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद्
Council of Scientific and Industrial Research

सीएसआईआर - केन्द्रीय नमक व समुद्री रसायन अनुसंधान संस्थान
CSIR- CENTRAL SALT & MARINE CHEMICALS RESEARCH INSTITUTE

द्विवार्षिक प्रतिवेदन
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सीएसआईआर - केन्द्रीय नमक व समुद्री रसायन अनुसंधान संस्थान

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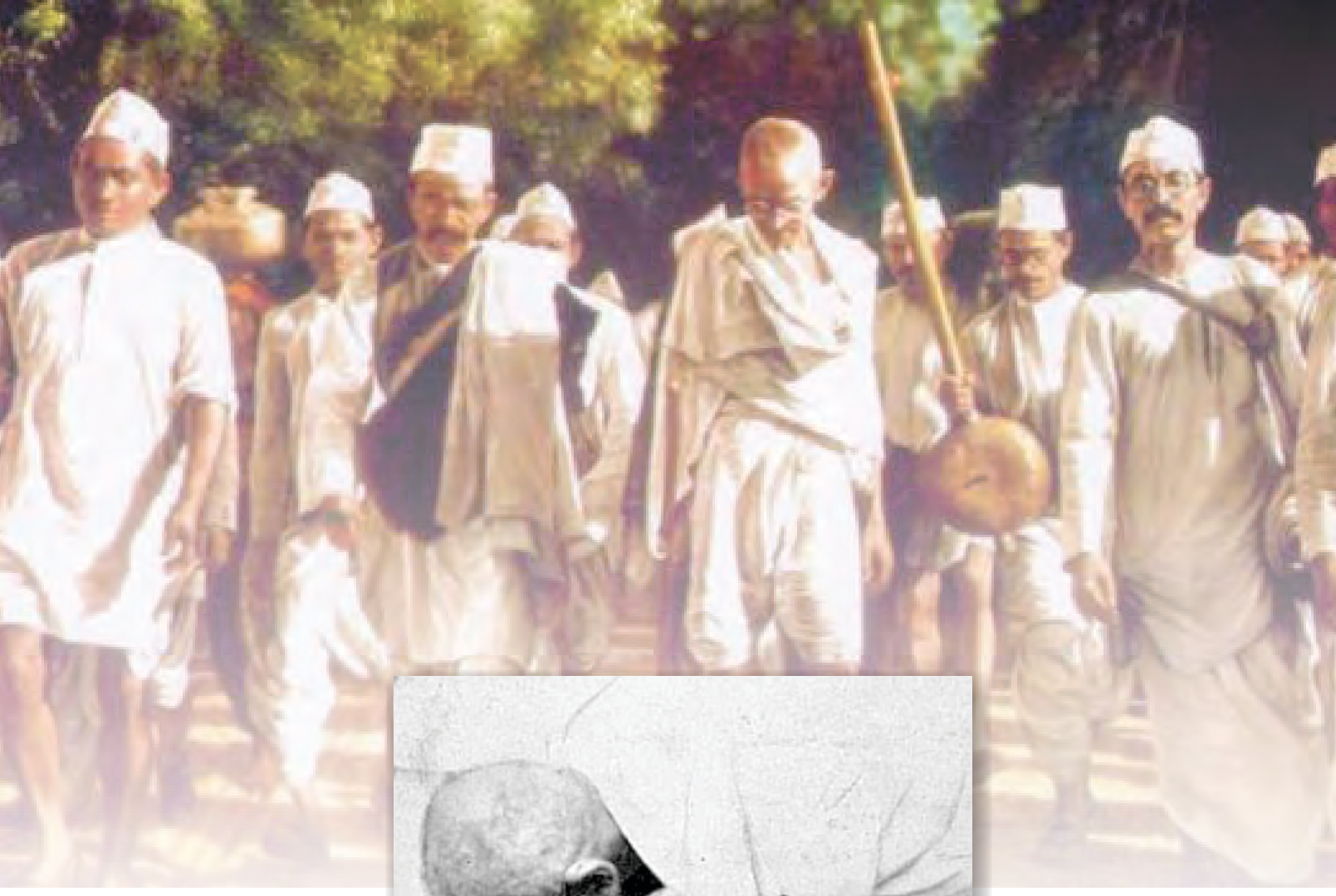




महात्मा गांधी, जिन्होंने ब्रिटिश साम्राज्य की जड़ों को हिला दिया और 6 अप्रैल, 1930 को दांडी समुद्री तट पर निडरता से नमक लेकर लोगों को प्रेरित किया।

The Mahatma who rocked the British Empire and galvanised the people by defiantly gathering salt at the Dandi seashore - 6th April, 1930.



''मैं नहीं चाहता कि इन प्रयोगशालाओं में कोई भी कार्यकर्ता सिर्फ अपनी आजीविका अर्जित करने के उद्देश्य से ही आये, मैं चाहता हूं कि हमारे युवा पुरुष और महिलायें जो यहाँ आयें उनमें हमारी समस्याओं के निवारण के लिये कार्य करने का उत्साह हो । वे ही इन संस्थानो को जीवन शक्ति देंगे । उनको यह एहसास होना चाहिये कि विज्ञान की सेवा सच्चे अर्थ में भारतभूमि की सेवा ही नहीं बल्कि संपूर्ण विश्व की सेवा है । विज्ञान की कोई सीमा नहीं होती ।''

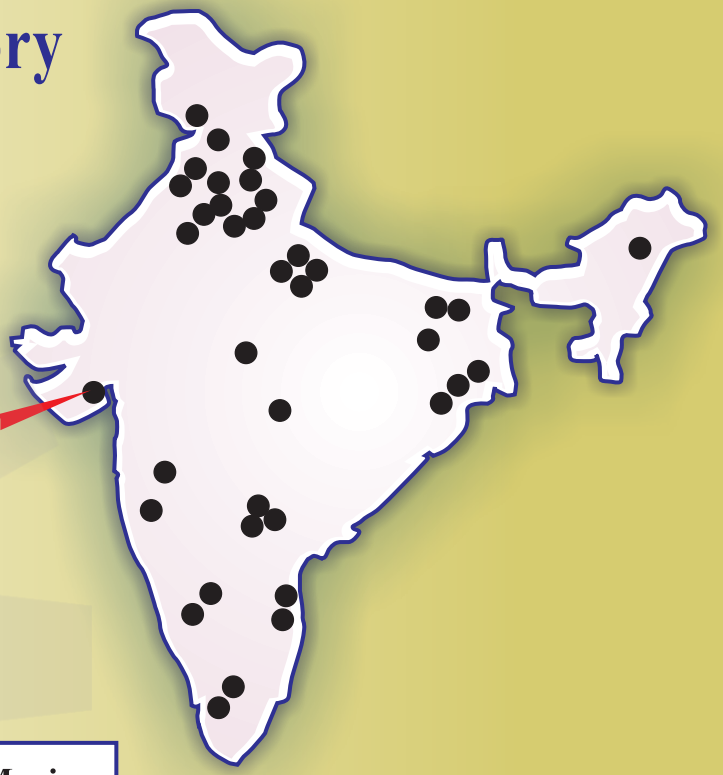
पंडित जवाहरलाल नहेरु
10 अप्रैल 1954 को दिये गये उदघाटन भाषण से उद्धृत

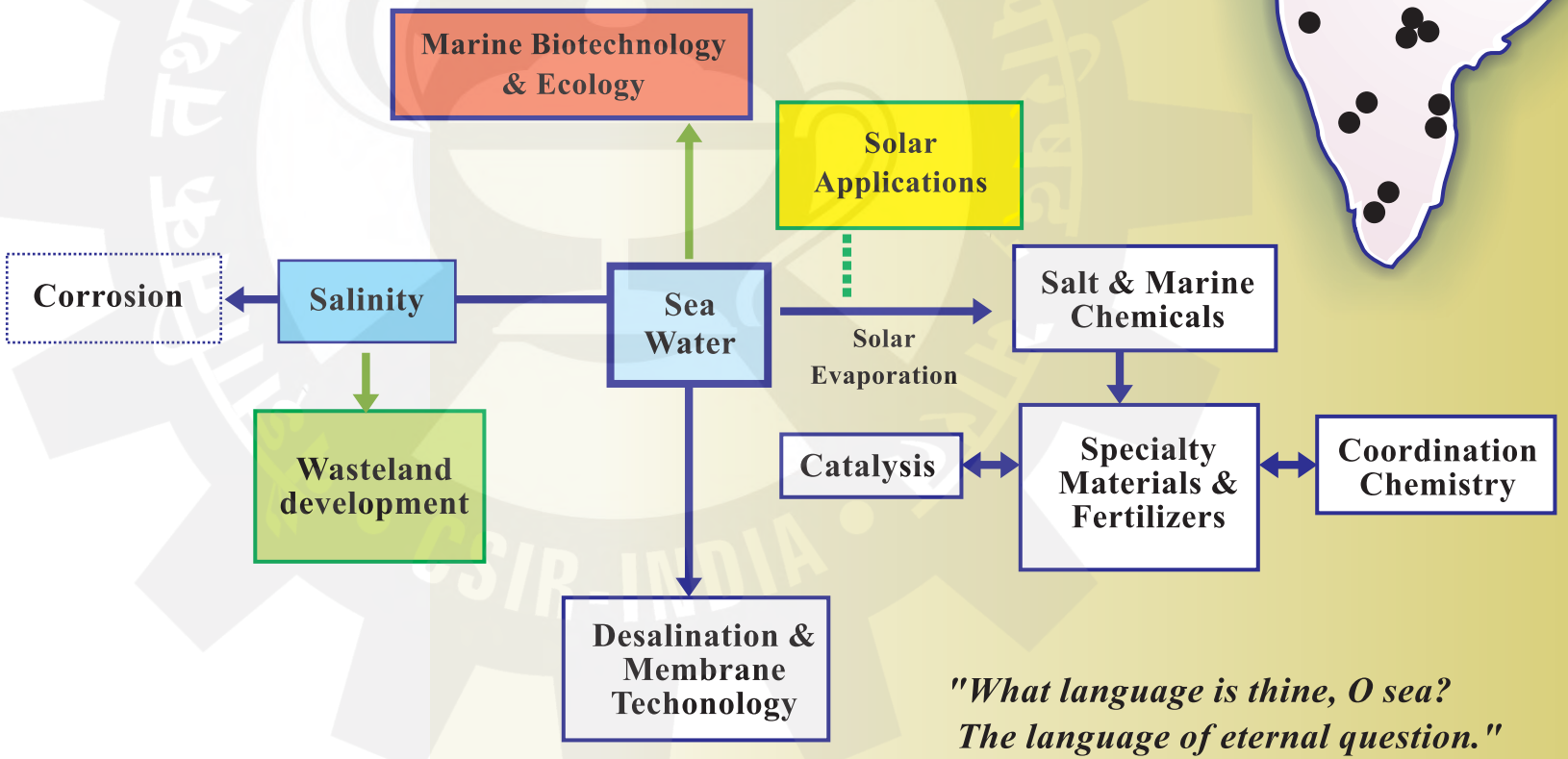
"I do not wish any worker to come to these laboratories merely with the aim of earning his living. What I wish is that our young men and women who come here should have a zeal for working out problems which would have great consequence. That would give vitality to these Institutes. They should realize that service to science is real service to India – no, even to the whole world; science has no frontiers"

Pandit Jawaharlal Nehru
Extract from the Inaugural address on 10th April, 1954

CSMCRI: A CSIR Laboratory

CSMCRI AT A GLANCE





"What language is thine, O sea?
The language of eternal question."
(Stray Birds, Rabindranath Tagore)

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निदेशक की कलम से...



मैं, सीएसआईआर–केन्द्रीय नमक व समुद्री रसायन अनुसंधान संस्थान, भावनगर के द्विवार्षिक प्रतिवेदन 2012-2014 को प्रस्तुत करने में अति हर्ष एवं सौभाग्य का अनुभव कर रहा हूँ। इस दौरान संस्थान ने किफ़ायती नवल प्रौद्योगिकियों तथा उत्पादों के विकास द्वारा देश की सेवा में अपने सतत प्रयासों में उल्लेखनीय प्रगति की है। औद्योगिक नमक की प्राप्ति और गुणवत्ता संवर्धन, समुद्री रसायनों की समाकलित प्रक्रिया द्वारा पुनर्प्राप्ति, विभिन्न हरित परिवर्तनों के लिए विशिष्ट अकार्बनिक पदार्थ एवं उत्प्रेरक, ठोस एवं द्रव अपशिष्टों से मूल्यवर्धित उत्पाद, आर.ओ. विलवणन सयंत्रों का कार्यकाल बढ़ाने हेतु मेम्ब्रेन की गुणवत्ता में वृद्धि, पर्यावरण मॉनीटरन, ऑडिट तथा इंपैक्ट अध्ययन के क्षेत्रों में संस्थान ने विभिन्न सेवाएं प्रदान कर अपनी विशेषज्ञता सिद्व की है। प्रौद्योगिकियों के विकास में संस्थान के प्रक्रिया डिज़ाइन एवं इंजीनियरिंग विभाग ने महत्वपूर्ण योगदान दिया है। संस्थान देश की सर्वोत्तम केंद्रीकृत उपकरण सुविधाओं से संपन्न है, जो मात्र संस्थान की विश्लेषण आवश्यकताओं की ही पूर्ति नहीं करता बल्कि अन्य संस्थानों को भी सेवायें प्रदान करता है।

इस प्रतिवेदन में 12वीं पंचवर्षीय योजना के प्रथम दो वर्षों का समावेश है, जिसमें काफी संख्या में नेटवर्क परियोजनाएं प्रारम्भ की गयीं। संस्थान दो परियोजनाओं में नोडल प्रयोगशाला होते हुए कुल 24 नेटवर्क परियोजनाओं में भाग ले रहा है जो यह प्रदर्शित करता है कि हमारा संस्थान सीएसआईआर की अन्य प्रयोगशालाओं के साथ काफी हद तक सहयोगन कर रहा है। इन परियोजनाओं के अर्न्तगत किये गये विभिन्न अनुसंधानों के परिणाम एवं संस्थान की अन्य उपलब्धियों को इस प्रतिवेदन में दर्शाया गया है।

मेरे लिये यह संतोषजनक है कि संस्थान के कार्य सम्पादन में सतत वृद्धि हो रही है जो विकसित की गयी प्रौद्योगिकियों, स्वीकृत तथा फाइल पेटेंटो तथा उच्च गुणवत्तावाले जरनलों में प्रकाशित वैज्ञानिक शोध–पत्रों की संख्या एवं परिणामों से पता चलता है। 2012-2014 के दौरान कुल 120 पेटेन्ट स्वीकृत हुए जिसमें से अधिकतर (113) भारत के बाहर के हैं तथा एक सौ चालीस पेटेन्ट (113 भारत के बाहर) फाइल किये गये। कई विकसित प्रौद्योगिकियां, उद्योगों को हस्तांतरित की गईं जिसमें कप्पाफायकस अल्वारेज़ी की समुद्री जल में खेती, मेसर्स गुजरात लाइवलीहुड प्रोमोशन लि. गांधीनगर को; ताजे कप्पाफायकस अल्वारेज़ी से समाकलित प्रक्रिया से सैप तथा कैरागीनान की एक साथ पुनर्प्राप्ति, प्रोस्मो एग्री तमिलनाडु को; ग्रेसिलेरिया ड्यूरा की समुद्री जल में खेती तथा उससे अगारोज़ का निष्कासन, मेसर्स अक्वाएग्री प्रोसेसिंग प्राइवेट लि. नई दिल्ली को; कप्पाफायकस अल्वारेज़ी ग्रेनूल्स से शुद्ध कप्पा–कैरागीनान, मेसर्स अक्वा एग्री प्रोसेसिंग प्राइवेट लि. नई दिल्ली को; समुद्री बिटर्न से पौटैशियम नाइट्रेट बनाने की विधि, मेसर्स लक्ष्मी इंडस्ट्रीज, तमिलनाडु को तथा निम्न स्तर कच्छ बाक्साइट से ज़ियोलाइट पाउडर बनाने की विधि, मेसर्स गुजरात क्रिडो मिनरल इंडस्ट्रीज लि. अहमदाबाद को प्रमुख हैं।

संस्थान का बाह्य नगद प्रवाह वृद्धि की तरफ अग्रसर रहा जो 2012-2013 में रु. 11.626 करोड़ से बढ़कर 2013-2014 में रु. 12.592 करोड़ हो गया। संस्थान द्वारा आयोडीन और लौह तत्वों युक्त नमक बनाने की विधि का विकास एक अन्य महत्वपूर्ण उपलब्धि है। यह डबल फ़ोर्टिफ़ाइड नमक भारतीय स्त्रियों एवं बच्चों में लौहतत्व की कमी की समस्या को दूर कर उनको रक्ताल्पता नामक रोग से बचाने में कारगर हो सकता है।

2012-2014 के दौरान विश्व के अनेक विशिष्ट वैज्ञानिक तथा विद्वान संस्थान में आये। संस्थान ने श्रेणीबद्ध संगोष्ठियों, सेमिनारों तथा कार्यशालाओं का आयोजन भी किया। मानव संसाधन विकास, संस्थान के अति महत्वपूर्ण कार्यक्रमों में से एक है।इस समयावधि में संस्थान में शोध कर रहे 40 छात्रों को पीएच.डी. उपाधियां प्रदान की गईं। इसके अतिरिक्त विभिन्न संस्थानों और विश्वविद्यालयों के 107 विद्यार्थियों ने एम.एससी./एम.टेक. के लिये संस्थान में डिजर्टेशन कार्य किये। ये सभी कार्यक्रम संस्थान में स्थापित वैज्ञानिक एवं नवीकृत अनुसंधान अकादमी (एसीएसआईआर) द्वारा निष्पादित हुए। इन दो वर्षों के दौरान संस्थान की वैज्ञानिक एवं नवीकृत अनुसंधान अकादमी में पीएच.डी. कार्यक्रम के अंतर्गत 57 शोधछात्र पंजीकृत हुए।

संस्थान के वैज्ञानिकों ने औसत 3.3 इंम्पैक्ट फैक्टर के साथ 2012-2013 तथा 2013-2014 के दौरान क्रमशः 161 तथा 170 शोधपत्र प्रकाशित किये। संस्थान के वैज्ञानिक अनेक पुरस्कारों एवं सम्मानों जैसे सीएसआईआर–युवा वैज्ञानिक, रमन अनुसंधान फेलोशिप, विविधलक्षी औद्योगिक संशोधन विकास केन्द्र पुरस्कार तथा भारतीय राष्ट्रीय विज्ञान अकादमी फेलो से सम्मानित किये गये। मैं इन सबको उनकी उपलब्धियों के लिए बधाई देता हूँ।

संस्थान ने अपने आपको, विशेष प्राकृतिक आपदाओं के दौरान समाज को सराहनीय सेवा प्रदान कर के विशिष्ट किया है। उदाहरणार्थ जुलाई 2013 की उत्तराखंड की विध्वंसकारी बाढ़ और अक्टूबर 2013 में उड़ीसा के फायलिन चक्रवात में पीड़ितों को शुद्ध पेयजल संस्थान के एक दल ने प्रदान करके साहसिक कार्य किया। पेयजल में आर्सेनिक की सीमा स्तर को विश्व स्वास्थ्य संगठन की सीमा में लाने हेतु आयन–चयनित रेज़िन और मेम्ब्रेन विकसित किये गये। 25 लीटर प्रति घण्टा क्षमता वाली पैंसठ घरेलू इकाईयां तथा 250 लीटर प्रति घण्टा क्षमता वाली समुदाय स्तर की पाँच इकाईयां पश्चिमी बंगाल के विभिन्न स्थानों पर आर्सेनिक मुक्त पेयजल प्रदान करने के लिये लगाई गईं। ये कार्यक्रम विस्तृत रुप से प्रिंट और इलेक्ट्रॉनिक मीडिया द्वारा रिपोर्ट किये गये।

मैं सहयोग एवं कार्य–निष्ठा के लिये संस्थान के सभी कर्मचारियों, अनुसंधान एवं प्रबंधन परिषद के अध्यक्षों एवं सदस्यों तथा सभी स्टेक होल्डरों का आभारी हूँ तथा महानिदेशक–सीएसआईआर तथा मुख्यालय के कर्मचारियों के प्रति भी निरन्तर सहयोग तथा हम पर विश्वास के लिए आभार व्यक्त करता हूँ। मैं विश्वस्त हूँ कि भविष्य में संस्थान उत्तमतर कार्य संपादन करता रहेगा।

(डॉ. एस डब्ल्यू ए नकवी)



From the Director's Desk

It is my great pleasure and privilege to present the Biennial Report of CSIR-Central Salt and Marine Chemicals Research Institute (CSMCRI), Bhavnagar, for 2012-2014. During this period CSMCRI continued to make significant progress in its endeavor to serve the nation through development of novel and affordable technologies and products.CSMCRI has proven expertise to offer a variety of services in improving the quality and yield of industrial salt, recovery of marine chemicals in integrated manner, preparation of specialty inorganic materials and catalysts for various green organic transformations, preparation of value added products from solid/liquid wastes, improving the membrane quality to enhance the life of Reverse Osmosis desalination plants, environment monitoring, audit and impact assessment studies. Process design and engineering significantly contributed to application of technologies developed by CSMCRI. The Institute also has one of the best central instrumentation facilities in the country that not only meets analytical needs of the Institute but also offers services to other institutions.

The report covers the first two years of the 12th Five Year Plan during which a large number of network projects were initiated. Overall, CSMCRI is participating in 24 CSIR Network Projects, being the nodal laboratory in two projects. This reflects the extent to which CSMCRI is collaborating with other sister laboratories of CSIR. Results of various investigations carried out under these projects and other achievements of the Institute are provided in this report.

It is gratifying for me to note that the performance of the institute has been continually improving, which is reflected in the outputs and outcomes in the form of the number of technologies developed, patents filed and granted, and scientific papers published in high quality journals. During 2012-2014, a total of 120 patents were granted, a majority of which (113) outside India. One hundred forty other patent applications (113 outside India) have been filed. Several technologies developed were transferred to industries. These include cultivation of the seaweed *Kappaphycusalvarezii* in coastal waters to M/s. Gujarat Livelihood Promotion Ltd., Gandhinagar; Integrated process for simultaneous recovery of sap and Carrageenan from fresh *Kappaphycusalvarezii* to M/s. PrasmoAgri, Tamil Nadu; Cultivation of *Gracilaria dura* in coastal waters and extraction of agarose thereof to M/s. AquAgri Processing Pvt. Ltd., New Delhi; Preparation of refined Kappa-carrageenan from *Kappaphycusalvarezii* granules via semi refined kappa-carrageenan to M/s. AquAgri Processing Pvt. Ltd. New Delhi; Process for production of potassium nitrate from sea bittern toM/s Laxmi Industries, Tamil Nadu; and Manufacture of

Zeolite-A detergent builder powder from low grade Kutch Bauxite to M/s. Gujarat Credo Mineral Industries Ltd., Ahmedabad.

The External Cash Flow showed an increasing trend, being Rs. 11.626 crores in 2012-2013, and Rs. 12.592 crores in 2013-2014. Another important achievement was the development of a process for production of salt fortified with iodine and iron. This double fortified salt canaddress the problem of iron deficiency that affects a large number of Indian women and children,making them anemic.

A large number of eminent scientists and scholars across the world visited CSMCRI during 2012-2014. The institute also hosted a series of conferences, seminars and workshops.

Human resource development is one of the most important activities in CSMCRI. During the two years under report 40 students working in the Institute were awarded Ph.D. degrees. In addition, 107 students from various institutes and universities did their M.Sc./M.Tech dissertations at the Institute. These activities have been further promoted by the establishment of the Academy of Scientific & Innovative Research (AcSIR). The AcSIR unit at CSMCRI registered 57 students under the Ph.D. programme during the 2 year period.

Scientists working at CSMCRI published 161 and 170 research papers in 2012-13 and 2013-14, respectively, with an average impact factor of around 3.3. A number of scientists were bestowed with awards such as the CSIR Young Scientist award, Raman Research Fellowship, Vividhlaxi Audyogik Samshodhan Vikas Kendra award, and recognitions such as Fellowship of the Indian National Science Academy. I wish to congratulate them for their achievements.

CSMCRI has distinguished itself by rendering commendable service to the society, especially at times of natural disasters. For example, during the devastating floods of Uttarakhandin July, 2013, and when Cyclone Phailin struck Odishain October, 2013, the Institute rushed in teams to provide safe drinking water to the victims. Ion-selective resins and membrane based processes have been developed to bring down the level of arsenic to safe drinking water limits set by WHO. Sixty five domestic units each of 25 LPH capacity and 5 community scale units each of 250 LPH capacitywere installed at different sites of West Bengal to provide arsenic-free drinking water. These activities were widely reported by the print and electronic media.

I wish to acknowledge the support and devotion of all staff members, Chairmen and members of the Management and Research Councils of CSMCRI as well as all other stakeholders. I extend my sincere thanks to DG-CSIR and staff of CSIR headquarters for their constant support and confidence in us. I am convinced that the Institute will do even better in coming years.

(SWA Naqvi)

संतुलित स्कोर कार्ड - (2012-2013)

CSIR द्वारा संवितरित निधि (2012 – 2013 के वित्तीय वर्ष में) – ₹ 42.589 करोड़, NMITLI को मिला कर।
बाह्य नकद प्रवाह (2012 – 2013 वित्तीय वर्ष में) ₹ 11.626 करोड़ NMITLI को छोड़ कर।

जनशक्ति संसाधन (31 मार्च 31, 2013) 245 स्थाई कर्मचारी तथा 266 अस्थाई कर्मचारी, वैज्ञानिक फेलो/शोध सहयोगी/ अध्येता/परियोजना सहायकों/एप्रेन्टिस आदि सहित

मानव संसाधन विकास

20 शोध छात्रों को पीएच.डी. की उपाधि से सम्मानित किया गया; 46 एम.एससी./एम.टेक. के छात्रों ने डिजर्टेशन किये।

- डॉ. संध्या मिश्रा–रसायन और उर्वरक मंत्रालय द्वारा सिपेट राष्ट्रीय पुरस्कार
- डॉ. अविनाश मिश्रा–सीएसआईआर–युवा वैज्ञानिक पुरस्कार
- डॉ. टी. एस. नटराजन तथा सहयोगी–केमिकल इंजीनियरिंग जर्नल, एल्सेविअर, एम्स्टर्डम, नीदरलैंण्ड द्वारा प्रकाशित शीर्षस्थ उद्घृत शोधपत्र के लिए सम्मान
- डॉ. पूयम सिंह–रमन रिसर्च फेलोशिप
- डॉ. प्रदीप अग्रवाल–रमन रिसर्च फेलोशिप
- डॉ. रामावतार मीना–इन्टरनेशनल पब्लिशिंग हाउस, नई दिल्ली द्वारा भारत के श्रेष्ठ नागरिकका पुरस्कार
- डॉ. आर. आई. कुरेशी–रासायनिक रिसर्च सोसायटी ऑफ इन्डिया द्वारा सीआरएसआई कांस्य पदक
- श्री संदीप कुमार वानिया–ईआरपी में उत्कृष्ट उपलब्धि पुरस्कार
- श्री प्रोवस पाल–मैटिरियल रिसर्च सोसायटी, इंडिया द्वारा सेमिनार में प्रदर्शित 'उत्तम पोस्टर' पुरस्कार
- श्री हिरेन रावल–इंटरनेशनल फ्रेंडशिप सोसायटी, इंडिया की ओर से भारत ज्योति पुरस्कार

शोधपत्र

161 शोधपत्र वैज्ञानिक जरनलों में प्रकाशित किए गए जिसका औसत इम्पैक्ट फैक्टर 3.29 रहा (अप्रैल 2012–मार्च 2013)

पेटेन्ट: (अप्रैल 2012 – मार्च 2013)
फाइल की गई : भारतीय – 17; विदेशी – 45 (17*);
स्वीकृतः भारतीय – 6; विदेशी – 42 (26*) (यू.एस. पेटेन्टस सहित) *अन्वेषणों की संख्या

प्रौद्योगिकी हस्तांतरण – 1

समुद्र (तटीय जल) में कप्पाफायकस अल्वारेज़ी की खेती–मेसर्स गुजरात लाइवली हुड प्रमोशन लिमिटेड, गांधीनगर

विशिष्ट सामाजिक कार्य

- सीमांत नमक उत्पादकों द्वारा उत्पादित नमक की गुणवत्ता में सुधार हेतु प्रशिक्षण
- तमिलनाडु के मरकानम में एक मॉडल सॉल्टफार्म की स्थापना
- ZnCr LDHs तथा उनके बहुलक यौगिकों द्वारा जलीय फ्लोराइड का निष्कासन
- पेयजल में आर्सेनिक का स्तर, विश्व स्वास्थ्य संगठन द्वारा निर्धारित सीमा तक लाने के लिए आयन चयनात्मक रेज़िन और
- मेम्ब्रेन आधारित प्रणाली का विकास
- जेट्रोफा बायो डीज़ल का बड़े पैमाने पर उत्पादन
- खाद्य पदार्थो को सुखाने हेतु के लिए छोटे समुदाय स्तर के ड्रायर का निर्माण

महत्वपूर्ण मीडिया कवरेज

- वैज्ञानिकों ने रक्ताल्पता से लड़ने वाले नमक का किया विकास–द टाइम्स ऑफ इंडिया, 06 अप्रैल, 2012
- सेन्ट्रल सॉल्ट द्वारा एनीमिया के रोगियों के लिए नमक पर अनुसंधान–सौराष्ट्र समाचार, 07 अप्रैल, 2012
- समुद्री शैवाल से कीमती बायोडीजल का उत्पादन–डीएनए, अहमदाबाद, 17 अप्रैल, 2012
- आपके घर पर समुद्री जीवन लाने के लिए समुद्री नमक–द टाइम्स ऑफ इंडिया, 18 जुलाई, 2012
- खारा पानी बन सकेगा मीठा–राजस्थान पत्रिका, 26 अगस्त, 2012
- गुजरात में मॉडल सोलार सॉल्ट फार्म का प्रवेश–द हिंदू, 11 सितम्बर, 2012
- सीएसएमसीआरआई में एक दशक के दौरान स्वीकृत 50 यूएस पेटेन्ट का जश्नः टाइम्स ग्लोबल, 20 सितम्बर, 2012
- गुजरात समुद्री शैवाल की खेती के लिये तैयार– द टाइम्स ऑफ इंडिया, 02 अक्टूबर, 2012
- बायोडीज़ल ईंधन से कार ने 2.14 लाख किमी की यात्रा की–द टाइम्स ऑफ इंडिया, 22 नवम्बर, 2012
- खारे पानी को मीठा बनाने में सेन्ट्रल सॉल्ट का शतक–सौराष्ट्र समाचार, 27 फरवरी, 2012

BALANCED SCORECARD (2012-2013)

Allocation from CSIR (2012-2013 financial year): ₹ 42.589 Crores including NMITLI
External Cash Flow (2012-2013 financial year): ₹ 11.626 Crores excluding NMITLI

Manpower Resources (March 31, 2013) 245 permanent and 266 temporary staff comprising scientists and fellows/ research associates/ research fellows/ project assistants/ apprentices

Human Resource Development

20 Research scholars were awarded Ph.D.; 46 M.Sc. /M.Tech. dissertation

- Dr. Sandhya Mishra- CIPET National Award by Ministry of Chemicals & Fertilizers
- Dr. Avinash Mishra-CSIR-Young Scientist Award in Biological Sciences
- Dr. T. S. Natarajan and co-workers- Recognition for Top Cited Papers by Chemical Engineering Journal, Elsevier, Amsterdam, Netherlands
- Dr. Puyam Singh-Raman Research Fellowship
- Dr. Pradeep Agarwal Raman Research Fellowship
- Dr. Ramavtar Meena-The Best Citizens of India Award by International Publishing House, New Delhi
- Dr. R I Kureshy-CRSI Bronze Medal by Chemical Research Society of India
- Mr. Sandipkumar Vaniya-Outstanding Achievement Award in ERP
- Mr. Provas Pal-Best Poster Award by the Material Research Society, India
- Mr. Hiren Raval-Bharat Jyoti Award by International Friendship Society, India

Papers: 161 papers in SCI Journals with Impact factor of 3.29 (April 2012- March 2013)

Patents – (April 2012 to March 2013)
Filed: 17 Indian, 45 (17*) Foreign **Granted:** 06 Indian 42 (26*) Foreign (including US patents)
* Number of inventions

Technology transfer

Cultivation of *Kappaphycusalvarezii* in the sea (coastal water).M/s. Gujarat Livelihood Promotion Ltd., Gandhinagar

Societal/Significant Initiatives

- Provided training to marginal salt producers on improving quality of salt production
- Established a model salt farm at Marakanam in Tamil Nadu
- Synthesized ZnCr LDHs and composites for aqueous fluoride removal from drinking water
- Prepared ion-selective resins and membranes based systems/processes to bring the level of arsenic to WHO limits in drinking water
- Production of Jatropha biodiesel at large scale
- Designed small community scale solar dryer for drying the food products

Important media coverage

- Scientists develop salt to fight anemia- The Times of India, 06 April, 2012
- Central Salt dwara anemia naderdiyo mate mithanusansodhan, Saurashtra Samachar, 07 April,2012
- Marine algae yield precious biodiesel- DNA, Ahmedabad, 17 April, 2012
- Marine salt to bring sea life at your doorstep-The Times of India, 18 July,2012
- Kharapani ban sakegameetha-Rajasthan Patrika, 26 August, 2012
- Model solar salt farm to come up in Gujarat-The Hindu, 11 September, 2012
- CSMCRI: celebrating half century of granted U.S. patents over a decade: Times Global, 20 September, 2012
- Gujarat set to cultivate seaweed - The Times of India, 02 October, 2012
- Biodiesel fueled car covers 2.14 lakhs kms- The Times of India, 22 November,2012
- Kharapani ne mithakarkama Central Salt ni century-Saurashtra Samachar, 27 February, 2013

संतुलित स्कोर कार्ड - (2013-2014)

CSIR द्वारा संवितरित निधि (2013 – 2014 के वित्तीय वर्ष में) – ₹38.722 करोड़, NMITLI को मिला कर।
बाह्य नकद प्रवाह (2013 – 2014 वित्तीय वर्ष में) ₹12.592 करोड़ NMITLI को छोड कर।

जनशक्ति संसाधन (31 मार्च 31, 2014) 250 स्थाई कर्मचारी तथा 272 अस्थाई कर्मचारी, वैज्ञानिक फेलो/शोध सहयोगी/ अध्येता/परियोजना सहायकों/एप्रेन्टिस आदि सहित

मानव संसाधन विकास

20 शोध छात्रों को पीएच.डी. की उपाधि से सम्मानित किया गया; 61 एम.एससी./एम.टेक. के छात्रों ने डिजर्टेशन किये।

- डॉ. राजेश तायडे–द कोरिअन फेडरेशन ऑफ साइन्स एण्ड टेकनोलॉजी द्वारा ब्रेनपूल फेलोशिप
- डॉ. ए.वी.आर. रेड्डी–रासायनिक विज्ञान तथा प्रौद्योगिकी में वासविक (विविधलक्षी संशोधन विकास केन्द्र) द्वारा पुरस्कार
- डॉ. रामावतार मीना–इन्डियन जरनल ऑफ मैटिरियल साइन्स के संपादकीय बोर्ड के सदस्य
- श्री संजय चौहान–ईआरपी कार्यान्वयन के लिए प्रोजेक्ट चैंपयिन पुरस्कार
- डॉ. राजेश तायड़े–केमिकल फिजिक्सलेटर एन्ड मैटिरियल्स रिसर्च बुलेटिन एल्सेविअर, एम्स्टर्डम नीदरलैंण्ड द्वारा विशिष्ट समीक्षक सम्मान
- श्री प्रोवस पाल–ICRANN सेमिनार के दौरान जेएनयू, नई दिल्ली में 'उत्तम पोस्टर' पुरस्कार
- सुश्री पुष्पिका उदावत–सेमिनार में 'उत्तम पोस्टर' प्रस्तुति के लिए युवा वैज्ञानिक पुरस्कार

शोधपत्र

170 शोधपत्र वैज्ञानिक जरनलों में प्रकाशित किए गए जिसका औसत इम्पैक्ट फैक्टर 3.24 रहा (अप्रैल 2013–मार्च 2014)

पेटेन्ट: (अप्रैल 2013 – मार्च 2014)

फाइल की गई : भारतीय – 10; विदेशी –68 (25*);
स्वीकृतः भारतीय – 1; विदेशी – 71 (23*) (यू.एस. पेटेन्टस सहित) *अन्वेषणों की संख्या

प्रौद्योगिकी हस्तांतरण – 5

- ताजा कप्पाफायकस एल्वारेजी शैवाल से अर्क और केरागीनान (अर्द्ध परिष्कृत तथा परिष्कृत) एक साथ प्राप्त करने के लिए समाकलित प्रक्रिया–मेसर्स प्रास्मो एग्री, तमिलनाडु
- समुद्र (तटीय जल) में कप्पाफायकस एल्वारेजी की खेती–मेसर्स प्रास्मो एग्री, तमिलनाडु
- समुद्र (तटीय जल) में ग्रेसिलेरिया ड्यूरा की खेती और उसमें से अगारोज़ का निष्कर्षण–मेसर्स अक्वा एग्री प्रोसेसिंग प्राइवेट लिमिटेड, नई दिल्ली
- अर्द्ध परिष्कृत कप्पा–केरागीनान के माध्यम से कप्पाफायकस एल्वारेजी कणिकाओं में से परिष्कृत कप्पा–केरागीनान तैयार करना–मेसर्स अक्वा एग्री प्रोसेसिंग प्राइवेट लिमिटेड, नई दिल्ली
- समुद्री बिटर्न से पौटैशियम नाइट्रेट के उत्पादन के लिए प्रक्रिया–मेसर्स लक्ष्मी इन्डस्ट्रीज, तमिलनाडु

विशिष्ट सामाजिक कार्य

- उत्तराखंड की बाढ़ (जुलाई–2013) तथा उड़ीसा के चक्रवात (अक्टूबर 2013) आपदा के समय पीड़ितों को पेयजल उपलब्ध कराया
- उड़ीसा राज्य में नमक उत्पादन–सक्षम क्षेत्रों का सर्वेक्षण
- राजस्थान के डीडवाना क्षेत्र में खाद्य ग्रेड के सौर नमक की गुणवत्ता में सुधार
- टारटेरिक एसिड का उपयोग कर चयनात्मक पोटाश अवक्षेपण के माध्यम से पोटाश रसायन और उर्वरक उत्पादन का तकनीकी प्रक्रम का विकास
- उड़ीसा में चक्रवात के कारण क्षतिग्रस्त जेट्रोफा उद्यान का पुनर्स्थापन

महत्वपूर्ण मीडिया कवरेज

- रामनाद में कार्यरत विलवणीकरण संयंत्रों को सर्विसिंग की आवश्यकता–द हिन्दू, 16 अप्रैल, 2013
- शैवाल की खेती बहुत बड़ा व्यापार–द टाइम्स ऑफ इंडिया, 13 अप्रैल, 2013
- आइक्यू उच्च करने वाले गुजराती शैवाल के लिये यूएस पेटेन्ट–द टाइम्स ऑफ इंडिया, 07 जुलाई, 2013
- समुद्र शैवाल का रस कुपोषण रोकने में कर सकता है मदद–द टाइम्स ऑफ इंडिया, 07 जुलाई, 2013
- गुजरात की प्रौद्योगिकी ने उत्तराखंड में जल शुद्ध किया–द टाइम्स ऑफ इंडिया, 06 जुलाई, 2013
- उत्तराखंड में कुछ जलशोधन ईकाई स्थापित की जाएगी–एनोनेमस, 15 जुलाई, 2013
- शैवाल की खेती गुजरात को करेगी समृद्ध–सौराष्ट्र समाचार, 23 जुलाई, 2013
- बायोडीजल के क्षेत्र परिक्षण को रेलवे की हरी झंडी–द टाइम्स ऑफ इंडिया, 11 सितंबर, 2013
- सीएसएमसीआरआई ने बाढ़ पीड़ित उड़ीसा की प्यास बुझाई–द टाइम्स ऑफ इंडिया, 13 अक्टूबर, 2013
- भावनगर के संस्थान ने उड़ीसा में फैलिन चक्रवात से उखड़े हुए जेट्रोफा के 7,000 पौधों को पुनः लगाया–द सन्डे एक्सप्रेस, 17 नवम्बर, 2013
- रतनज्योत की खोज में उदयपुर आए वैज्ञानिक–राजस्थान पत्रिका, 05 दिसंबर, 2013
- बायोडीग्रेडेबल प्लास्टिक को युरोपियन पेटेन्ट मिला–सौराष्ट्र समाचार, 16 फरवरी, 2013

BALANCED SCORECARD (2013-2014)

Allocation from CSIR (2013-2014 financial year): ₹ 38.722 Crores including NMITLI
External Cash Flow (2013-2014 financial year): ₹ 12.592 Crores excluding NMITLI Societal

Manpower Resources (March 31, 2014): 250 permanent and 272 temporary staff comprising scientists and fellows/ research associates/ research fellows/ project assistants/ apprentices

Human Resource Development

20 Research scholars were awarded Ph.D.; 61 M.Sc. /M.Tech. dissertation

- Dr. Rajesh Tayade-Brainpool Fellowship by Korean Federation of Science and Technology, Korea
- Dr. A.V. R. Reddy-VASVIK Award in Chemical Sciences & Technology
- Dr. Ramavatar Meena- Member, Editorial Board, Indian Journal of Materials Science
- Mr. Sanjay Chauhan- Project Champion Award for ERP Implementation
- Dr. Rajesh Tayade-Distinguished Reviewer by Chemical Physics Letter, and Materials Research Bulletin Elsevier, Amsterdam, The Netherlands
- Mr. Provas Pal-Best Poster Award during ICRANN at JNU, New Delhi
- Ms. Pushpika Udawat-Young Scientist Award for the 'Best Poster' presentation in seminar
- Prof. B. Jha-Fellow, Indian National Science Academy, New Delhi

Papers: 170 papers in SCI Journals with Impact factor of 3.24 (April 2013- March 2014)

Patents – (April 2013 to March 2014)
Filed: 10 Indian, 68 (25*) Foreign **Granted:** 01 Indian, 71 (23*) Foreign . (including US patents)
* Number of inventions

Technology transfer – 5

- Integrated process for simultaneous recovery of Sap and Carrageenan from fresh *Kappaphycusalvarezii*(*K. alvarezii*) seaweed the basic raw material. M/s. PRASMO AGRI, TamilNadu
- Cultivation of *K. alvarezii* in the sea (coastal water). M/s. PRASMO AGRI, Tamil Nadu
- Cultivation of *Gracilaria dura* in the sea (Coastal water) and extraction of agarose thereof. M/s. AquAgri Processing Pvt. Ltd., New Delhi.
- Preparation of refined Kappa-carrageenan from *K.alvarezii* granules via semi refined kappa-carrageenan. M/s. AquAgri Processing Pvt. Ltd., New Delhi.
- Process for production of potassium nitrate from sea bittern. M/s Laxmi Industries, Tamil Nadu

Societal/Significant Initiatives

- Responded to the Uttarakhand Flood (July 2013) and Odsiha cyclone (October 2013) Tragedies
- Surveyed of potential areas of salt production in the state of Odisha
- Work done to improve the quality of solar salt to edible grade in Didwana region of Rajasthan
- Process developed to know-how for production of potassic chemicals and fertilizers through selective K-precipitation using tartaric acid
- Work done for rehabilitation of damage to Jatropha plantation at Odisha due to cyclone

Important media coverage

- Ramnad looks at servicing old desalination plants-The Hindu, 09 April,2013
- Weeding is Big Business-Times Of India, 13 April, 2013
- US patent for Gujarat weed that gives IQ high-The Times of India, 07 July,2013
- Seaweed Juice can help tackle malnutrition- The Times of India, 07 July,2013
- Gujarat tech purify water in Uttarakhand-The Times of India, o9 July,2013
- Few water purifying units to be installed in Uttarakhand-Anonymous, 15 July, 2013
- Sheval ni kheti Gujarat ne karshe samrudh-Saurashtra Samachar, 23 July,2013
- Rly clears biodiesel for field trails- The Times of India, 11September, 2013
- CSMCRI quenches thirst of flood-hit in Orissa-The Times Of India, 28 October,2013
- Bhavnagar institute replants over 7,000 Jatropha uprooted by Phailan in Orissa-The Sunday Express, 17 November, 2013
- Ratnajyot ki khoj main Udaipur aye vegyanik- Rajasthan Patrika, December 05,2013
- Biodegradable plastic ni European Patnet Mali: Saurashtra Samachar, 16 February, 2014

प्रकरण 1
CHAPTER 1



रसायन विज्ञान
CHEMICAL SCIENCES

नमक एवं समुद्री रसायन
अकार्बनिक पदार्थ एवम् उत्प्रेरण

Salt & Marine Chemicals
Inorganic Materials & Catalysis

नमक व समुद्री रसायन विभाग

नमक व समुद्री रसायन विभाग, सौर नमक उत्पादन प्रक्रियाओं के क्षेत्र में नवोन्मेष केन्द्रित सराहनीय अनुसंधान तथा विकास कार्य कर रहा है। मूल्य वर्धित उत्पादों के साथ नमक उत्पादन की मात्रा एवं गुणवत्ता में सुधार करने के हमारे प्रयासों में हमने मौलिक अध्ययन, विकास प्रक्रिया, उत्पादन विकास, अपशिष्ट प्रबंधन, जैव–रासायनिक अध्ययन तथा सामाजिक गतिविधियों पर कार्य किया है।

प्रक्रिया विकास के लिए हमारे प्रयासों के अंतर्गत आयोडीन तथा लौहतत्व की कमी के प्रतिकूल प्रभावों को दूर करने के लिए, अकार्बनिक मैट्रिक्स यौगिक के उपयोग द्वारा साधारण नमक को आयोडीन तथा लौह तत्व, दोनों से समृद्ध करने के लिए एक नवीन तरीका विकसित किया गया। अतिशय वातावरणीय परिस्थितियों में इस 'डबल फोर्टीफाइड नमक' की स्थिरता अत्यधिक संतोषजनक रही है। और इसकी जैव उपलब्धता का अध्ययन प्रगति पर है। इस प्रक्रिया पर एक "नोवेल डबल फोर्टीफाइड सॉल्ट कम्पोजीशन्स कन्टेनिंग आयरन एन्ड आयोडीन एन्ड प्रोसेस ऑफ प्रिपरेशन देयर ऑफ" नामक पेटेन्ट फाइल किया गया है (संदर्भ 0607DEL2012)।

घरेलू एवं मरीन एक्वेरीयम में विभिन्न प्रकार के मरीन सूक्ष्मजीव संवर्धन के लिए समुद्री जल का प्रयोग किया जाता है। देश में ऐसे स्थान हैं जहां पर समुद्री जल आसानी से उपलब्ध नहीं होते। संस्थान ने ऐसी लागत प्रभावी विधि विकसित की है जिसके द्वारा समुद्री जल हेतु प्राकृतिक नमक सूत्रीकरण एवं रिवर्स ऑस्मोसिस/इलेक्ट्रोडायालिसिस (RO/ED) तकनीकी से शुद्ध किये गए जल का खनिज फोर्टिफिकेशन किया जा सकता है। ये प्राकृतिक नमक संरुपण समुद्री जल से सीधे ही बनाये गये हैं। इन नमक संरुपण के मिश्रण का मरीन सूक्ष्मजीव संवर्धन के लिए भी हमारे प्रायोगिक साल्ट फार्म में प्रयोग किया गया और इनका उपयोग करने से समुद्री जल की तुलना में ज्यादा संवृद्धि दर पायी गयी। समुद्री नमक संरुपण का उपयोग RO/ED संकर घरेलू विलवणीकरण इकाई के प्राप्त जल के रीमिनरेलाइजेशन के लिए उपयोग किया गया।

इन निरुपणों का कई कार्मिकों द्वारा परीक्षण किया गया तथा अनुसंधान एवं विकास प्रयोगों के लिए आईआईटी खड़गपुर, कलकत्ता विश्वविद्यालय तथा सीएसआईआर–एनसीएल जैसे संस्थानों को भेजा गया। भारतीय पेटेन्ट कार्यालय में "कॉस्ट–इफेक्टिव नेचुरल सॉल्ट फोर्म्यूलेशन फॉर सीवाटर सब्सीट्युशन, मिनरल फोर्टीफिकेशन एन्ड प्रोसेस देयर ऑफ" नामक अस्थायी पेटेन्ट फाइल किया गया है (संदर्भ. सं. 3422/DEL/2011, दिनांक 29/11/2011)।

ब्राइन के वाष्पीकरण दर को तेज़ करके नमक उत्पादकता तथा बिटर्न रासायनिक उत्पादकता बढ़ाने में ब्रिलियंट ब्लू तथा फास्ट ग्रीन जैसे खाद्य रंजक एवं काली स्याही,वाष्पीकरण दर को 25-35% बढ़ाने में बहुत प्रभावी पाये गये। सौर नमक क्रिस्टलाइजर में ब्राइन का रिसाव रोककर नमक उत्पादन बढ़ाने के लिए विभिन्न मिश्रणों का प्रयोग किया गया जिनमें फ्लाई ऐश+बेन्टोनाइट मिश्रण, ब्राइन रिसाव रोकने में बहुत प्रभावी पाया गया। विज्ञान एवं प्रौद्योगिकी विभाग, भारत सरकार द्वारा वित्तपोषित परियोजना के अंतर्गत सल्फेट ऑफ पोटाश संयंत्र हेतु काइनाइट प्रकार के मिश्रित नमक की आवश्यकता को पूर्ण करने के लिए भावनगर (मेसर्स भावनगर सॉल्ट वर्क्स), घोघा (मेसर्स मल्होत्रा सॉल्ट वर्क्स, मेसर्स मरचेंट सॉल्ट वर्क्स), कच्छ का ग्रेटर रण (मेसर्स एग्रोसेल इन्डस्ट्रीज़ लिमिटेड) तथा पोर्ट विक्टर (मेसर्स जीएचसीएल लिमिटेड) जैसे विविध स्थलों पर समुद्री बिटर्न को परिस्कृत किया गया। इन स्थानों से प्राप्त काइनाइट मिक्स साल्ट का सल्फेट ऑफ पोटाश संयंत्र हेतु उपयोग किया जा रहा है।

लघु नमक उद्योगों को सक्षम बनाने तथा नमक उत्पादन में शामिल मज़दूरों के कठिन परिश्रम को कम करने के उद्देश्य से हमारे विभाग ने मिनी ट्रेक्टर, सॉल्ट वोशरी (5 टीपीएच क्षमता वाला) जैसे अर्धयांत्रिक उपकरणों के विकास के लिए पहल की है तथा वर्तमान ब्राइन फीडींग चैनल के रखरखाव तथा क्रिस्टलाइज़र के नवीकरण एवं प्रदर्शन हेतु छोटे पैमाने पर प्रोटोटाइप मॉडल सॉल्ट फार्म के लिए प्रस्ताव किया गया है। ब्राइन तंत्रों पर कुछ मूलभूत अध्ययन जैसे NaCl के जलीय विलयनों में नाइट्रेट सॉल्ट (MNO_3, जहाँ M = Na, K तथा NH_4) मिलाने पर कैल्शियम सल्फेट डाइहाइड्रेट (जिप्सम, $CaSO_4 \cdot 2H_2O$) की घुलनशीलता व्यवहार पर प्रभाव, जल में Na_2SO_4 की ताप आधारित घुलनशीलता परिवर्तन तथा मौलिक तथा औद्योगिक अनुप्रयोगों की दृष्टि से उसमें NaCl के प्रभाव पर भी अध्ययन किया गया। ब्राइन/बिटर्न में से बहुमूल्य तत्वों (Li और Sr) को पुनःप्राप्त करने के हमारे प्रयास के अंतर्गत, हमने पहली

बार देखा कि साधारण नमक बनने से पहले समुद्री ब्राइन को सल्फेटविहीन करने पर बिटर्न स्ट्रोंशियम तथा लिथियम दोनों से समृद्ध हुआ, जिससे इनका प्रभावी पृथक्करण संभव है। हमने चिलींग प्रोसेस द्वारा सल्फेट विहीनीकरण के माध्यम से समुद्री बिटर्न से कार्नेलाइट की सरल तरीके से पुनःप्राप्ति करने के लिए भी कार्य किया है।

इस विभाग ने तरल नमक (आयनिक तरल) के गुणधर्म तथा उनके संभावित अनुप्रयोगों को समझने के लिए भी अनुसंधान एवं विकास कार्य किया है। इस संदर्भ में हमने आयनिक तरल का उपयोग करके अगरोज–काइटोसन संकर पदार्थ तथा नैनोसंघटित आयनो जेल बनाने पर कार्य तथा उसके संरचना, स्थिरता एवं फिज़ियोकेमिकल गुणधर्मो का अध्ययन किया है,जो *Green Chem.* 2014, 16, 320 – 330 में प्रकाशित हुआ है। हमने प्रथम बार आयनिक तरल एल–प्रोलीन आइसोप्रोपाइल एस्टर लौरयल सल्फेट का अन्य जलस्नेही तथा जलविरोधी आयनिक तरल में पुटिका तथा प्रतिवर्ती पुटिका निर्माण देखा और अध्ययन किया जो *Chem Commun.* 2013, 49 (73),8111 – 8113 में प्रकाशित हुआ है।

हमने सतह सक्रिय आयनिक तरल के साथ काइटोसन के स्वरुप के यौगिकीय व्यवहार का अध्ययन किया है जो *J Colloid Interf Sci.* 2013, 407,361 – 369. में प्रकाशित हुआ है। हमने इसकी क्रियाविधि समझने के लिए सतह सक्रिय आयनिक तरल का जलीय माध्यम में जेलिंग जैव बहुलक अगरोज़ के साथ परस्पर क्रिया व्यवहार पर मूलभूत अध्ययन किया। हमने पर्यावरणीय तथा आर्थिक लाभ के प्रति अपने प्रयासों के अंतर्गत विभिन्न औद्योगिक अपशिष्टों पर खारे प्रवाह प्रबंधन पर भी कार्य किया है। इस संदर्भ में हमने तामिलनाडु के चर्मशोधन तथा टेक्सटाइल उद्योगों के खारे अपशिष्ट प्रवाह में से क्रमशः नैनो फिल्टरेशन, सल्फेट विहीनीकरण/फ्रिज़ क्रिस्टलाइजेशन तथा आइसोथर्मल वाष्पीकरण द्वारा अतिशुद्ध नमक की पुनःप्राप्ति पर कार्य किया है। हमने नमक के मिश्रणों (Na_2CO_3, K_2CO_3& KOH) का बहुमूल्य उत्पादों जैसे KNO_3, $NaNO_3$ तथा $KClO_4$ अथवा $KC_4H_5O_6$ में रुपांतरण पर तथा विनाती ओर्गेनिक्स लिमिटेड के आइसोब्युटाइल बेन्जीन (IBB) उत्पादन संयंत्र द्वारा प्रयुक्त जल में से इनका सरलता से पृथक्करण किया और यह प्रौद्योगिकी वाइरल अल्कलीज़ लिमिटेड, महाड, महाराष्ट्र को हस्तांतरित की है।

नमक कार्यों के आर्थिक तथा पर्यावरणीय लाभ के लिए नमक कार्यों के जैविक प्रबंधन का कार्य शुरु किया गया है और सूक्ष्मजैवीय तंत्रों पर अनेकों कार्य पूर्ण हो गये हैं। इस संबंध में सूक्ष्मशैवाल आधारित जैव इंधन के बेहतर व्यवसायीकरण के लिए हमने ताज़े एन्कीस्ट्रोडेमस फेल्कट्स सूक्ष्मशैवाल की आकारिकी तथा शरीर क्रिया विज्ञान पर विभिन्न माध्यम रचना, प्रकाश तीव्रता तथा प्रकाश अवधि के प्रभाव पर अध्ययन किया है। परिणामों से ज्ञात हुआ कि एन्कीस्ट्रोडेसमस फैलकेट्स ने बीजी–11 माध्यम में 60 माइक्रोमोल प्रति वर्गमीटर प्रति सेकण्ड पर 12:12 रोशनी:अंधेरे के प्रकाशकाल में बायोमास उत्पादकता (7.9 मिग्राप्रति ली. प्रतिदिन) कुल लिपिड (65.74% प्राकृतिक लिपिडयुक्त) तथा इष्टतम विकास (0.20 μ) के साथ 35% से अधिक पैदावार दर्शायी। जारुक्स माध्यम में उगाये गये संवर्धन में 67.2% उच्चतम कुल लिपिड उपज (प्राकृतिक लिपिड 72.68%) पायी गई लेकिन इनमें परिवर्तित कोशिकीय आकारिकी तथा सूक्ष्म संरचनात्मक परिवर्तन पाये गये।

Scenedesmus CCNM 1077 को बायोडीजल तथा बायो–एथनॉल उत्पादन के लिए एक संभावित फीड–स्टॉक बनाने के लिए हमनें सीमित नाइट्रोजन के साथ अनुक्रमिक नाइट्रोजन अभाव के कारण इसके आकारिकी तथा जैव–रसायनिक परिवर्तनों पर भी अन्वेषण किया है। वृद्धि माध्यम से नाइट्रेट पूर्णतया हटाने पर उच्चतम लिपिड (27.93%) तथा कार्बोहाड्रेट मात्रा (45.75%) पायी गई जो इसे बायोडीजल तथा जैव इथेनोल उत्पादन के लिए संभावित फीडस्टॉक बनाती है।

विभिन्न विकास अवस्थाओं पर कार्बन अधिग्रहण (सीक्वेस्ट्रेशन) तथा लिपिड उत्पादन के लिए सूक्ष्म शैवाल मोनोरैफीडियम मिनटम् पर अध्ययन किया गया। इस अध्ययन से यह निश्चित हुआ कि यह संतृप्त फैटी एसिड से समृद्ध (30.92-68.94%) सूक्ष्म शैवाल है जिसकी निम्न स्तर की असंतृप्त तैल गुणवत्ता (42.06-103.99) उसे बायोडीजल उत्पादन में संभावित प्रार्थक बना सकती है।

जेट्रोफा बायोडीजल अवशेष अर्थात् कच्चे ग्लिसरॉल और हाइड्रोलाइजेट खली से पॉलीहाइड्रोक्सीआल्का–नोएट (पीएचए) के उत्पादन के बारे में पहले वर्णित है। एक वाइल्ड समुद्री नस्ल हेलोमोनस हाइड्रोथर्मलिस (एमटीसीसी पंजीकरण सं. 5445; एनसीबीआई जीन बैंक पंजीकरण सं. GU938192) का इस जैव संश्लेषण में उपयोग किया गया। वर्तमान अध्ययन बहुलक के गुणों में परिवर्तन के लिए शुरु किया गया था। समुद्री शैवाल से व्युत्पन्न कच्चे लेवोलीनिक एसिड (एसडीसीएलए) जिसमें फोर्मिक एसिड, अवशिष्ट शर्करा तथा अतिरिक्त विघटित खनिज निहित होते हैं,

उसे बायोडीजल अवशेषों के साथ सह पोषक के रुप में सिंचित किया गया। बैच प्रक्रम में 100 मि.ली. पर प्रयोग किये गये। केवल बायोडीजल के अवशेषों का उपयोग किये जाने पर पीएचए उपज सिर्फ 0.40 ग्राम थी, जबकि एसडीसीएलए की उपस्थिति में पीएचए की उपज 1.07 ग्राम बढ़ी। इसके अनुरुप कार्बन उपयोग क्षमता क्रमशः 29.3% तथा 57.5% थी।

एसडीसीएलए की उपस्थिति में बहुलक गुण में परिवर्तन के साथ पीएचए में 3-हाइऑक्सी वेलरेट का समावेश स्पष्ट देखा गया। एसडीसीएलए के स्थान पर शुद्ध लेवुलीनिक एसिड का उपयोग करने पर माइक्रोबियल संश्लेषण ने क्षीण प्रदर्शन किया। अतः हेलोमोनस हाइड्रोथर्मलिस ने लेवुलीनिक एसिड के लिए खराब प्रतिक्रिया दी तथा एसडीसीएलए में मौजूद अन्य घटकों ने पीएचए संचय तथा जीवाणु कोशिकीय विभाजन में महत्वपूर्ण भूमिका निभाई। अध्ययन के एक भाग के रुप में नम मिट्टी में जैवनिम्नीकरण परीक्षण भी किये गये।

हमने चांदी के नैनोंकणों को नवीन तिर्यकबंधित बीडेड पॉलीस्टाइरीन/पॉलीएमिडोक्सीम परस्पर अनुक्रमित बहुलक नेटवर्क (IPNs) पर कार्य किया तथा इनकी जीवाणुरोधी गतिविधि का अध्ययन किया। सामाजिक कार्यों की भागीदारी में भी विभाग ने व्यापक कार्य किया है जिसका वर्णन प्रकरण–7 में किया गया है।

अकार्बनिक पदार्थ एवं उत्प्रेरण

ऊर्जा संबंधी समस्याओं के निराकरण में उपयोग हेतु तथा अधिशोषण एवं उत्प्रेरक रुपान्तरण पर विशिष्ट ध्यान देने के साथ विभिन्न अनुप्रयोगों, इच्छित चयनशीलता, अधिशोषण/पृथक्करण के लक्ष्य के साथ तकनीकी रुप से उन्मुख, औद्योगिक रुप से महत्वपूर्ण अधिशोषण तथा कार्बनिक संश्लेषण के लिए वर्तमान हरित प्रौद्योगिकी की मांग को ध्यान में रखते हुए पर्यावरण अनुकूल उत्पाद संरचना के लिए विशिष्ट अकार्बनिक पदार्थ विकसित करने हेतु अनुसंधान एवं विकास कार्य किया गया। गैस पृथक्करण तथा भंडारण हेतु कुशल अधिशोषक तथा विभिन्न अनुप्रयोगों हेतु नैनो पदार्थ विकसित किये गये और अनेकों औद्योगिक परियोजनाओं का संचालन किया गया। उक्त अनुसंधान एवं विकास कार्यों ने तापीय शक्ति उत्पादन कंपनियों, उर्वरक तथा पेट्रोकेमिकल उद्योगों, लिथियम–बैटरी निर्माताओं, खदान मालिकों तथा खनिज संसाधक, पर्यावरण मंत्रालय/फर्मों, फार्मा उद्योग, रासायनिक उद्योगों तथा बेहतर पर्यावरण के क्षेत्र में उल्लेखनीय औचित्य दर्शाया है।

मेसर्स थर्मेक्स लिमिटेड, पुणे के साथ सहयोगी परियोजना के अंतर्गत वायुमंडल शीतलन प्रणाली के लिए अधिशोषक सामग्रियों पर अनुसंधान एवं विकास करते हुये महत्वपूर्ण विवरण तैयार किया गया। नोयडा स्थित कोर्पोरेट अनुसंधान एवं विकास केन्द्र बीपीसीएल के साथ निधियन एवं सहयोग से हाइड्रोजन के उत्पादन हेतु संकरित अधिशोषण वर्धित स्टीम रीफोर्मिंग प्रोसेस के लिए उचित अधिशोषक विकसित करने हेतु अन्वेषण किया गया। निम्नस्तरीय कच्छ बॉक्साइट से डिटरजेन्ट बिल्डर जिओलाइट–ए पाउडर के निर्माण की प्रौद्योगिकी को पीडीइसी तथा डीआइएमसी विभाग द्वारा संयुक्त रुप से मेसर्स गुजरात क्रेडो मिनरल इन्डस्ट्रीज लिमिटेड, अहमदाबाद को स्थानांतरित किया गया। ब्वायलर (8-15 आयतन % CO_2) से फ्ल्यू गैस सफलतापूर्वक एकत्रित की गयी और इसका उपयोग जिप्सम को कैल्शियम कार्बोनेट और अमोनियम सल्फेट में परिवर्तित करने के लिए समेकित सॉल्वे–मेसबर्ग–सीएसएमसीआरआई प्रक्रिया में किया गया।

कार्बनिक मिट्टी (ओर्गेनो–क्ले) का औषधि वितरण प्रणाली, ओर्गेनो परिवर्तित/विभाजित एलडीएच तथा उनका पर्यावरण सुधार में उपयोग पर शोधकार्य किया गया। नैनोसंरचित ऑक्साइड तथा स्तरीय टाइटनेट्स, TiO_2 हॉलो स्फीयर्स, सेलेनाइड नैनो–क्रिस्टल्स, नैनोसंरचित MnO_2 का संश्लेषण किया गया तथा उनके विद्युत रासायनिक गुणधर्मों, विशेष रुप से लिथियम–बैटरी तथा विषाक्त धातु आयनों के उद्ग्रहण का अध्ययन किया गया। क्षारीय तथा क्षारीय मृदा धातु आयनों के संवेदन के लिए लैंथेनाइड–हेलीकेट संयोजन संश्लेषित किये गये। पीसीबी तथा लिथियम–आयन बैटरियों जैसे ई–कचरे से सोना, पैलेडीयम, चांदी, तांबा, टिन, सीसा, कोबाल्ट, मैंगनीज़ और लिथियम की पुनर्प्राप्ति पर ध्यान केन्द्रित किया गया।

विभिन्न विशिष्ट अकार्बनिक पदार्थों तथा उनके अनुप्रयोगों पर शोधकार्य किये गये, जिनमें लेयर्ड डबल हाइड्रोक्साइड (एलडीएच) के लिए एमिनो एसिड मध्यस्थ सोल्वोथर्मल संश्लेषित प्रोटोकॉल; विषाक्त धातु आयन के सुधार के लिए बहुलक विभाजित

एलडीएच नैनोसंघटक; प्लास्टिक कचरे के उपयोग द्वारा कार्बन माइक्रोस्फीयर्स का संश्लेषण और उनका नैनोक्रीस्टलाइन कॉपर (II) ऑक्साइड हॉलो स्फीयर्स के लिए टेम्पलेट के रुप में उपयोग; प्लास्टिक कचरे से प्याज के आकृति की कार्बन सूट तथा इसके लक्षण का वर्णन; कक्ष तापमान पर एमसीएम–41 सिलिका का बड़े पैमाने पर संश्लेषण; संदीप्त फॉस्फेट संवेदक; धातु नैनोंकणों युक्त नैनों छिद्रवाली बहुलक फिल्मों का निर्माण तथा उनका अपशिष्ट जल शोधन तथा उत्प्रेरण में संभावित उपयोग; मोन्टमोरीलोनाइट/पॉली (एल–लैक्टाइड) सूक्ष्म संघटक स्फीयर्स का औषधि वाहक के रुप में विकास; मीसोपोरस हेक्टोराइट्स (एमएसएच) का टेम्पलेट मुक्त संश्लेषण; श्रेणीबद्ध प्रोटॉनीकृत स्तरीय टाइटेनेट्स/एनाटेज TiO_2 हॉलो स्फीयर्स का कार्बन मुक्त निम्न ताप पर सीधा संश्लेषण तथा उनका कार्य विशेष अनुप्रयोग तथा समान धातु सेलेनाइड नैनोंकणों के लिए वैकल्पिक जलीय संश्लेषण आदि शामिल हैं।

उत्प्रेरण के क्षेत्र में बायोमास तथा कार्बन डाइऑक्साइड के उत्प्रेरित रुपांतरण पर विशेष ध्यान देते हुए समांग–विषमांग तथा प्रकाश–उत्प्रेरण परिस्थितियों में शोध कार्य किये गये। बायोमास से व्युत्पन्न उत्पादों में कच्चे माल तथा ऊर्जा के भविष्य के स्रोत की क्षमता है, अन्य C_1 स्रोतों की तुलना में ग्रीनहाउस गैस कार्बन डाइऑक्साइड के प्रचुर, रियायती तथा विषरहित होने के कारण, मूल्यवान रसायनों के संश्लेषण के लिये कार्बन स्रोत के रुप में इस गैस के फीड–स्टॉक उपयोग में रुचि बढ़ी है। इसे देखते हुए उत्प्रेरण में मुख्यतः तीन मुख्य प्रवृत्तियाँ (1) प्रभावी उत्प्रेरण द्वारा बायोमास/व्युत्पन्न उत्पादों का रुपांतरण। (2) CO_2 की वृद्धि तथा पर्यावरणीय प्रभावों को संतुलित रखने के लिए औद्योगिक रुप से महत्वपूर्ण विभिन्न कार्बनिक यौगिकों के संश्लेषण में क्षमतावान हरित उत्प्रेरक प्रणाली में कार्बन डाइऑक्साइड का उपयोग। (3) सुगंधित पदार्थों तथा औषधि उद्योगों के लिए महत्वपूर्ण असममितिक (काइरल) उत्प्रेरण तथा औद्योगिक रुप से महत्वपूर्ण चयनात्मक जैविक रुपान्तरणों के लिए नवीन उत्प्रेरक प्रणाली पर अन्वेषण कार्य किये गये।

बायोमास/व्युत्पन्न उत्पादों तथा CO_2 के मूल्यवर्धित कार्बनिक रसायनों में प्रभावी तथा हरित रुपान्तरण के लिए सक्षम उत्प्रेरक प्रणाली के विकास हेतु शोध कार्य किये गये। इपॉक्साइडाइज़्ड केस्टर ऑयल का ट्रान्सेस्टरीफिकेशन; इथाइल लीनोलेट का समन्वयन; ठोस अम्लीय उत्प्रेरकों का उपयोग करके सुगंधी एस्टर के संश्लेषण के लिए फिनॉल के साथ लेवुलिनिक एसिड का कीमो–चयनित एस्टरीकरण; कीमो–एंजाइमी उत्प्रेरण का उपयोग करके सेल्युलोज का जलीय विश्लेषण; जिरकोनिया आधारित उत्प्रेरक तथा इपोक्सीडेशन पर एस्टरीकरण पर शोधकार्य द्वारा इस दिशा में उल्लेखनीय प्रगति की गई। CO_2 तथा इपोक्साइड के असममितिक साइक्लोएडिसन, ऑक्सीडेटिव कार्बोक्सीलेशन द्वारा फैटी चक्रिय कार्बोनेट का एक ही बार में संश्लेषण, मेथेनोल तथा CO_2 से डाइमिथाइल कार्बोनेट के प्रत्यक्ष संश्लेषण, CO_2 का फॉर्मिक एसिड में विषमांग हाइड्रोजनीकरण के लिए नवीन उत्प्रेरक प्रणाली के विकास हेतु CO_2 के उपयोग पर शोधकार्य किये गये।

चयनात्मक कार्बनिक संश्लेषण के लिए एक ही बार में विषमांग हाइड्रोएमिनों मेथाइलेसन, C-H सक्रियण के माध्यम से बेन्जोओक्सजोल का ऑक्सीडेटीव एमीनेशन, वर्धित उत्प्रेरक लक्षणों के साथ छिद्रयुक्त ZnO (नैनोफ्लेक्स एवं सूक्ष्म नलिकायें) तथा छिद्रयुक्त सीज़ियम व्याप्त MgO (Cs–MgO) नैनोफ्लेक्स, O_2 के द्वारा स्टाइरीन के चयनात्मक ऑक्सीकरण के लिए CeO_2 नैनो–तार, (m-ZRP) के स्थान पर O_2 के उपयोग द्वारा कक्ष तापमान पर बी.वी ऑक्सीकरण, मीसोपोरस बोरेटेड जिरकोनियाः एक ठोस एसिड–आधारित द्विकार्यात्मक उत्प्रेरक और $MnCO_3$ के माध्यम से पदानुक्रम अनुसार छिद्रालु, कमल आकार के नैनोसंरचित MnO_2 पर अनुसंधान तथा विकास कार्य किये गये।

काइरल उत्प्रेरण में पुनर्चक्रित करने योग्य धातु काइरल संयोजन निर्मित किए गए तथा विषम स्ट्रेकर प्रतिक्रिया के माध्यम के विभिन्न मध्यवर्ती संश्लेषण जैसे साइनाइड के विभिन्न स्रोतों के साथ एल्डीहाइड्स का सायनेशन, असममित रिंग ओपेनिंग क्रियायें, रेसिमिक इपॉक्साइड का एमीन्स के साथ गतिज विभेदन, नाभिकस्नेही जल एवं CO_2, असममित हेनरी तथा एजा हेनरी क्रियायें, कार्बोनिल यौगिकों की असममित फ्रीडल क्राफ्ट क्षारीयकरण और एलायलेसन क्रियाओं के लिए इनका उपयोग किया गया। प्रकाश उत्प्रेरण के अंतर्गत, सीधे सूर्यप्रकाश प्रदीप्त के तहत रोडामाइन बी (RhB) रंजक के अवकर्षण के लिए बिस्मथ–डोप्ड TiO_2 नैनोट्यूब्स (Bi-TNT) प्रकाश उत्प्रेरकों का कुशलतापूर्वक उपयोग किया गया। वक्र तथा पुष्प आकार की दृश्य प्रकाश सक्रिय बिस्मथ टंगस्टेट (Bi_2WO_6) प्रकाश उत्प्रेरक तथा बहुभित्तीय कार्बन नैनोट्यूब-TiO_2 नैनोट्यूब (MWCNT/TNT) संघटित पदार्थ संश्लेषित किये गये। दृश्य प्रकाश में नाइट्रोएरेन्स के प्रकाश उत्प्रेरित अपचयन पर भी कार्य किया गया।

SALT & MARINE CHEMICALS

Double Fortified Salt

Iron and iodine are essential elements for the human body. Iodine deficiency disorder (IDD) and iron deficiency anemia (IDA) caused by insufficient intake of iodine and iron respectively have serious detrimental effects on the economic and social development of entire populations. An innovative route for fortification of salt with iodine and iron using inorganic matrix compound which exhibits white colour and retains its concentration intact over a long period of time to control the problems of iodine deficiency and anemia has been developed. The double fortified salt (DFS) has been tested for its stability under varying climatic conditions and the nutrients are found to be quite stable even under extreme atmospheric conditions.The additional nutrition that one gets out of this salt is magnesium. Magnesium is very important nutrient in the body that helps in preventing diabetes mellitus. The Institute has completed extensive studies on stability of DFS for 3 years. Feedback was obtained from the Salt Department regarding the stability of the iron and iodine double fortified salt developed by the institute. Process has been scaled up and optimized (30 gm to 3 kg) for iron fortifying agent. Bioavailability test of the DFS in collaboration with Bhavnagar Medical College is in progress. Patent application on the development is filed. A patent, “Novel double fortified salt compositions containing iron and iodine and process of preparation thereof” is filed (Ref. 0607DEL2012).

Scale up of the process for cost-effective natural salt formulations for seawater substitution and mineral fortification

There are places in the country as well as overseas wherein sea water is not easily amenable for such purposes. The institute has come out with an innovative route for the production of natural salt formulations for sea water substitution in aqua culture and mineral fortification of pure product water produced through Reverse Osmosis-Electro Dialysis (RO/ED) technique. These natural formulations are made directly from sea water through innovative processes. Various fractions of salt formulations were collected and choose fractions were used based on its application. The mix fraction was employed for the culture of marine microalgae in our own experimental salt farm and they are found to grow equally well as compared to sea water. The sea water formulation prepared as above was dispatched to various personnel for its use as a sea water substitute in marine aquarium and the sea water fishes, which were found to be very comfortable in the sea water medium prepared from the above formulations.

100 kg each of samples of sea water formulation prepared as above have been sent to institutes like IIT Kharagpur, University of Calcutta and CSIR-NCL to conduct R&D experiments using this formulation as seawater substitute. The sea water formulation prepared was used for the re-mineralization of drinking water obtained from an ED/RO hybrid domestic desalination unit having a total dissolve salts (TDS) of 36 – 40 ppm. The product water obtained from the desalination unit was treated with solid sea mix to obtain product drinking water having a TDS of 450 ppm. A provisional patent application entitled "Cost-effective natural salt formulations for seawater substitution, mineral fortification and processes thereof” has been filed with the Indian Patent Office (Ref. No. 3422/DEL/2011, dt. 29/11/2011).





Solid Sea Samples sent to various institutes

Accelerating the evaporation rate of sea brine using black ink in small ponds at ESF

The black ink showed remarkable absorptivity in visible range of spectrum with λ_{max} of 580 nm. Therefore, black writing ink 30 ppm was chosen for the experiments for accelerating evaporation rate of sea brine system 4° Be' in mini fields at experimental salt farm (ESF). Data of volume reduction as a function of time was collected for blank and black ink containing systems. It was observed that density reached to 25° Be' in ink containing system in 19 days whereas it took 23-25 days for the blank system. This observation suggests that black ink can accelerate the brine evaporation rate significantly. However, as the concentration of black ink increased with the brine volume reduction it started precipitating out due to solubility limitations. Experiments have been carried out to improve the solubility of black ink. Gallic acid, the main component of black ink was complexed with iron and other metals in such a manner that it remains solubilize in brines even at higher density levels.

Accelerating the evaporation rate of sea brine using edible dyes

In order to develop a greener process of faster brine evaporation, a series of evaporation (total 8) experiments were performed with different food edible color dyes (with an initial concentration of 10 ppm) to examine the relative difference in evaporation rate of colored seawater to normal seawater. The table below shows the comparative data of evaporation of sea water using different dyes:

Dyes	Day-1 °Be'	Day-7 °Be'	Day-14 °Be'	Day-21 °Be'	Day-28 °Be'	Day-35 °Be'	Day-42 °Be'	Day-49 °Be'
Black PN Supra	4.23	5.84	7.42	8.46	10.49	13.65	16.45	17.57
Sunset Yellow	4.23	5.84	7.42	8.46	10.49	13.42	16.45	17.54
Indigo Carmine	4.23	5.97	7.42	8.46	10.74	13.18	16.22	17.34
Briliant Blue Supra	4.23	5.84	7.68	8.72	11.48	14.25	18.25	19.97
Fast Green	4.23	5.84	7.68	8.72	10.98	15.53	18.13	19.81
Blending - 1	4.23	6.64	7.68	8.97	11.97	16.22	21.06	22.80
Blending - 2	4.23	6.77	7.94	8.72	12.70	16,68	22.32	24.51
Blank	4.23	6.24	7.16	8.20	9.73	13.18	16.68	17.90

*Blending-1:- 1:1 mixture of Black PN Supra and Sunset Yellow;
Blending-2:- 1:1 mixture of Brilliant Blue and Fast Green

Mixture of Brilliant Blue and Fast Green was then chosen as potential combination to enhance the brine evaporation rate in solar salt pans. Brine evaporation rate of blank and dye mixture added brine was then compared in small size pans.

Day	Height (cm)		Density (°Be)	
	Blank	Blending	Blank	Blending
Day-1	13.5	13.5	28.9	28.9
Day-3	13.4	13.4	29	30.9
Day-5	13.4	12.6	29.3	31.2
Day-7	11.5	11.0	31.5	33
Day-9	10.9	10.0	32.1	33.6
Day-10	10.1	10.5	33	34.4



An increase of 35 % in brine evaporation rate could be achieved using mixture of Brilliant Blue and Fast Green. Further studies in large solar salt pans and on recycling/degradation of dyes will be carried out in coming salt season.

Accelerating the evaporation rate of desulphated bittern during production of carnallite

It has been reported that edible dyes which can absorb the solar radiations can be employed in solar salt works for increasing the evaporating rate of brine. Many large solar salt works had practiced the above process. However, acceleration of concentrated brine (which is left after the recovery of common salt) is not reported. In an attempt to modify the above process, studies were undertaken to accelerate the evaporation rate of desulphated Schoenite End Liquor during the production of crude carnallite in the field using green dyes. The experiments were conducted on a mini field scale mixing the optimized quantity of dye with the desulphated liquor. About 25% acceleration in evaporation rate was recorded by using green dyes. The products recovered during the evaporation of the liquor had initially a green tinge which was found to be easily washable and the washings were recycled in the process liquor. The carnallite decomposed liquor and the end bittern generated was also processed for the recovery of magnesium hydroxide and the washed product was found to be free of any green colour. The experiments are being repeated to validate the results.

Studies on brine percolation prevention in solar salt pans

Experiments were carried out towards prevention of brine percolation in solar salt pans in order to increase the salt yields. For the purpose various small size salt pans were constructed and beds were prepared utilizing 4 types of mixtures: (a) Fly Ash, (b) Bentonite, (c) mixture of Fly ash and Bentonite and (d) mixture of Fly ash, Bentonite and small amounts of Guar Gum. Fly ash + Bentonite mixtures (group 'c') were found to be very effective in brine percolation prevention whereas addition of small amount of guar gum could further reduce the brine percolation in salt pans. Studies will be validated in large scale solar salt pans.



Photograph showing brine percolation experiments in CSIR-CSMCRI ESF

Production of kainite type mixed salt atvarious locations

Activities for the recovery of kainite type mixed salt have been continued to cater the needs of (SOP Test Bed under DST funded project. The sea bittern left after salt production was processed for the recovery of kainite type mixed salt at various locations such as Bhavnagar (M/s. Bhavnagar Salt Works), Ghogha (M/s. Malhotra Salt Works, M/s. Merchant Salt Works), Greater Runn of Kutch (M/s. Agrocel Industries Limited) and Port Victor (M/s. GHCL Limited) to cater the needs of SOP recovery under the above DST funded project.







Activities related to kainite mixed salt production at various locations:M/s. Bhavnagar Salt Works, Experimental Salt Farm, CSIR-CSMCRI, and Port Victor - M/s. GHCL Limited

Mechanization of solar salt works

At present a number of mechanical approaches are being used during salt manufacturing process. However, most of the machines are useful only for large salt works having pucca crystallizers. On the other hand, solutions are being sought which are adaptable to small units where one can work with light machinery. These are important in making small salt works competitive, especially in our country. It is essential to make competitive and low cost systems within the country itself. Similarly, modernization of traditional salt harvesting methods is also favored because their adaptation to modern techniques of salt manufacturing would require use of equipment of low investment. CSIR-CSMCRI has initiated development of various semi-mechanization equipments keeping in mind the Indian conditions as well as small solar salt works. Semi mechanization process can considerably reduce the drudgery of labour involved in the harvesting of salt. The following activities have been initiated:

- Procurement of Mini Tractor with Front End Loader and Salt Loader suitable to load loose salt onto standard tractor trailer was done towards implementation of semi mechanization methods in the experimental salt farm for salt harvesting processes.

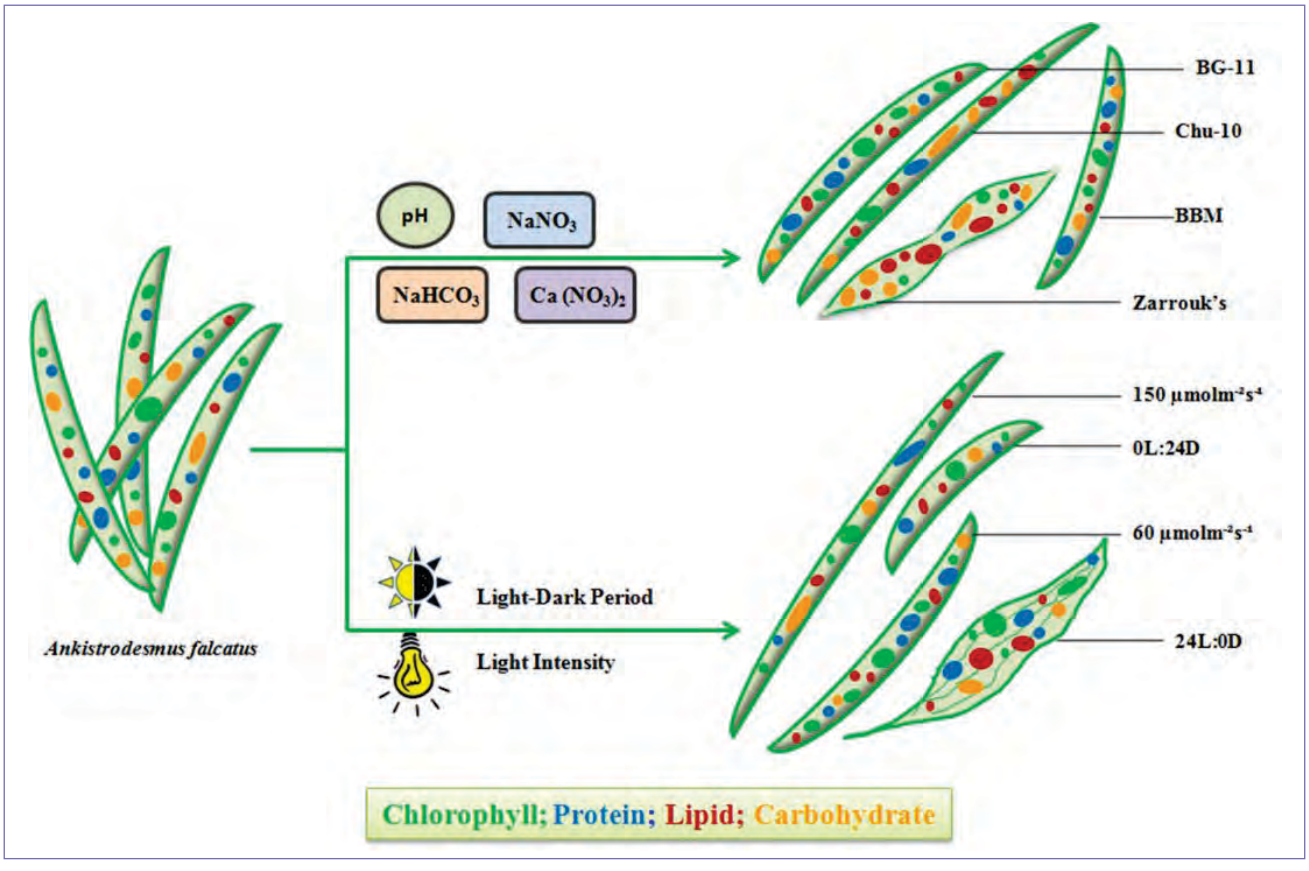
- Salt Washery (5 TPH capacity) has been designed which is expected to be installed in coming salt manufacturing season itself.
- Small scale prototype model salt farm for demonstration and carrying R&D experiments purpose at ESF (area approx. 100 Meter x 41 Meter, and Depth 1 ft). Renovation / Maintenance of existing pond at ESF for storage of Sea Bitterns (50 Meter x 50 Meter, Depth 12 ft approx.) is designed and construction will be initiated soon.
- Renovation of crystallizers is going on.
- Renovation / maintenance of existing brine feeding channel has been proposed. Designs have been completed.



Photographs showing semi mechanization activities implemented in ESF

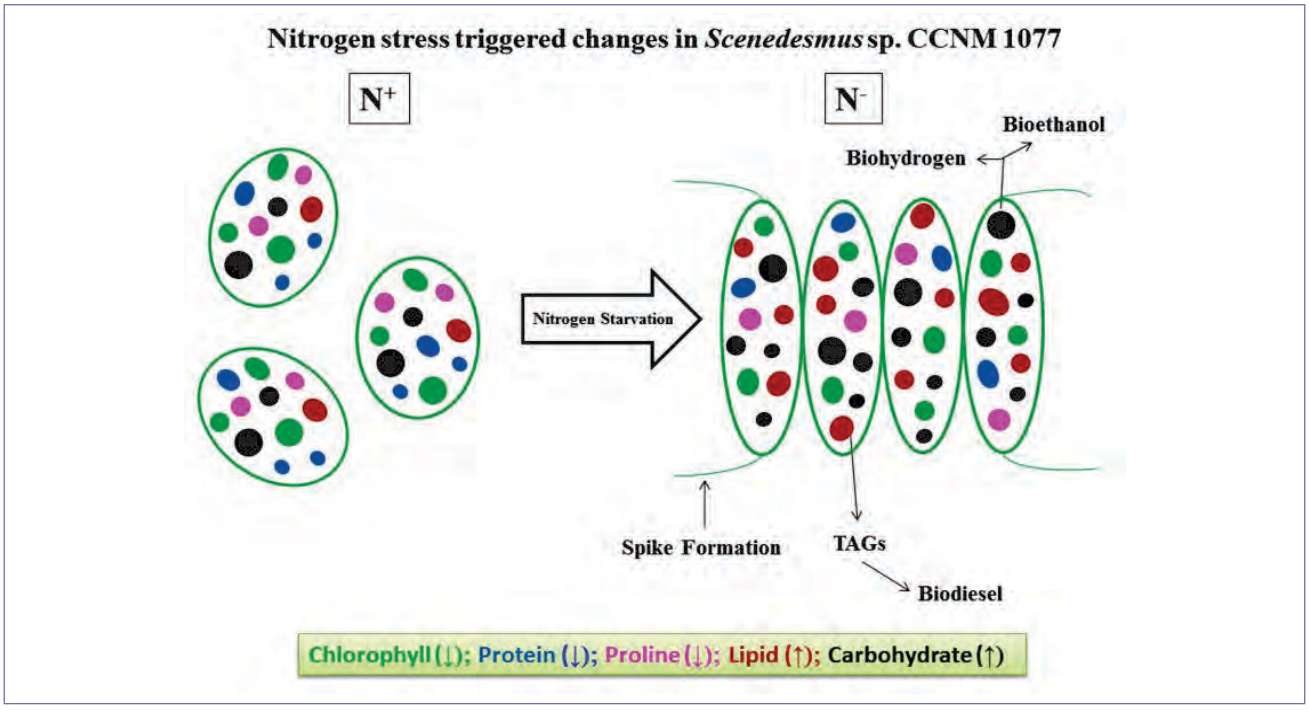
Effects of different media composition, light intensity and photoperiod on morphology and physiology of freshwater microalgae *Ankistrodesmus falcatus* - a potential strain for bio-fuel production

Media composition, light intensity and photoperiod significantly affect the algal growth and productivity and their optimization is important for the commercialization of microalgae based biofuels. We studied the effects of different culture medium, light intensity and photoperiod on growth, biomass productivity, and biochemical composition of a fresh water microalgae *Ankistrodesmus falcatus* in batch culture. The results revealed that *A. falcatus* could yield more than 35% of total lipid (containing around 65.74% neutral lipid) along with optimal growth (0.20 μ) and biomass productivity (7.9 mg/L/day) in the BG-11 medium under a light intensity of 60 μmol m^2 s^1 and 12:12 (Light: Dark) cycle. The highest total lipid yield of 67.2% (containing 72.68% of neutral lipid) was observed in Zarrouk's medium grown culture but with altered cell morphology and ultra-structural changes.

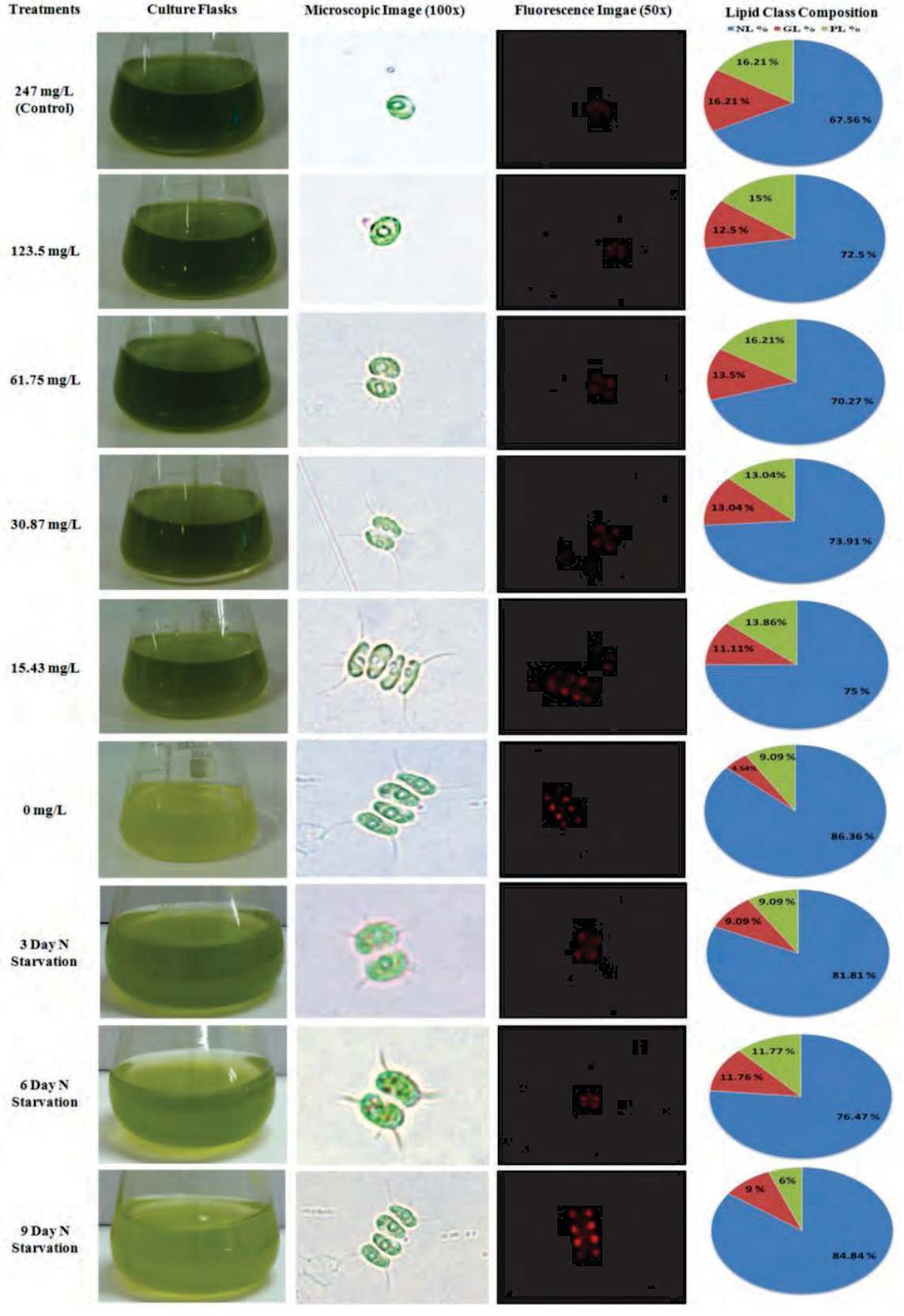


Nitrogen stress triggered biochemical and morphological changes in the microalgae *Scenedesmus sp.* CCNM 1077

We investigated the effects of nitrogen limitation as well as sequential nitrogen starvation on morphological and biochemical changes in *Scenedesmus* sp. CCNM 1077. The results revealed that nitrogen limitation and sequential nitrogen starvation conditions significantly decreases the photosynthetic activity as well as crude protein content in the organism, while the dry cell weight and biomass productivity are largely unaffected up to nitrate concentration of

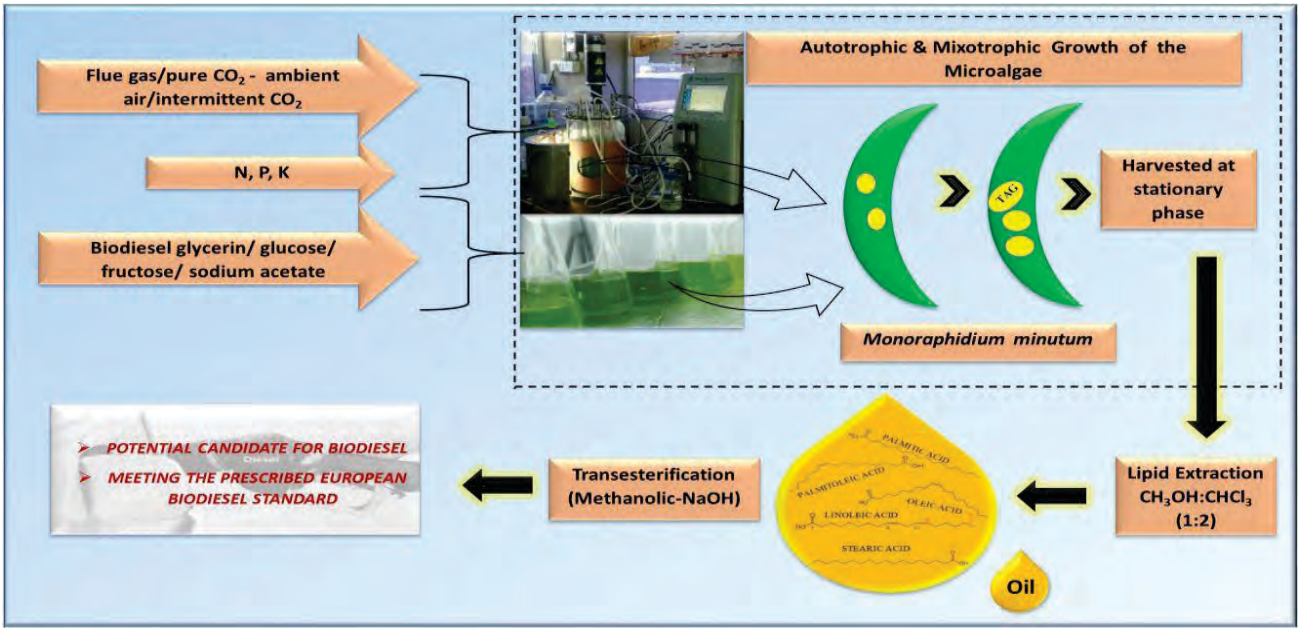


about 30.87 mg/L and 3 days nitrate limitation condition. Nitrate stress was found to have a significant effect on cell morphology of *Scenedesmus* sp. CCNM 1077. Total removal of nitrate from the growth medium resulted in highest lipid (27.93 %) and carbohydrate content (45.74 %), making it a potential feed stock for biodiesel and bio-ethanol production. This is an unique approach to understand morphological and biochemical changes in freshwater microalgae under nitrate limitation as well as sequential nitrate removal conditions.



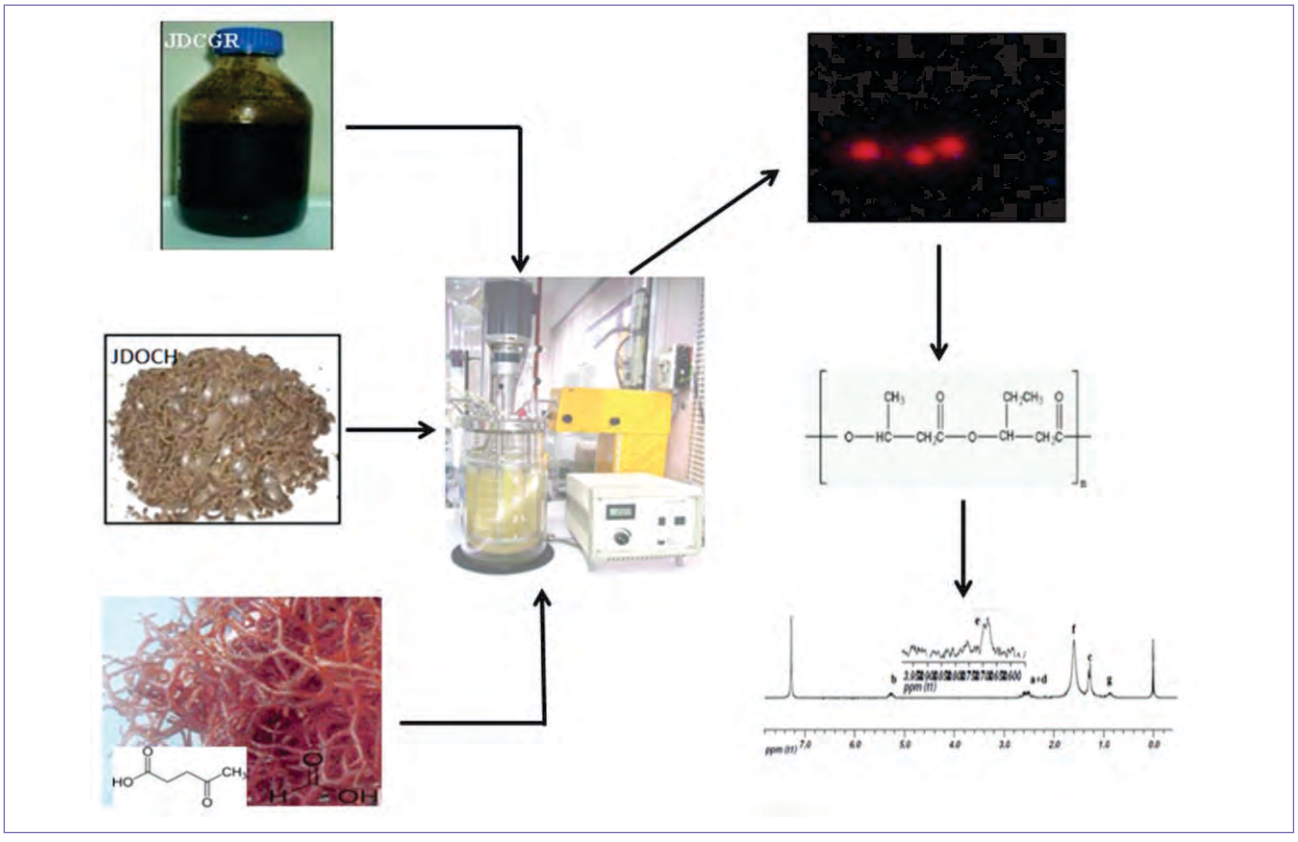
Potential of *Monoraphidium minutum* for carbon sequestration and lipid production in response to varying growth mode

Mixotrophic growth at flask level and, autotrophic-mixotrophic and autotrophic growth in photobioreactor by utilizing CO_2/air/flue gas were checked for the isolated strain of *Monoraphidium minutum* from a polluted habitat. Our study confirmed that it is a saturated fatty acid rich (30.92-68.94%) microalga with lower degree of unsaturation oil quality (42.06-103.99) making it potential biodiesel producing candidate. It showed encouraging biomass productivity (80.3-303.8 $mgl^{-1}day^{-1}$) with higher total lipid (22.80-46.54%) under optimum glucose, fructose, microalgal biodiesel waste residue and sodium acetate fed mixotrophic conditions. The pH control by intermittent CO_2, continuous illumination with 30% flue gas, and utilization of biodiesel glycerin were effective schemes to ameliorate either biomass productivity or % lipids or both of these parameters at photobioreactor scale (7.5 L working volume). The modulation of environmental variables (pH control, CO_2 and organic substrates concentration) could augment % saturated fatty acids, such as C16:0.



Microbial synthesis of polyhydroxyalkanoate using seaweed-derived crude levulinic acid as co-nutrient

Production of polyhydroxyalkanoates (PHA) from *Jatropha* biodiesel residues, namely crude glycerol and oil cake hydrolysate, has been reported previously. *Halomonas hydrothermalis* (MTCC accession no. 5445; NCBI Genbank accession no. GU938192), a wild marine strain, was used in the bio-synthesis. The present study was initiated to vary the properties of the polymer. Seaweed-derived crude levulinic acid (SDCLA), containing formic acid, residual sugars and dissolved minerals additionally, was proposed as a co-feed along with the biodiesel residues. Experiments were conducted at 100 mL scale in batch process. Whereas the PHA yield was only 0.40 g when only biodiesel residues were employed, it rose to 1.07 g in presence of 0.35% (*w/v*) of SDCLA. The corresponding carbon utilization efficiencies were 29.3% and 57.5%, respectively. 3-hydroxy valerate incorporation in the PHA was pronounced in presence of SDCLA, with associated changes in polymer properties. The microbial synthesis fared poorly when SDCLA was substituted with pure levulinic acid. Thus, *Halomonas hydrothermalis* had a poor response to levulinic acid, as such, and other constituents present in SDCLA appear to have played a vital role in bacterial cell division and accumulation of PHA. Biodegradability tests in moist soil were also conducted as part of the study.



Silver nanoparticle anchored with novel crosslinked beaded polystyrene/polyamidoxime sequential interpenetrating polymer networks (IPNs) and its antibacterial activity

We investigated the anti-bacterial effects of silver nanoparticle impregnated cross-linked beaded polystyrene/polyamidoxime interpenetrating polymer network (IPN) for evaluating its disinfection potential. It showed complete bacterial inhibition within 4-6 hours. The beads were also investigated for their efficiency to be used multiple times; results indicated their promising anti-bacterial activity even after repeated usage.

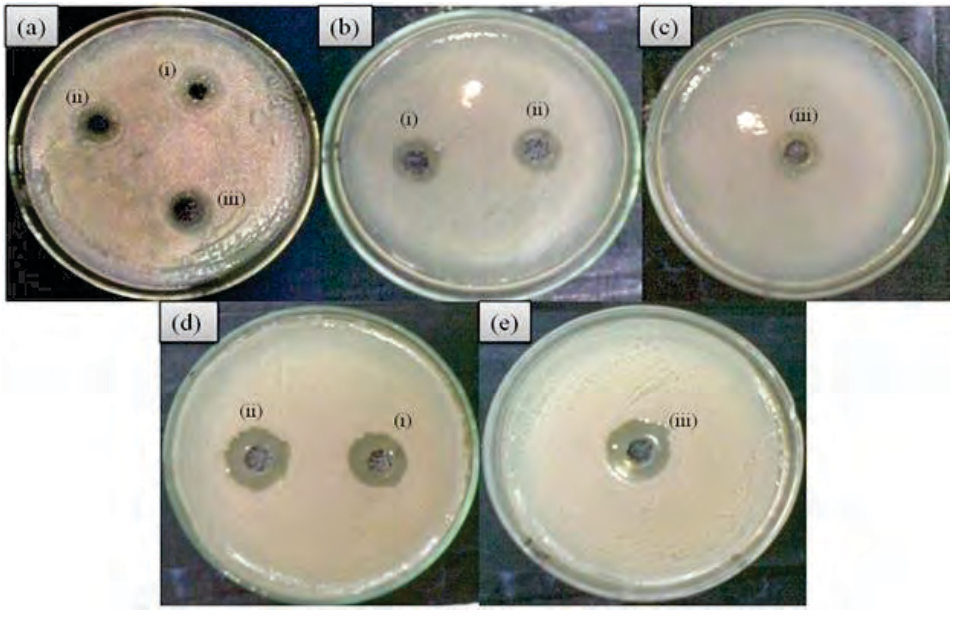
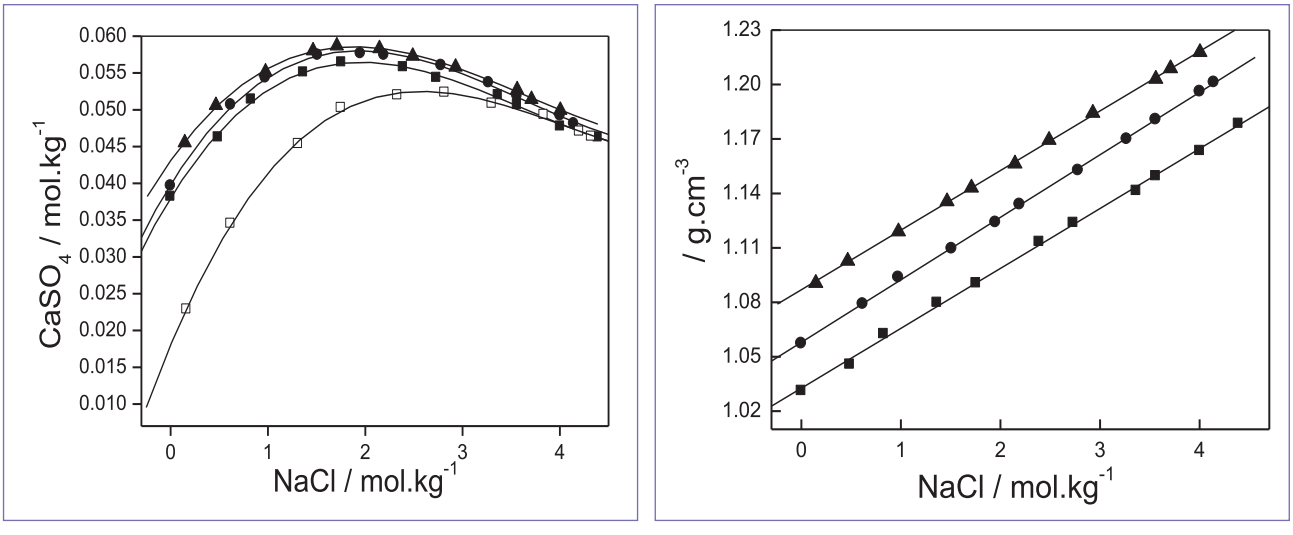


Plate method for antibacterial analysis showing zone of inhibition with different bacteria tested (a) *B. licheniformis* (i) IPNO.05, (ii) IPNO.1, (iii) IPNO.2. (b) *E.coli*, tested with (i) IPNO.05, (ii) IPNO.1, (c) IPNO.2. (d) *P.stutzeri* tested with (i) IPNO.05, (ii) IPNO.1, (iii) IPNO.2. [Colour figure can be viewed in the online issue, which is available at wileyonlinelibrary.com]

Basic Studies On Brine Systems

Effect of addition of nitrate salts on solubility of gypsum in brines

The effect of addition of nitrate salts (MNO_3, where M = Na, K and NH_4) on the solubility behavior of calcium sulfate dihydrate (Gypsum, $CaSO_4 \cdot 2H_2O$)in aqueous NaCl solutions has been examined at 308.15 K. Addition of nitrate salts in aqueous NaCl system increased the $CaSO_4 \cdot 2H_2O$ solubility significantly and the increase was higher at lower salinities. The order of increase in $CaSO_4 \cdot 2H_2O$ solubility with addition of different salts was: NH_4NO_3> $NaNO_3$> KNO_3. The maximum solubility of $CaSO_4 \cdot 2H_2O$ in aqueous NaCl solutions with the addition of nitrate salts was found to shift towards the lower salinities. We also measured accurate density (ρ) and speed of sound (u) for the quaternary systems containing $CaSO_4 \cdot 2H_2O$, NaCl, nitrate salts and H_2O at 308.15 K. Measurements of speed of sound and density have been used to determine solution isentropic compressibility (κ_S). Empirical equations describing the solubility, density, speed of sound and isentropic compressibility in these systems are presented

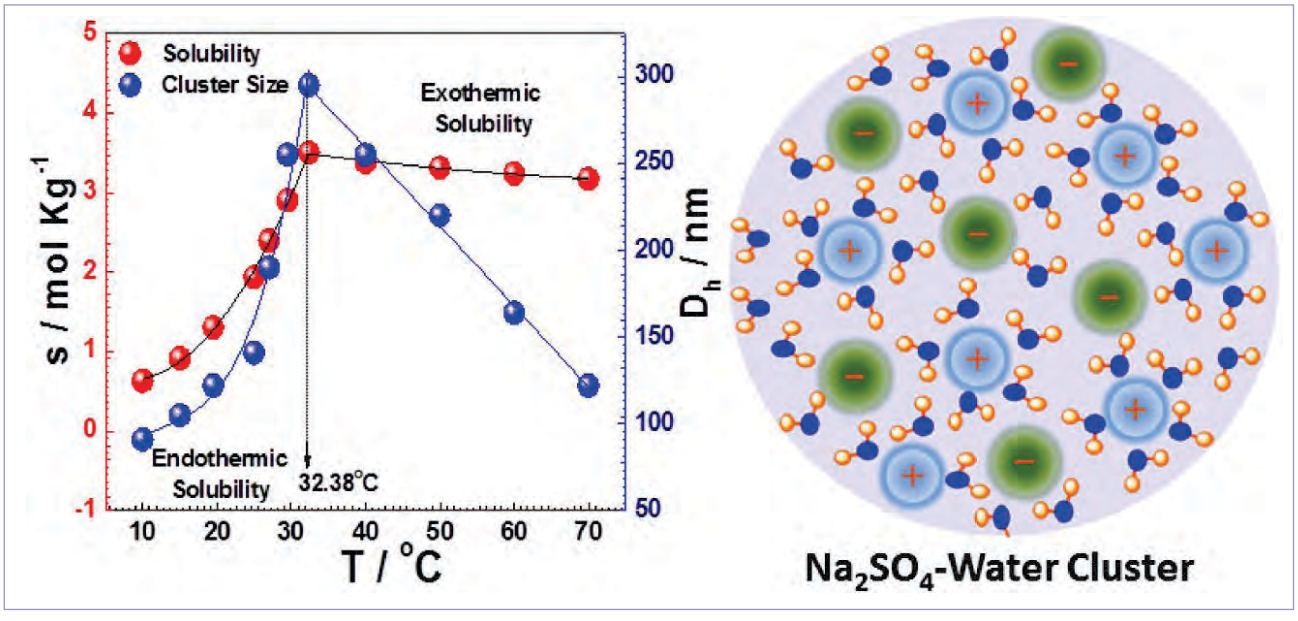


Comparison of solubility of $CaSO_4 \cdot 2H_2O$ at 308.15 K in aqueous NaCl-solutions containing: (□) 0; (■) 5%; (●) 10%; and (▲) 15% $NaNO_3$(left). Densities of the corresponding solutions at 308.15 K. Lines are polynomial and linear fit to the experimental data(right).

Temperature dependent solubility transition of Na_2SO_4 in water and effect of NaCl therein

Na_2SO_4 has an interesting temperature dependent aqueous solubility behavior wherein the solubility increases sharply up to 32.38°C and becomes almost constant (showing only a slight decrease) thereafter. The release of crystal water above 32.38°C has been cited as the reason for this behavior. We have thrown light on this phenomenon by analysing the Na_2SO_4-water clusters (growth and stability) detected from temperature dependent dynamic light scattering experiments, solution compressibility changes derived from the density and speed of sound measurements, and water structural changes/ Na_2SO_4 (ion pair)-water interactions observed from the FT-IR and 2D DOSY ^{1}H NMR spectroscopic investigations. It has been observed that Na_2SO_4-water clusters grows with the increase in Na_2SO_4 concentration (till solubility transition temperature) and then starts decreasing afterwards. An unusual decrease in cluster size and solution compressibility has been observed with the rise in temperature for the Na_2SO_4 saturated solutions below the solubility transition temperature, whereas an inverse pattern is followed thereafter. DOSY experiments have indicated different types of

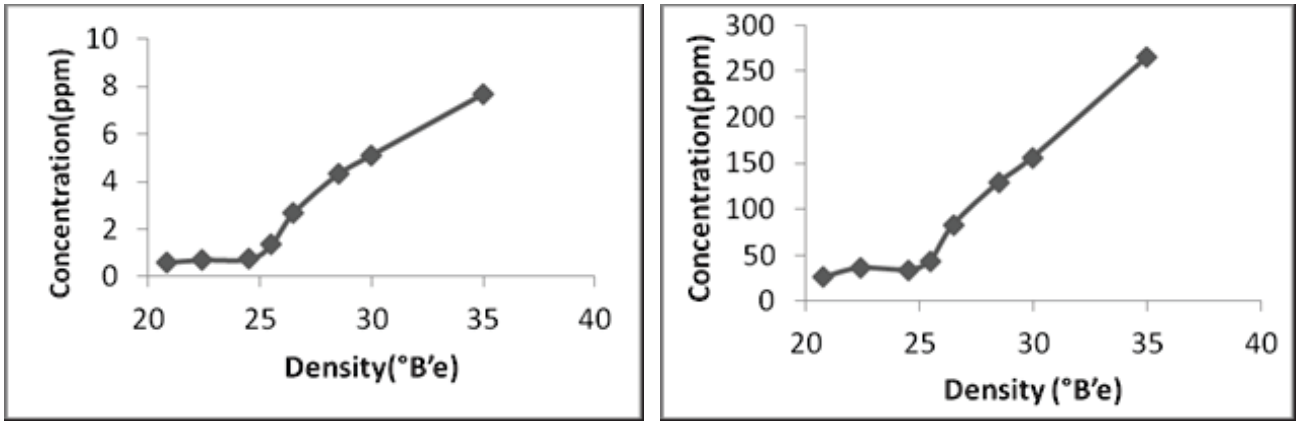
water cluster species in saturated solutions at different temperatures with varying self-diffusion coefficients. The effect of NaCl (5-15 wt%) on the solubility behavior of Na_2SO_4 at different temperatures have also been examined. The studies are important both from fundamental and industrial application point of view, for example, towards the clean separation of NaCl and Na_2SO_4 from the effluent streams of textile and tannery industries.



Temperature dependent Na_2SO_4 solubility in water and cluster growth in Na_2SO_4 saturated solutions (left) depiction of salt-water cluster in Na_2SO_4saturated solutions (right).

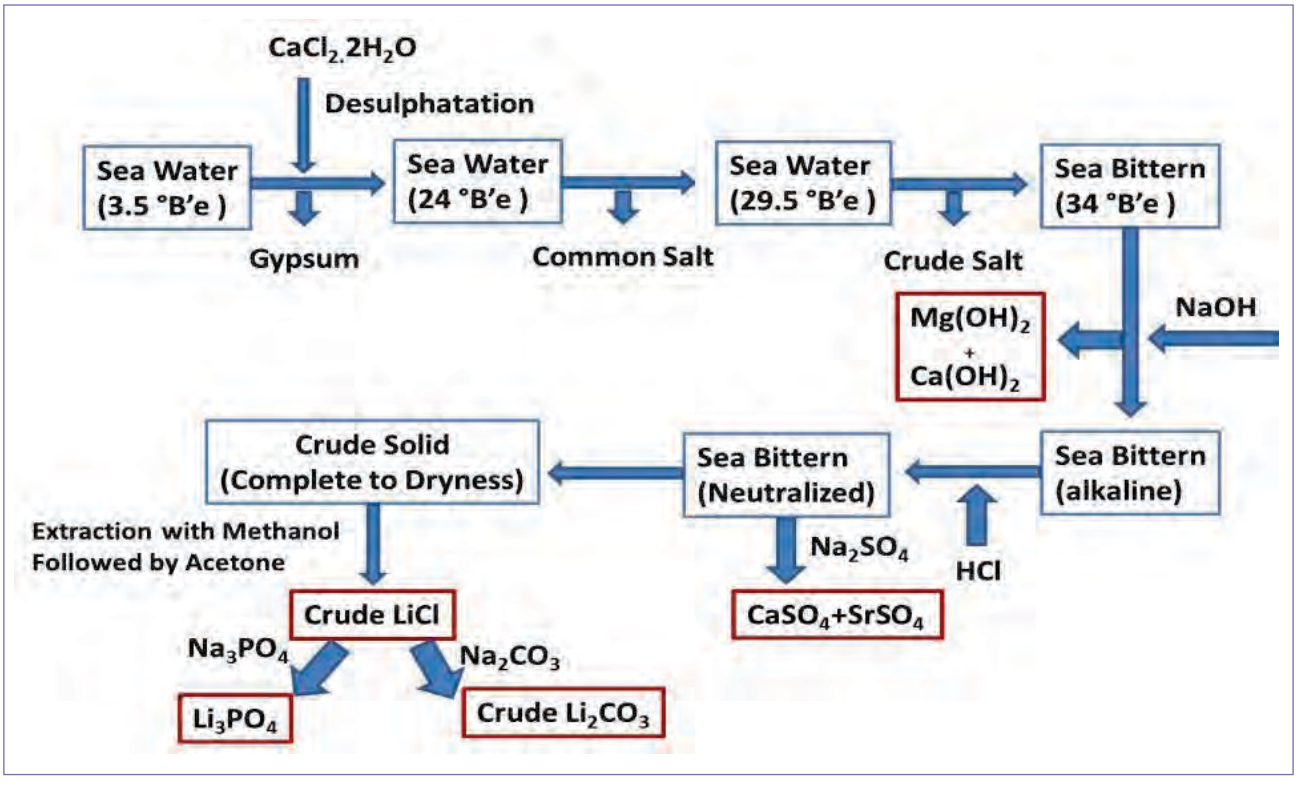
Studies on recovery of valuable trace elements (Li & Sr) from brine/bittern

Previous studies on mapping of Li^+& Sr^{2+} ion concentration by ICP-OES analysis on sea brine of different density (^{0}Be') showed that with increasing density of brine, the lithium concentration increases (max. 10 ppm) while that of strontium increases up to 25^{0}Be' (max. 50 ppm) and then decreases to zero ppm. It was assumed that due to high solubility of lithium salts it remains in solution even at 38^{0}Be'. But for strontium initially it increases but slowly gets saturated in forms of $SrSO_4$ and precipitates out. To enrich both Li^+& Sr^{2+} in bittern, desulphatation of sea water was done at 22^{0}Be' by adding stoichiometric amount of $CaCl_2.2H_2O$ with respect to SO_4^{2-} anion. It was observed that concentration of both Li^+& Sr^{2+} ion increases with density (max. 8 ppm for Li^+& 265ppm for Sr^{2+} at 35^{0}Be').

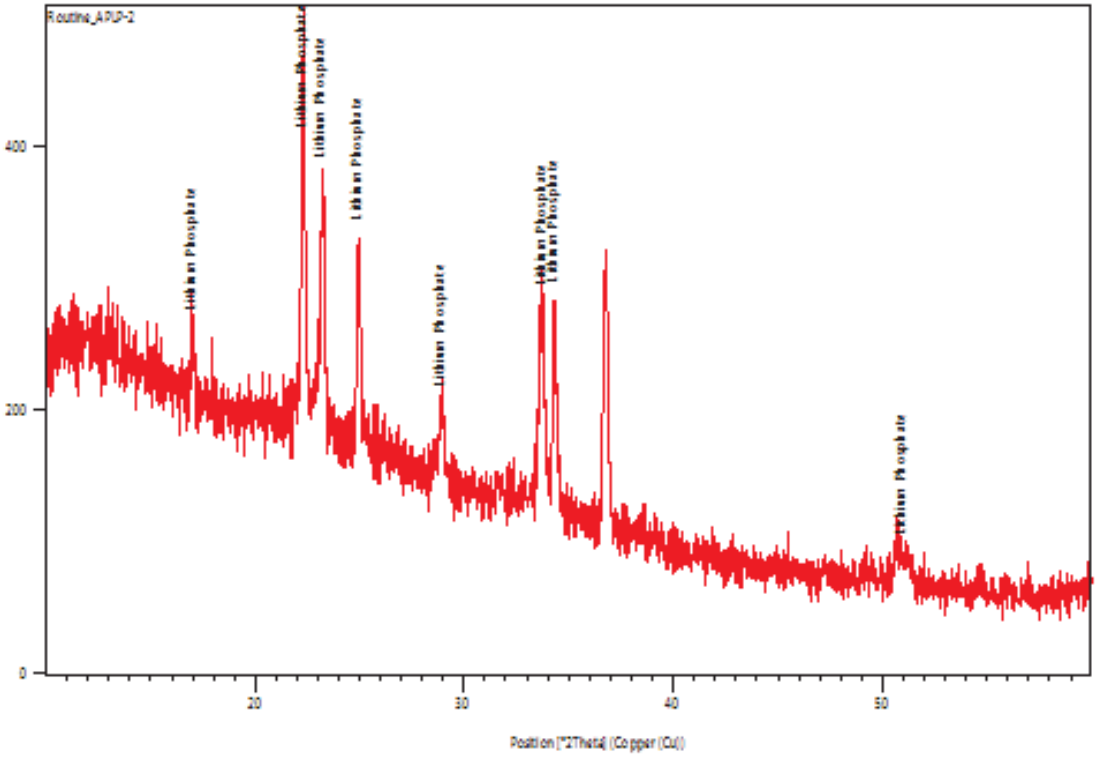


Left:ICP-OES analysis of Li^+ conc. Vs density; Right: ICP-OES analysis of Sr^{2+} conc. Vs density in sea water withdesulphatation.

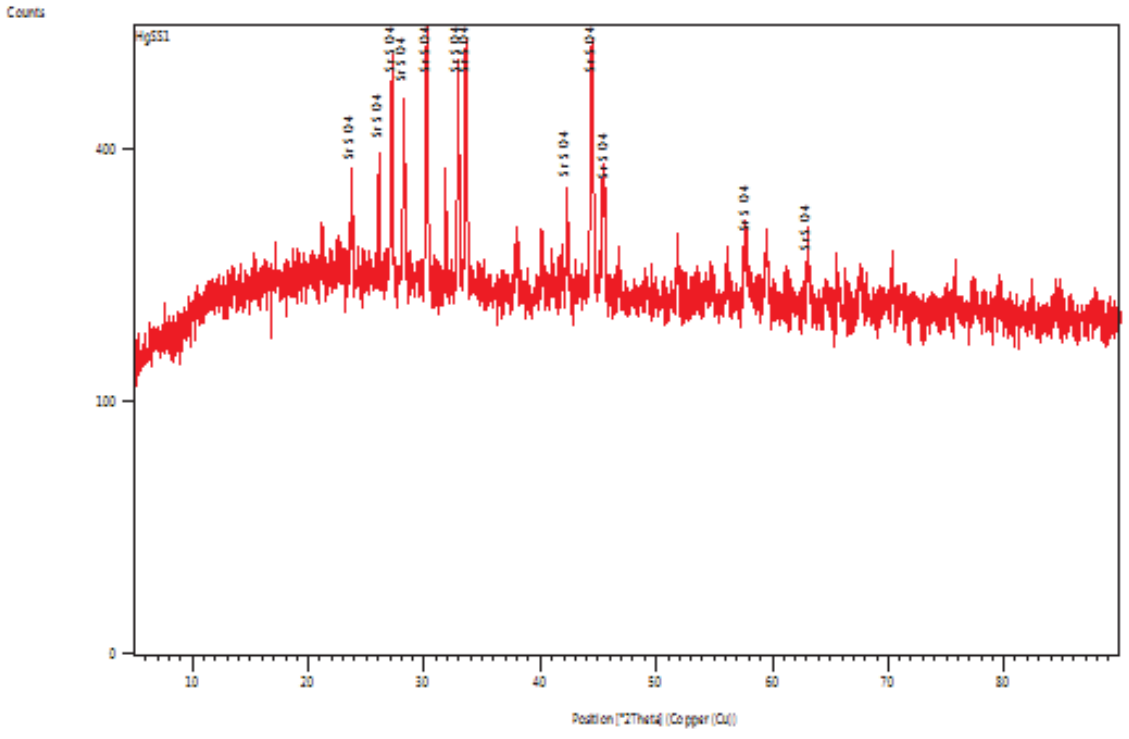
So, based on these findings, an integrated extraction process for Li^{+} & Sr^{2+} was attempted from the desulphated bittern as shown in the chart.



It was observed that lithium can be isolated as Li_3PO_4 in pure form but isolation of strontium as strontium sulphate did not come pure and continued.



Powder XRD of Li_3PO_4 obtained from sea bittern.



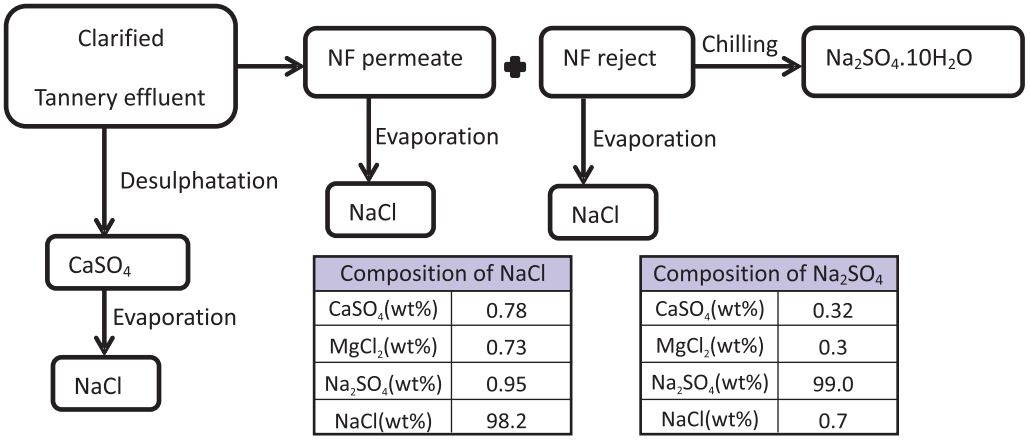
Powder XRD of $SrSO_4$ obtained from sea bittern.

Saline effluent management studies

Many industrial sectors like: power, manufacturing, refining, mining, petroleum and leather industries are producing high saline waste water. The discharge of such saline wastewater without prior treatment is known to adversely affect the aquatic life, water portability and agriculture. Thus, the treatment of saline wastewater and salt removal is nowadays compulsory for all industries. In this view, saline effluent from various industries has been studied and pure salts have been recovered.

Studies on saline effluent of tannery and textile industries, Tamil Nadu

The studies were conducted for recovery of high purity salts from saline effluent of tannery and textile industries, Tamil Nadu. The tannery effluent contains NaCl, $CaSO_4$ and Na_2SO_4 as its major constituents with minor quantities of $MgCl_2$ and other insoluble and soluble impurities. The pure NaCl and $CaSO_4$/Na_2SO_4 were recovered by nano-filtration, desulphatation / freeze crystallization and isothermal evaporation respectively. The textile effluent contains NaCl as its major constituents and KCl, $MgCl_2$, Na_2SO_4 as minor constituents. The pure NaCl and $CaSO_4$ were recovered by desulphatation and isothermal evaporation.



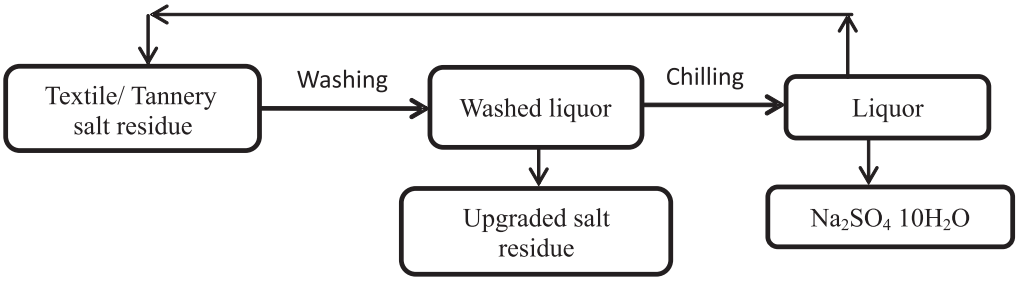
Composition of NaCl	
$CaSO_4$(wt%)	0.78
$MgCl_2$(wt%)	0.73
Na_2SO_4(wt%)	0.95
NaCl(wt%)	98.2

Composition of Na_2SO_4	
$CaSO_4$(wt%)	0.32
$MgCl_2$(wt%)	0.3
Na_2SO_4(wt%)	99.0
NaCl(wt%)	0.7

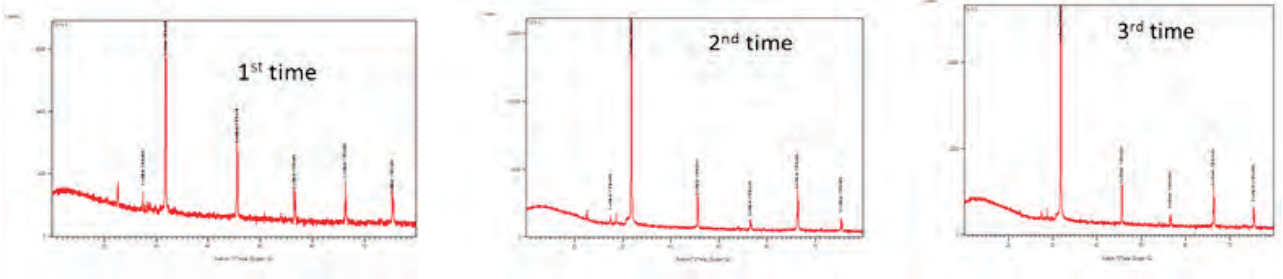
Presently in both tannery and textile processing units, the saline effluent is subjected to RO desalination. The reject water is evaporated to dryness stage using forced evaporation. The disposal of solid residue is again a big problem for industries. The solid residue from textile unit is a mixture of NaCl (93-95 wt%) and Na_2SO_4 (7-6wt%) and tannery unit is a mixture of NaCl (96 wt%) and Na_2SO_4 (4wt%) with some other impurity. Both the residues were upgraded to high NaCl content by washing with its saturated solution in cyclic manner and $Na_2SO_4.10H_2O$was recovered by chilling at lower temperature.

Change in chemical composition of textile/tannery salt residue with washing

Textile	Before washing	After washing	Tannery	Before washing	After washing
$CaSO_4$(wt%)	1.12	1.08	$CaSO_4$(wt%)	0.017	-
$MgCl_2$(wt%)	0.15	0.31	$MgCl_2$(wt%)	0.086	0.023
Na_2SO_4(wt%)	7.02	1.64	Na_2SO_4(wt%)	4.06	0.2
NaCl(wt%)	93.39	96.51	NaCl(wt%)	95.95	99.61



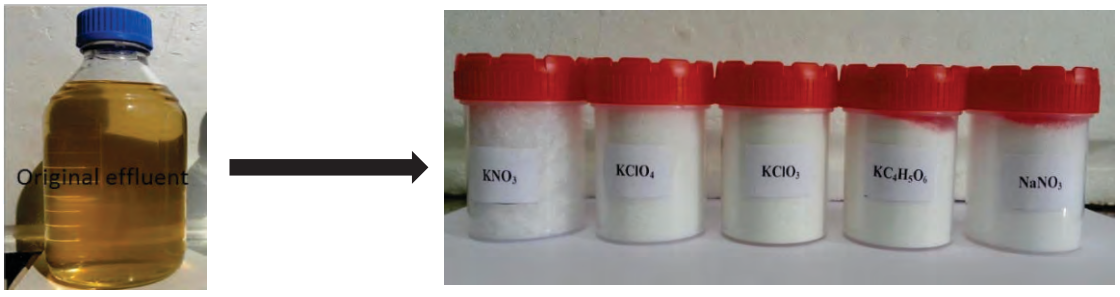
PXRD of washed textile salt residue in cyclic process



Studies of saline effluent of Viral Organics Ltd, Maharashtra

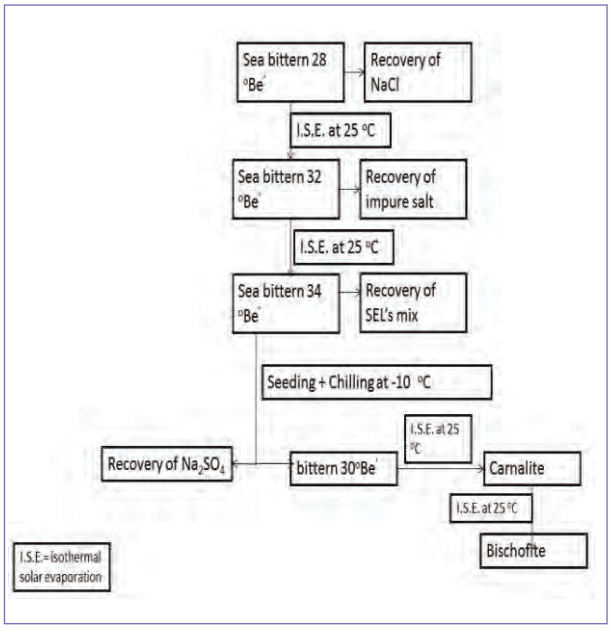
Study was conducted under sponsored project for recovery of high purity (value added product) from saline effluent of Viral Organics Limited. The effluent is a mixture of K_2CO_3, Na_2CO_3 and KOH. The corresponding carbonates were converted to more value added nitrate products, and high purity KNO_3 and $NaNO_3$ were recovered. During process approximately 20% of the remaining KNO_3 was converted to low solubility salts such as potassium perchlorate ($KClO_4$) / potassium chlorate ($KClO_3$) / potassium tartarate ($KC_4H_5O_6$). The equivalent amount of CO_2 was also recovered in $CaCl_2$ solution. The purity of all products collected was minimum 99%. The standardization of process at large scale is under way.

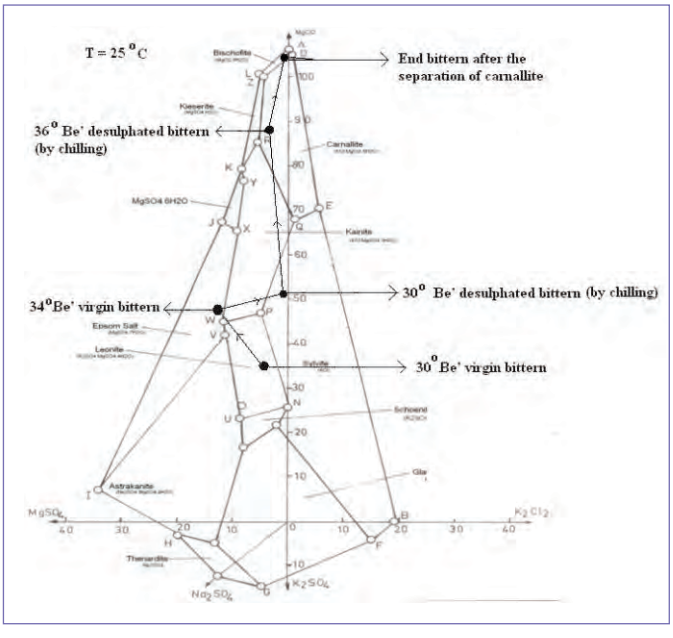
Physical and chemical composition of liquid		
Colour	Brown	
PH	13.33	
TOC	8443.54ppm	
Chemical composition in (wt%)	K^+ (w/v) %	Na^+ (w/v) %
	15.18	2.9



Preparation of carnallite from sea bittern through desulphatation by chilling process

The chilling process was further modified so that crude carnalilte with minimum NaCl content can be recovered from sea bittern. The 29°Be' bittern left after the separation of salt was evaporated isothermally in the temperature range of 25 – 35°C till it attained a density of 34°Be'. At this stage the bittern was enriched with maximum amount of sulphate. The bittern of 34°Be' was chilled to – 8 to – 10°Be' to separate the sulphate present in the bittern as Glauber's salt ($Na_2SO_4.10H_2O$). After the separation of Glauber's salt the sulphate content of bittern was reduced by almost 50%. The Glauber's salt was separated through filtration and the filtrate was further evaporated for the recovery of carnalltie mixed salt. The process is described in the flow diagram. The path of bittern evaporation is plotted in following phase diagram.





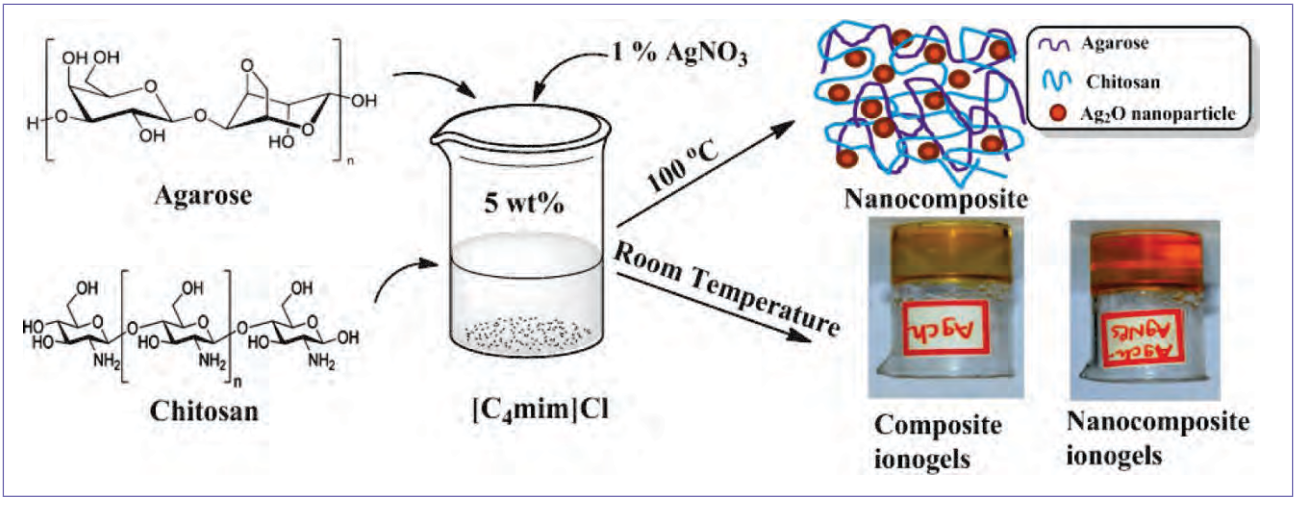
Composition of bittern before chilling				
°Be'	$MgSO_4$	$MgCl_2$	KCl	NaCl
26.96	3.50	6.78	1.75	20.6
28.87	6.46	12.54	2.62	15.61
30.00	7.14	16.94	3.25	10.76
31.04	7.19	17.33	3.37	10.17
31.90	8.17	18.98	3.75	6.44
34.00	9.66	22.29	4.00	6.41

Composition of carnallite separated				
	9.1	25	15.62	8.50

Studies on Liquid Salts (Ionic Liquids)

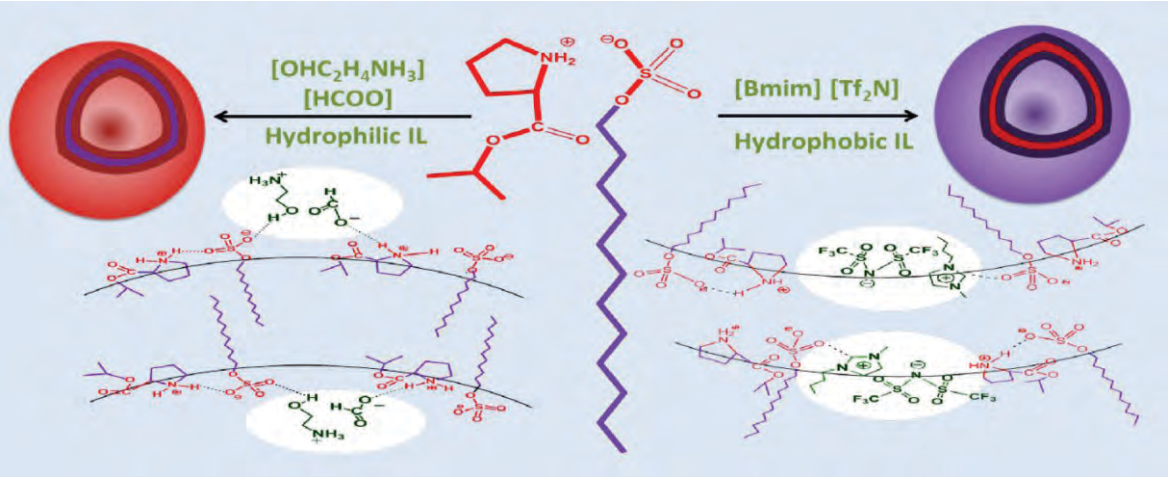
Facile preparation of agarose-chitosan hybrid materials and nanocomposite ionogels using an ionic liquid

Simultaneous dissolution of agarose (AG) and chitosan (CH) in varying proportions in the ionic liquid (IL), 1-butyl-3-methylimidazolium chloride [C_4mim][Cl] has been carried out. Composite materials were constructed from AG-CH-IL solutions using antisolvent methanol, and IL was recovered from the solutions. Composite materials could be uniformly decorated with silver oxide (Ag_2O) nanoparticles (*Ag NPs*) to form nanocomposites in a single step by *in situ* synthesis of *Ag NPs* in AG-CH-IL sols, wherein the biopolymer moiety acted as both reducing and stabilizing agent. Cooling of *Ag NPs*-AG-CH-IL sols to room temperature resulted in high conductivity and high mechanical strength nanocomposite ionogels. Structure, stability and physiochemical property of composite materials and nanocomposite were characterized via several analytical techniques, like Fourier transform Infrared (FTIR), CD spectroscopy, differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), gel peuneaion mission chromatography (GPC), and scanning electron micro graph (SEM). The result showed that composite materials have good thermal and conformational stability, compatibility and strong hydrogen bonding interactions between AG-CH complexes. Decoration of *Ag NPs* in composites and ionogels was confirmed from UV-Vis spectroscopy, SEM, TEM, EDAX and XRD. Mechanical and conducting properties of composite ionogels have been characterized from rheology and current-voltage measurements. Since *Ag NPs* show good antimicrobial activity, the *Ag NPs*-AG-CH composite materials have a potential to be used in biotechnology and biomedical applications whereas the nano composite ionogels will be suitable as precursors for applications such as quasi-solid dye sensitized solar cells, actuators, sensor or electrochromic display (*Green Chem. (2014), 16, 320 – 330*).



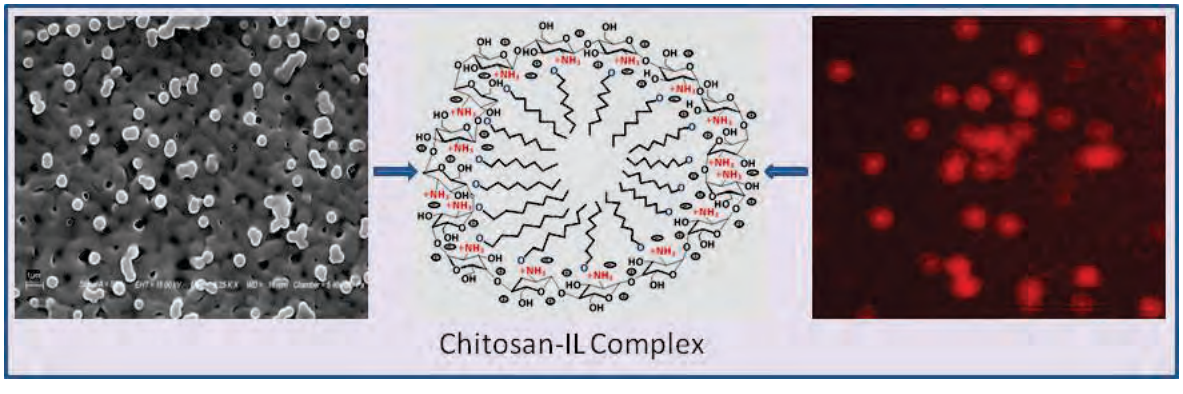
Vesicles and reverse vesicles of an ionic liquid in ionic liquids

First evidence and mechanism of closed bilayer structure formation by a single chain amino acid ionic liquid (IL), L-proline isopropylester laurylsulfate in both hydrophilic and hydrophobic ILs has reported. Such ionic self-assemblies are shown to be guided by fine balance of solvophobic effect and ionic arrangements via hydrogen bonding and electrostatic interactions. Such vesicular structures, being non-aqueous, non-volatile, and able to dissolve both hydrophilic and hydrophobic solutes can provide unique benefits in applications of drug delivery, bio-transformations, catalysis and material synthesis. Moreover, being entirely the ionic systems one can envisage desired morphological transitions in vesicles under electric fields (*Chem Commun.(2013), 49, 8111 – 8113*).



Complexation of chitosan with surfactant like ionic liquids

Interactional behavior of chitosan (*Ch*) with surface active ionic liquids (ILs)—1-butyl-3-methylimidazolium octylsulfate, $[C_4mim][C_8OSO_3]$ or 3-methyl-1-octylimidazolium chloride, $[C_8mim][Cl]$—has been probed at air solution interface and in the bulk in aqueous medium at pH 3.0 using multi-technique approach, viz. tensiometry, conductometry, turbidimetry, dynamic light scattering (DLS) and atomic force microscopy (AFM). At the interface, a strong complexation is observed in *Ch*-$[C_4mim][C_8OSO_3]$ system. In bulk $[C_4mim][C_8OSO_3]$ interacts with *Ch* to form *Ch*-$[C_4mim][C_8OSO_3]$ complex which precipitates out at higher IL concentrations whereas comparatively weaker *Ch*-$[C_8mim][Cl]$ complexes remain solubilized in the solution. DLS measurements showed that *Ch* chain contracts before cmc and expands after cmc upon interaction with both the ILs. Interaction of ILs with *Ch* resulted in facile preparation of uniformly distributed *Ch* nanoparticles with good sphericity and control which have been verified using DLS, SEM, AFM and fluorescence microscopy. Present study provides an understanding of forces governing the complexation behavior of *Ch* with surface active ILs and their efficacy to produce *Ch* nanoparticles (*J Colloid Interf Sci. (2013), 407, 361 – 369*).



Interactional behaviour of surface active ionic liquids with gelling biopolymer agarose in aqueous medium

Interactions of surfactant-like ionic liquids (ILs), 1-butyl-3-methylimidazolium octylsulfate $[C_4mim][C_8OSO_3]$ and 3-methyl-1-octylimidazolium chloride $[C_8mim][Cl]$ with a neutral biopolymer agarose (*Ag*) have been studied in aqueous medium through an array of techniques, viz. tensiometry, isothermal titration calorimetry (ITC), turbidimetry, dynamic light scattering (DLS), conductometry, scanning electron microscopy (SEM) and Fourier transform infrared spectroscopy (FTIR). ILs binds with *Ag* (though a neutral biopolymer) to a

significant extent via ion dipole and hydrogen bonding interactions between *Ag* oxygens and positively charged imidazolium ring or acidic proton (C2) of imidazolium respectively. The surface tension behaviour of both the systems investigated has been found more like charged polymer–surfactant systems rather than neutral polymer–surfactant system because of electron rich oxygens on *Ag* chain. Both the ILs interacts exothermically with *Ag* at low concentration i.e. < 6 mmol.kg^{-1} and endothermically afterwards. In the *Ag*-[C_4mim][C_8OSO_3] system there is an interplay between ion dipole interaction of [C_4mim] with *Ag* oxygen and electrostatic interaction between [C_4mim] and [C_8OSO_3]. 1.25 kJ.mol^{-1} enthalpy is absorbed for the interaction [C_4mim][C_8OSO_3] micelles with *Ag* at cmc. In *Ag*-[C_8mim][Cl] system strong ion dipole interaction between *Ag* oxygen and [C_8mim] cation, causes initial heat release whereas Cl anion disrupts the hydrogen bonding network of *Ag*. 0.98 kJ.mol^{-1} enthalpy is absorbed for the interaction of [C_8mim][Cl] micelles with *Ag* at cmc. Significant red shift in the in the FTIR spectra of peaks due *Ag* (O–H group and glycosidic oxygen) indicates strong hydrogen bonding with both the ILs below C_1. Turbidimetric and DLS studies have shown that both the ILs forms coacervates on interaction with *Ag*. SEM micrographs confirmed the complex formation of *Ag* with both the ILs. (*RSC Adv. (2013), 3: 19600 – 19608*)

Extension activities

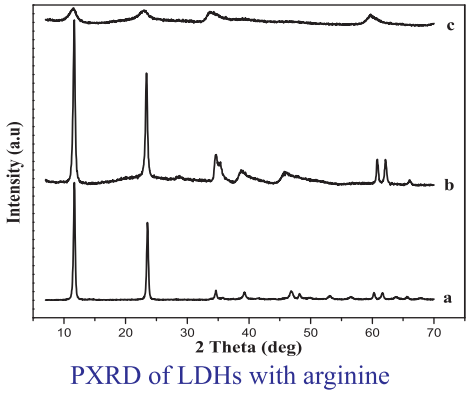
Exhaustive work in service of society has done by the division such as improving quality of salt produced by the marginal salt producers at Rajula AHRM-CSMCRI project, survey of potential areas of salt production in the state of Odisha,establishing a Model Salt Farm at Marakanam in Tamil Nadu and improving the quality of solar salt to edible grade in Didwana region of Rajasthan. The details of all has been given in chapter-7 of this report.

INORGANIC MATERIALS & CATALYSIS

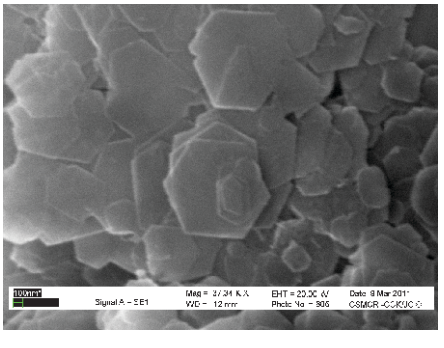
Materials

Amino acid mediated solvothermal synthetic protocol forlayered double hydroxide

In a new reproducible synthetic methodology for the preparation oflayered double hydroxide (LDH) through amino acid hydrolysis, initial studies using glycine, lysine and arginine as hydrolysing agents, revealed the formation of boehmite phase with glycine and lysine and well crystalline LDH with arginine. Under optimised conditions, the metal pairs: CoAl, MgAl, and ZnCr yielded phase pure LDHs. A hydrolytic mechanism involving basic amino acids is proposed for the crystallization of LDH using various physicochemical (PXRD, FT-IR, SEM and LC-MS) and experimental studies.



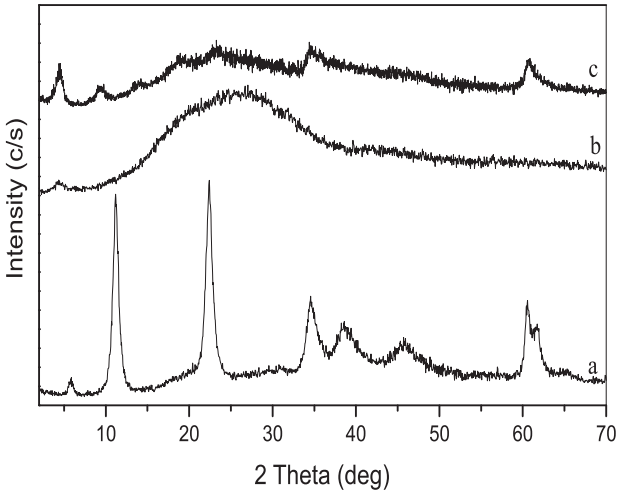
PXRD of LDHs with arginine
(a) CoAl-LDH (b) MgAl-LDH and (c) ZnCr-LDH



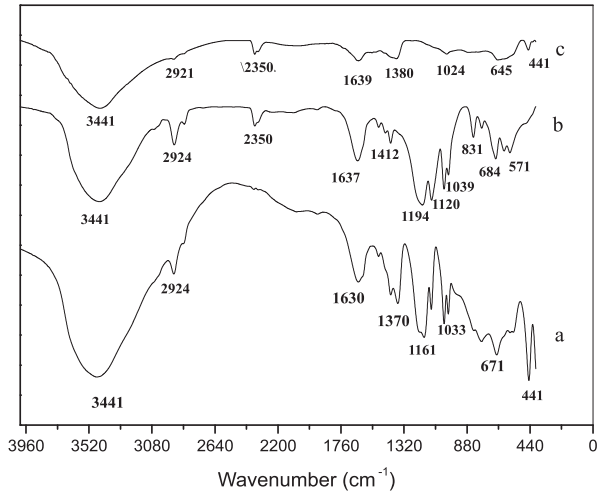
SEM of CoAl-LDH synthesized using arginine

Synthesis of polymer-delaminated LDH nanocomposite for toxic metal ion remediation

Metal ions containing LDHs synthesized by coprecipitation under constant pH, and delaminated/exfoliated in water using ultrasonication gave very stable colloidal suspension having particles (120-135 nm) with higher weight % of material showing (TEM) hexagonal platelets (0.1 μm) in lateral dimension. The nanocomposites were prepared using polystyrene sulfonate (MW=70000) under hydrothermal conditions at 110 ^{0}C in an autoclave using this colloidal suspension. SEM images showed a random clump-like structure in contrast to parent LDHs that showed flaky well-defined morphology. The high intensity XRD peaks for parent MgAl-Cl-LDH were reduced and the d-spacing shifted from 7.77 to 19.68 Å confirmed successful intercalation of polymer in re-assembled LDH galleries. These nanocomposites were used in the remediation of different environmentally toxic heavy metal ions in aqueous solution through adsorption phenomenon. Elemental analysis for nickel ion revealed a higher uptake for nanocomposite compared to the parent MgAl-LDH.



PXRD of (a) $MgAl_3$-Cl-LDH (coprecipitation), (b) Polystyrene sulfonate, (c) $MgAl_3$-Cl-PS LDH (Hydrothermal 110 ^{0}C, 48 h)



FTIR of (a) Mg_2Al-Cl-PS-LDH (Hydrothermal 110 ^{0}C, 48 h), (b) Polystyrene sulfonate and (c) Mg_2Al-Cl-LDH (co-precipitation)

Solid state NMR: A powerful tool for structure analysis with environmental significance

For borate remediation, an interesting structural transformation of tetraborate ($B_4O_7^{2-}$) to monoborate ($[B(OH)_4]^-$ and $B(OH)_3$) in the interlayer LDH was observed during a long period (~38 days) drying. The transformation occurred through hydrolytic decomposition of tetraborate supported by the change in the relative abundance of coordination of boron species monitored using ^{11}B MAS NMR. During early days of drying (till 15 days) interlayer/surface adsorbed water molecules were involved in the hydrolytic decomposition while on latter stage, structural hydroxide were involved as elucidated from ^{1}H MAS NMR. (*J Phys Chem C. (2013), 117, 6578-6586).*

Utilization of plastic wastes for synthesis of carbon microspheres and their use as a template for nano crystalline copper (II) oxide hollow spheres

The metal- and solvent-free single-step synthesis of carbon microspheres (1−8 μm) using various municipal plastic wastes at 700°C under autogenic pressure was done and characterized with different microscopic and spectroscopic techniques. Among them only polyethylene, polypropylene, and polyacrylate could be converted into carbon spheres with 100% purity, whereas carbon particles of irregular shapes were observed with other plastic wastes. The absence of catalyst makes the carbon spheres free from metal impurities and avoids the further

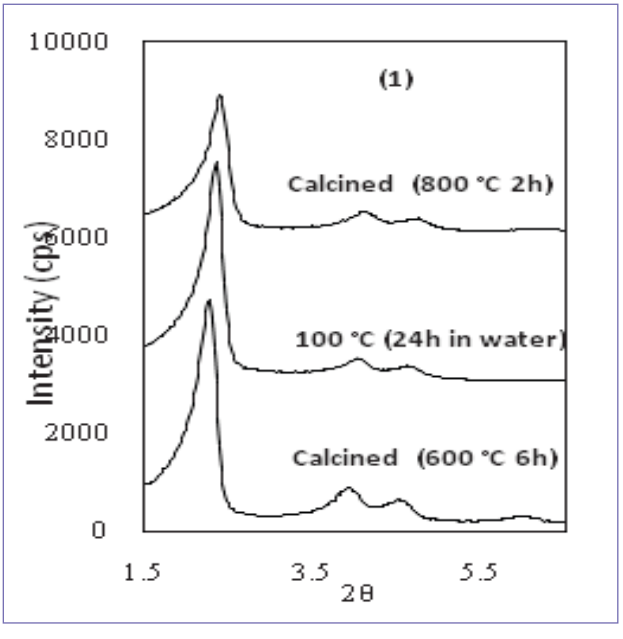
purification process. The nano crystalline CuO hollow spheres with ~ 130 nm wall thickness were prepared using plastic waste-derived carbon spheres as the template material under ultrasonic treatment (*ACS Sustainable Chem Eng. (2013)*, ***1,*** *1390-1397).*

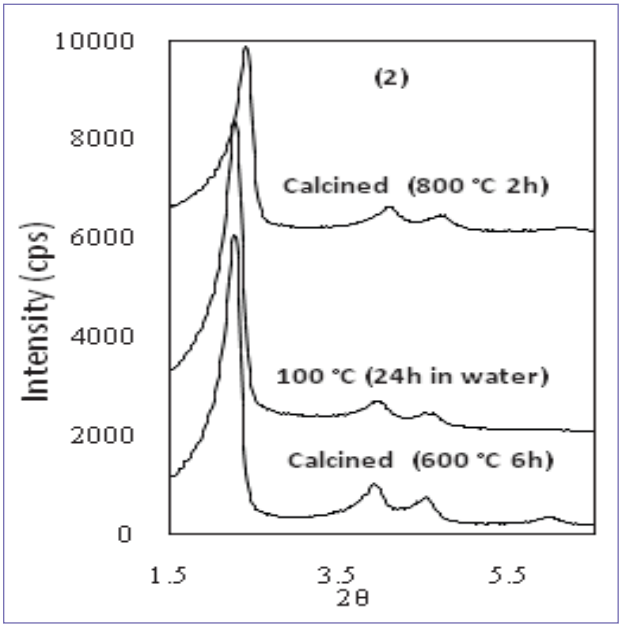
Formation and characterization of onions shaped carbon soot from plastic wastes

The characterization of carbaneous soot obtained from the pyrolysis of different plastic wastes under static atmosphere showed the formation of carbon onions of 60±10 nm. Various physico-chemical studies have been carried out to explore the surface as well as bulk properties of carbon onions. The pyrolysis of plastic wastes such as polypropylene, polyethylene (high and low density) and polyacrylate completely resulted into the carbon onions, whereas crystalline carbon residue with carbon onions was obtained with the pyrolysis of polyethylene terephthalate, polyvinyl chloride and polystyrene *(Mater Lett. (2013), 94, 132-135).*

Scale up work on synthesis of MCM-41 silica at room temperature

Scale up work of the synthesis of MCM-41 type mesoporous silica at room temperature with improved thermal and hydrothermal stability is carried out after optimising the conditions for 3 kg per batch scale using commercial sodium silicate and CTAB. Highly ordered mesoporous silica with hexagonal channels of uniform pore diameter (2.9 nm) was obtained and this ordered structure was retained even after thermal (800 C 1h) and hydrothermal (100 C 24h in water) treatments, as confirmed by PXRD-intensity of d_{001} peak and unit cell dimension a_0 and values of surface area, pore size and total pore volume. PXRD patterns of MCM-41 silica before and after (1) thermal and (2) hydrothermal treatment are given below.



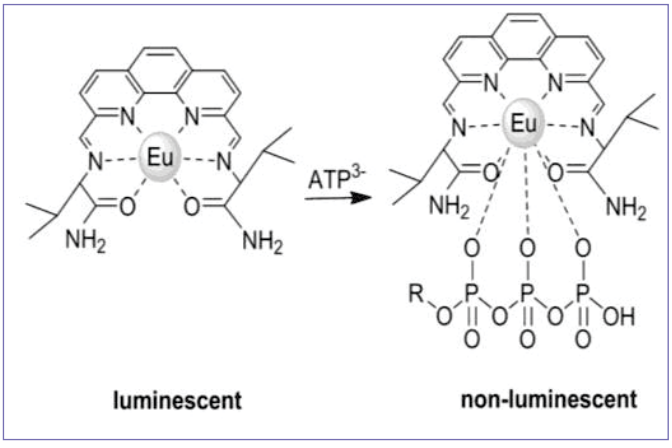


Luminescent phosphate sensor

The achiral ligand L^1 and its respective Eu(III) and Tb(III) complexes are found to be non-luminescent, while the corresponding chiral Eu(III) complex exhibits luminescent, giving red emission in solid and solution state when excited with near UV radiation. Chiral Eu(III) complex showed selective sensing of phosphate anions among other anions: F^-, Cl^-, Br^-, I^-, NO_3^- and SO_4^{2-} etc. in aqueous media at physiological pH. The study has been further extended to polyphosphates of biological importance [ATP, ADP and AMP], where ATP have superior interaction leading to the distinguishable difference in the Eu(III) luminescence (*Chem A Eur J.(2012), 18, 16784-16792).*

To improve this antenna effect, the Schiff base

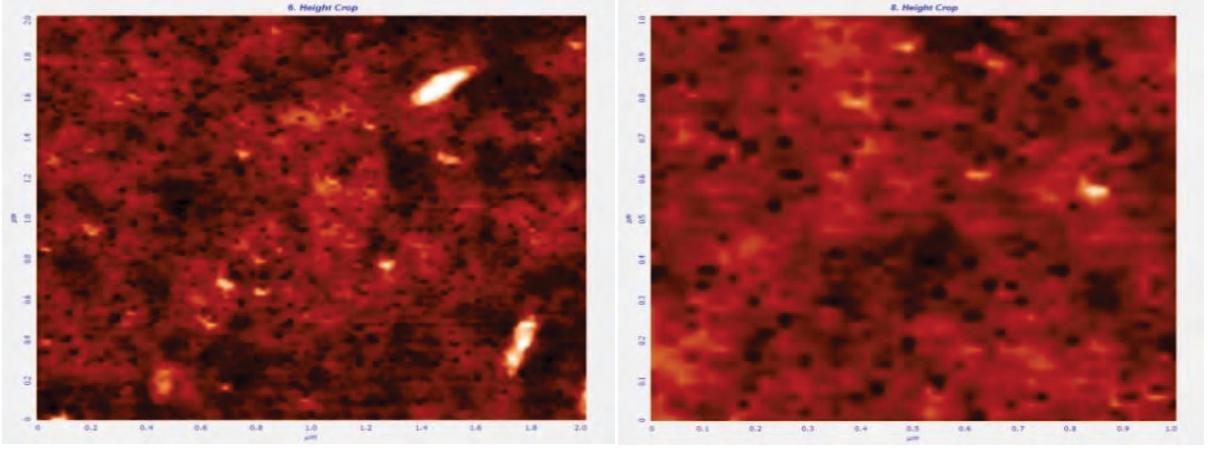
ligand reduced L^2using $NaBH_4$ has been incorporated with Eu(III) and Tb(III) and the resultant complexes are interestingly found to emit red and green respectively. This emission property has been further investigated towards sensing of ATP, ADP and AMP. This systematic study explores the EuL^2Cl_3 and TbL^2Cl_3 as universal sensor for ATP, ADP and AMP and studies related to its application as staining agent on microalgal cell "*Chlorella vulgaris*" was explored in detail.



Europium complex as fluorescent sensor using L^1

Fabrication of nanoporous polymer films containing metal nanoparticles: Possible application in waste water treatment and catalysis

Cross linked polymer has good chemical, thermal and mechanical stability. Pressure-driven membranes are of interest to design for applying in reverse osmosis for desalination, microfiltration for removing particulate material, microbial cell residues and turbidity, ultrafiltration for taking out large organic molecules, and nanofiltration for small organic molecules removal etc. *In situ* synthesized metal nanoparticles-embedded cross-linked polymer membrane was fabricated using environment-friendly reagents. The AFM images given below showed the membrane films embedded with metal nanoparticles with pore diameter of ~ 50-100 nm.

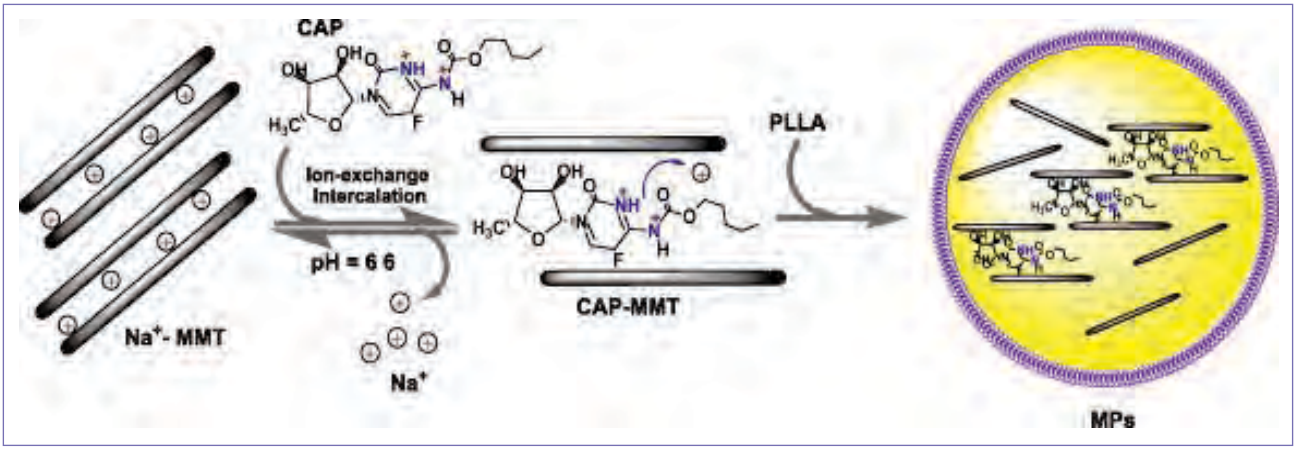


Metal recovery from e-waste using organic acids

Printed circuit boards (PCBs) from various discarded analytical instruments scarps of institute`s instrument section, were collected and non-mounted components like capacitor, relay, transistor, resistor and plug pins were physically dismantled and the obtained flat PCB was cut into 1.5x1.5 cm. To liberate the metals, PCB was pre-treated by immersing in DMF for 2h at 120°C, separating by filtration, drying in vacuum oven at160°C and then was used for metal (Cu, Pb and Sn etc.) leaching. The metallic content digested in aqua regia, analyzed by ICP showed Cu(⩽ 60%), Pb(<6%), Sn(<28%), Fe(<5%) and Ni , Zn (~ 0.5%). Organic (acetic-, formic- and citric-) acids with H_2O_2 are used for the recovery of Cu, Sn and Pb. Cu was recovered as copper acetate with > 99% purity. Leaching efficiency of formic acid was found for Sn and Pb without H_2O_2. Sn was recovered as $Sn(HCOO)_2$ with 98.6% purity. Lead was recovered as $PbSO_4$ with 99% purity by precipitation with sulphuric acid. The recovered metal salts were characterized by PXRD and other physico-chemical methods.

Evaluation of montmorillonite/poly (L-lactide) microcomposite spheres as drug carrier

Cationic intercalation of capecitabine (CAP), an antineoplastic agent, and 6-mercaptopurine (6-MP), an antineoplastic drug, in the interlayer gallery of sodium –montmorillonite (Na^+-MMT) was evaluated. It was further compounded with poly (L-lactide) to form microcomposite spheres (MPs) for potential use as oral chemotherapy of breast cancer. *In vivo* pharmacokinetics of MMT-drug hybrids in rats suggested that CAP-MMT hybrids and MPs can be of considerable value in chemotherapy of malignant neoplastic disease with reduced side effects and clearly demonstrated that MMT not only plays a role as a delivery matrix for drug but also facilitates significant increase in the delivery proficiency *(Compos. Sci. Technol. (2014) 193–201) (Colloids Surf. B.(2013),112, 400–407).*



Template free synthesis of mesoporous hectorites (MSH): Efficient host for pH responsive drug delivery

Two novel MSH materials: MSH3 and MSH4 with diverse composition and pore performance have been synthesized by a template free route and studied for the controlled drug delivery applications. MSH3 with 0.14LiF:5.93 $Mg(OH)_2$:8.0 SiO_2 synthetic composition exhibited higher quinine (QUI) adsorption than that by MSH4 (2.8LiF:4.6 $Mg(OH)_2$:8SiO_2). *In vitro* studies showed controlled drug release with respect to the variation in pH while following Eudragit VR L100 coated gelatin capsules. *(Int J Pharm. (2013), 446, 145–152)*

Adsorption

Storage of flue gas and its use in integrated Solvay-Merseberg-CSMCRI process

Flue gas from boiler was collected, compressed and filled in a cylinder up to 30 bars using gas booster system. Its GC-MS analysis showed 8-14 vol. % CO_2. Experiments were carried out to convert gypsum to calcium carbonate and ammonium sulphate by reacting with stored flue gas in presence of ammonia solution. Both the filtrate and solids were analysed for sulphate and carbonate contents. The gypsum reacts with aqueous ammonia and CO_2 of flue gas to produce ammonium sulphate and calcium carbonate. The conversion of gypsum to $CaCO_3$ was >97% and the results were reproducible.

Zeolite L based adsorbents for CO_2 capture

The CO_2 and N_2 adsorption of alkali and alkaline earth cation exchanged zeolite L were investigated by volumetric measurements and GCMC simulation. Because of its unique open-channel framework and linked cancrinite and intercage sites, zeolite KL showed lower degree

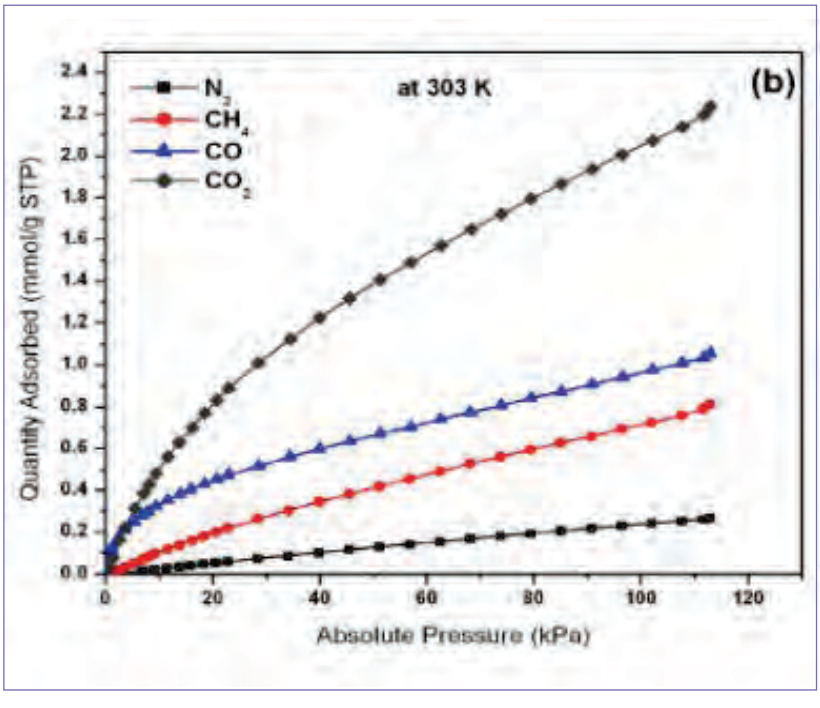
of cation-exchange. CO_2 and N_2 adsorption isotherms were recorded for zeolite L and its cation exchanged forms up to 101.3 kPa at 293 and 303 K. For CO_2 the isosteric heat of adsorption (kJ mol^{-1}) was in the range 42.7-52.5 and for N_2 18.4-24.3. The equilibrium selectivity for CO_2/N_2 obtained at 101.3 kPa and 303 K is in the range of 122.5-247.6. Simulated and experimental results matched reasonably well. CO_2 adsorption capacity is highest for the LiL (70.7 cm^3/g) but the highest CO_2/N_2 selectivity (247.6) at 303K and 101.3 kPa is obtained for the CaL *(Ind J Chem A.(2012), 51A, 1238-1251).*

Sorption of CO_2, CH_4, CO and N_2 on MIL-101(Cr): Volumetric measurement and dynamic adsorption studies

MOF material, MIL-101(Cr), synthesized by hydrothermal method was granulated using starch and sodium carboxyl methyl cellulose as binder. The selectivity of CO_2 over N_2 in MIL-101(Cr) was found to be 12.6 at 303 K, more than those for CO_2 over CH_4 (5.69) and CO (2.90). The CO_2 dynamic adsorption studies from binary gas mixture (CO_2 + N_2) with five different CO_2 concentration in the range 5–50 vol.%, and with two different feed gas flow rates (50 and 100 ml/min) were carried out on MIL-101(Cr) granules. The regeneration of adsorbent was feasible at a relatively low temperature attributed to physical adsorption of CO_2. *(Chem Eng J.(2012),195, 359-368).*

Solid-state dechlorination pathway for the synthesis of few layered functionalized carbon nanosheets (FCNS) and their greenhouse gas adsorptivity over CO and N_2

A simple solid-state dechlorination route has been demonstrated to synthesize few FCNS of 6–12 nm thickness (TEM analysis), utilizing hexachloroethane as carbon source and copper as reducing agent under the autogenic pressure at 300 °C. The particle nature of the FCNS provided the excess porosity having the surface area 836 m^2/g. The very strong adsorbate–adsorbent interaction observed in case of CO compared to other gases, resulted in higher heat of adsorption for CO. The FCNS showed the very high equilibrium selectivity for CO over N_2 (197) followed by CH_4 (61) and CO_2 (7.3) at 288 K *(*Carbon. *(2014), 68, 210–220).*



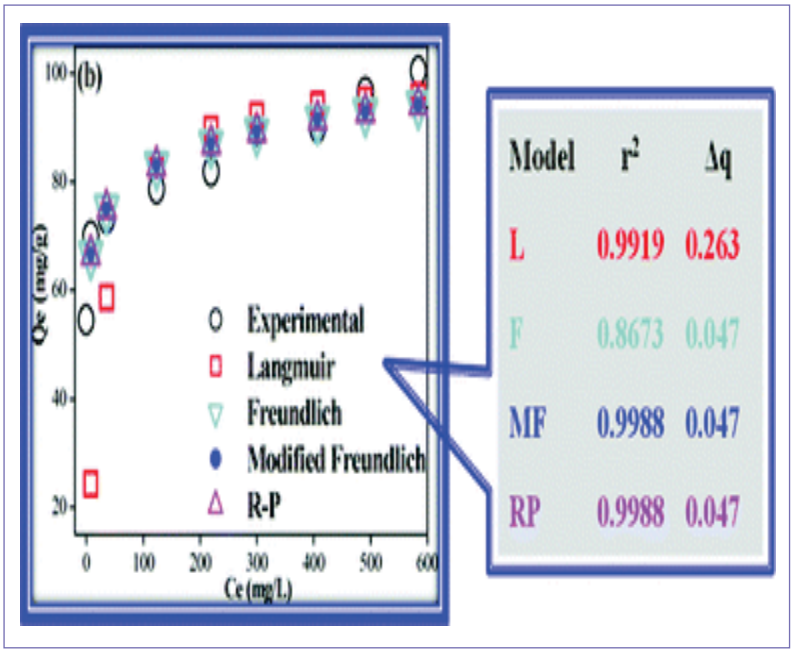
Copper metal mediated reduction of tetra chloro ethylene (carbon precursor) resulted in the horn shaped carbon nanotubes with high yield and structural selectivity. These nanotubes showed good adsorption capacity for CO_2 (45 cm^3/g) and CO (17 cm^3/g) at 303 K and 850 mmHg pressure with high equilibrium selectivity (73.3 for CO_2 and 110.7 for CO at 318 K) and capacity selectivity (9.1 for CO_2 and 3.1 for CO at 850 mmHg and 318 K) over nitrogen which provides the tool for the separation of CO_2 from its mixture with nitrogen observed in flue gas of thermal power plants and boilers, as well as with CO such as syngas. (*J Hazard Mater. (2012), 227, 317 – 326)*

Scale up preparation of AC@Cu-BTC with enhanced methane storage capacity

A method is developed for scale-up (500 g/batch) preparation of AC@Cu-BTC, in good yield and having enhanced methane uptake capacity up to 190 cm^3/g. The synthesized AC@Cu-BTC showed maximum methane uptake capacity of 190cm^3/g at 303K up to 35 bars.

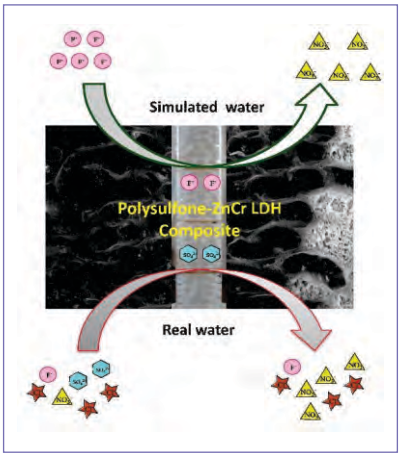
Adsorption of an anionic dye from aqueous medium by organoclays: equilibrium modeling, kinetic and thermodynamic exploration

Adsorption of an anionic dye, Remazol brilliant blue R (RBBR) from aqueous solution, on organically modified attapulgite (ATP) and bentonite (BNT) clays was investigated. Beneficiated ATP and BNT samples were modified by the cationic surfactant CTAB, by the ion exchange method. The adsorption capacity of modified ATP is lower than that of modified BNT. However, considering the requirement of CTAB for modification of the clay, ATP is the more economical adsorbent than modified BNT*(RSC Adv.(2012),2, 8663–8671).*



Aqueous fluoride removal using ZnCr LDHs and their polymeric composites

Fluoride uptake studies over synthesized nitrate containing ZnCr LDHs with Zn/Cr in a batch reactor showed a maximum uptake capacity of 31 mgF/g for ZnCr3-NO_3-LDH. The uptake occurred in the wide pH range (3-10) through ion-exchange as inferred by PXRD. Uptake studies in presence of competing anions revealed a preferential uptake of certain monovalent anions and divalent anions that followed the popular Miyata series. LDHs were found to be stable in the composite beads (polysulfone/ZnCr) and gave high efficiency for fluoride removal in wet state than that of dried form. High fluoride removal capacity, stability in wide concentration, and better diffusivity with composite suggested that these composites could be used as potential sorbents for the removal of fluoride in columns. The shown SEM image of the composite indicated porous structure *(Chem Eng J. (2013),234, 406-415).*



ZnAl layered double hydroxides as potential molybdate sorbents and valorize the exchanged sorbent for catalytic wet peroxide oxidation of phenol

ZnAl LDHs containing interlayer chloride, nitrate or carbonate synthesized at different Zn/Al atomic ratios, explored for molybdate uptake showed higher molybdate uptake capacity for chloride and nitrate containing samples than carbonate. 100 % molybdate uptake obtained using ZnAl3-Cl-LDH in 100 mg Mo/L solution showed a maximum uptake of 114 mg Mo/g in wide pH range (2.3 to 10). The material after molybdate uptake (ZnAl3-MoO_4-LDH) was

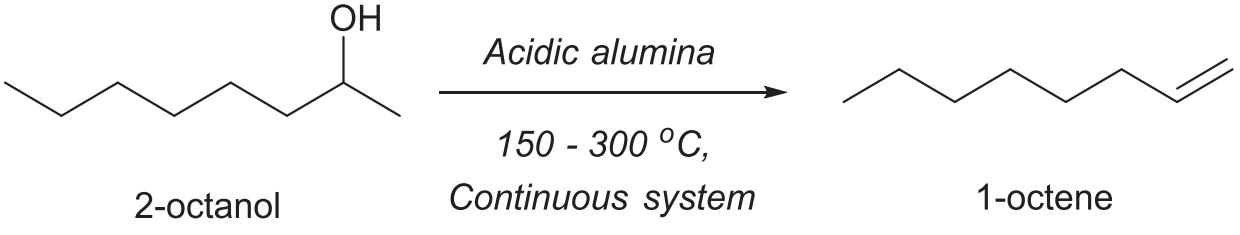
valorized for the catalytic wet peroxide oxidation of phenol. A maximum phenol degradation of 43% was achieved at 0.5 g/L of 100 mg/L phenol solution. This work demonstrates the dual utility of LDH material as an ion-exchanger and catalyst as well *(Ind Eng Chem Res. (2013), 52, 7373-7381)*.

Heterogeneous catalysis

Ultrasound assisted biodiesel production from neat and blended vegetable oils using LDH-derived base catalysts

Different synthesized LDHs were tested as heterogeneous catalysts for ultrasound assisted transesterification of sunflower oil with methanol for the preparation of fatty acid methyl esters (FAMEs) (or) biodiesel using < 6:1 methanol:oil molar ratio. Among them, mixed oxides derived by calcining CaAl2-LDH at 700 °C ($CaAl2_{700}$-CLDH) was the most active catalyst. Edible, non-edible and used cooking oils were transesterified with 80-90% yield of FAME under ultrasound at 40 C within 90 min. The yield of FAME (for sunflower oil) through conventional heating was only 9% while under ultrasound was 63%. A single step process was developed for biodiesel production from high free fatty acids (FFA) containing *Jatropha* oil by blending it with sunflower oil or used cooking oil (60/40 weight ratio) that gave 89% yield of FAME in both cases. $CaAl2_{700}$-CLDH showed moderate reusability up to two cycles and decreased thereafter while its activity could be restored by recalcining the recovered catalyst at 700 C (*Int J Adv Eng Sci Appl Math.(2013), 5, 210-218*).

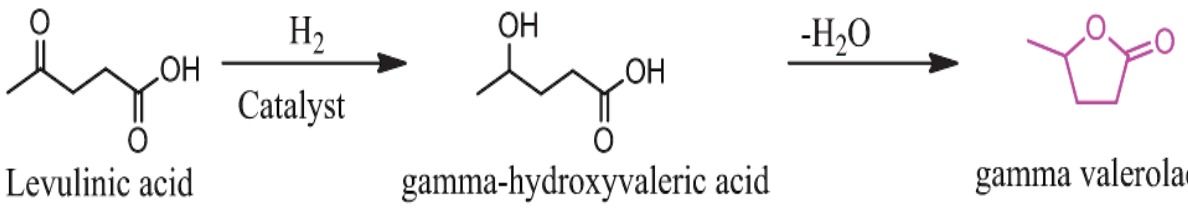
Dehydration of 2-octanol to 1-octene



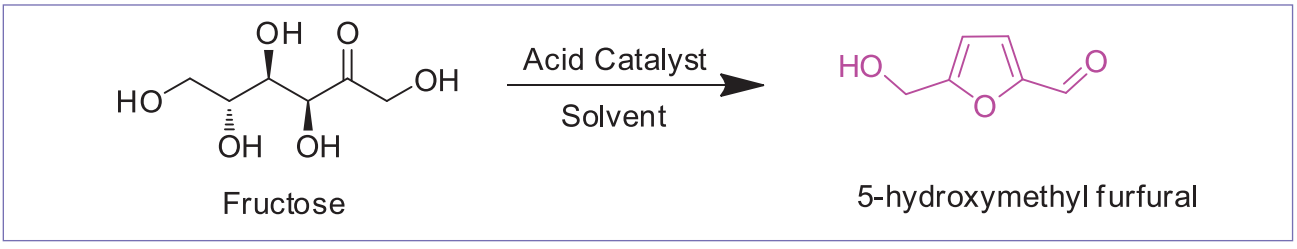
2-octanol dehydration reaction was carried out in a continuous micro reactor using commercial acidic alumina as catalyst at 150 - 300 °C. 100% conversion of 2-octanol with 23% yield of 1-octene was achieved at 275 °C at 2-octanol flow rate of 0.1 ml/min. Conversion decreased marginally while the selectivity distribution of octene isomers varied significantly upon increasing the flow rate.

Selective hydrogenation of levulinic acid to -valerolactone (Gvl) over Ru-supported catalysts

Ru-exchanged NaY zeolite catalyst afforded > 99% yield of Gvl under less energy intensive optimized conditions (120 °C, 5 h, 20 bar, catalyst:substrate weight ratio 1:20 with less than 1 wt% Ru, which is better than commercial 5 wt% Ru/C catalyst (94%) and Ru-Clay (74%). The reaction was scaled at 20 g and 75% yield was obtained (100% conversion of LA and 75% selectivity of Gvl) with intermittent supply of hydrogen to maintain pressure.

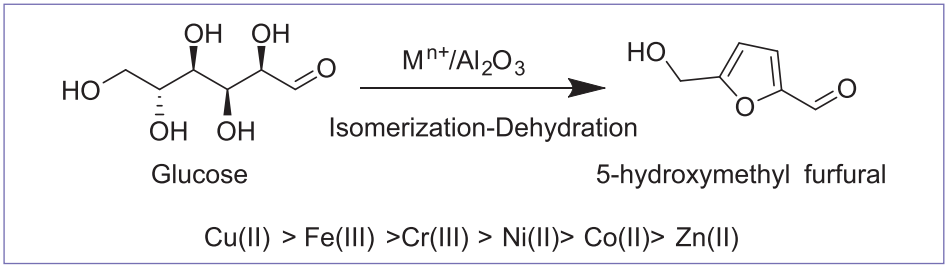


Regeneration studies for dehydration of fructose to 5-hydroxymethyl furfural over Amberlyst-15



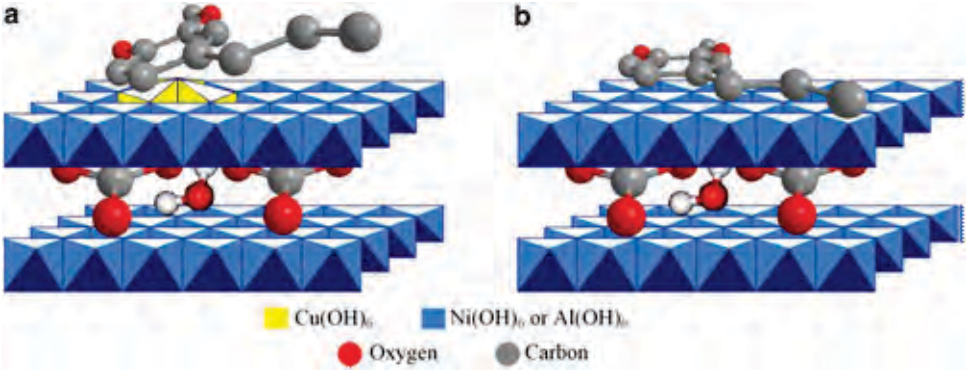
5-hydroxymethyl furfural (HMF) is produced commonly by dehydration of fructose over acid catalysts (see scheme). We have indicated earlier that the acid catalyst Amberlyst-15 was deactivated after four cycles when DMF was used as solvent for this reaction. We have overcome the deactivation by treating the dead catalyst with sulphuric acid and regenerated the activity of Amberlyst-15. To test the efficacy of other acids such as HCl or HNO_3, the dead catalyst was treated with these acids (1 N), washed with water and methanol, dried and tested for dehydration of fructose. The yield obtained were similar (60-65%) irrespective of the acid used. To surmise, the acid sites on the catalyst were neutralised with basic amino groups of DMF thereby poisoning the active sites and those sites were recovered by treating with dilute mineral acids *(Catal Commun. (2013, 37,) 41-44)*.

Dehydration of glucose to 5-hydroxymethyl furfural (HMF) over metal supported catalysts



The activity order for the catalysts with different metal salts on alumina support studied for the dehydration of glucose was observed to be Cu(II) > Fe(III) >Cr(III) > Ni(II)> Co(II)> Zn(II). Reaction with different sugar substrates were studied using $2\%CuCl_2/Al_2O_3$ catalyst and all sugars gave good yields (30-70%) of HMF and furfural. The HMF yield was lesser (~10%) when $CuCl_2$ or alumina alone was used as catalyst even with larger amount of the former with respect to $2\%CuCl_2/Al_2O_3$. Among sulphate, chloride and nitrate as copper salt precursor, chloride showed highest yield of HMF. Similar trend was noted even for other metal salts. The reaction was successfully scaled to 30 g without any significant change in the yield of HMF (57%).

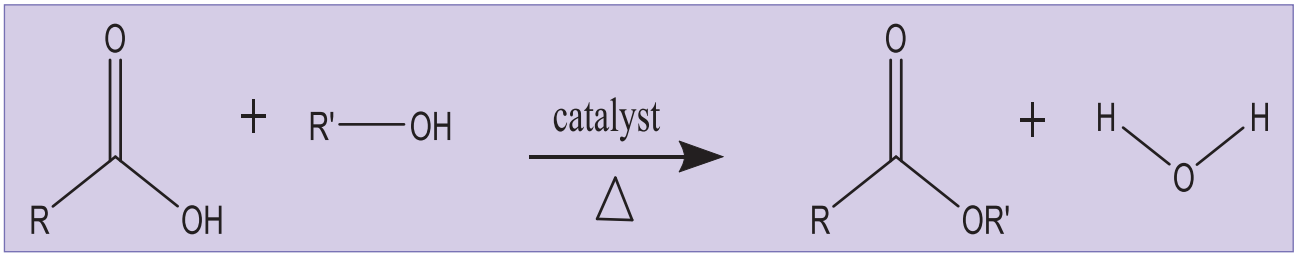
Eugenol isomerization – Unravelling the unprecedented influence of Cu^{2+} over NiAl LDHs through operando DRIFT spectroscopy



Schematic representation of interaction of eugenol with wells of hydroxyls in NiCuAl-HT (a) and NiAl-HT (b) Hydroxyl groups (not indicated) correspond to the corners of the octahedral.

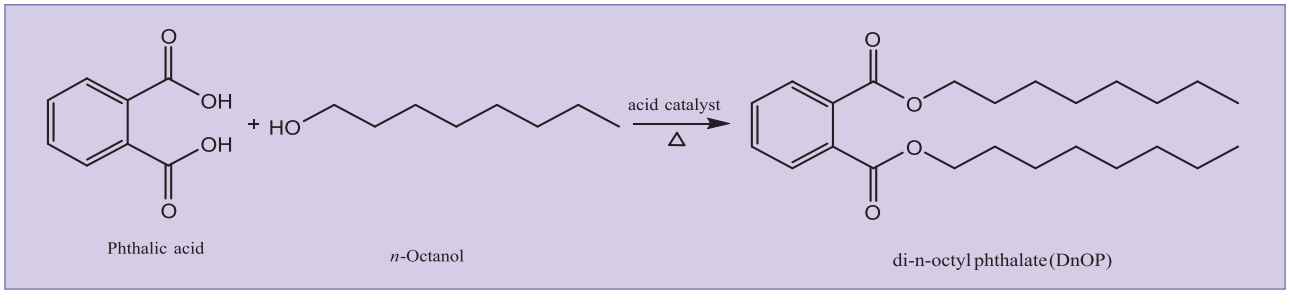
In the isomerization of alkenyl aromatics over NiAl3 (Ni/Al atomic ratio 3.0) (LDHs), minimal incorporation of Cu^{2+} drastically reduced the efficacy of the catalyst. *Operando*DRIFT spectroscopic analysis for NiAl3 and NiCuAl (with Ni:Cu atomic ratio of 90:10) LDHs using eugenol as a model compound suggested that the mode of eugenol adsorption is critical wherein the activity enhanced when eugenol adsorbed with the benzene ring parallel to the catalyst surface (see scheme). It was revealed that at reaction temperatures where the isomerization reaction may proceed (>160 °C), the non-uniform surface and less basicity of NiCuAl9010 catalyst cause the adsorption of eugenol mainly with benzene ring away from the surface. On the contrary, for NiAl3 catalyst eugenol adsorbed predominantly with the benzene ring parallel to the catalyst surface that in turn facilitated the reaction. The surface coverage and the mode of adsorption changed significantly for the samples that were preheated at 300 °C *(Catal Commun. (2012), 28, 100-104).*

Synthesis of fatty acid alkyl esters (FAAE))



Alkyl esters in presence of nano-crystalline sulfated zirconia (SZ) catalyst with different short chain alcohols were prepared. A small concentration of SZ catalyst (0.1-0.5 wt% to acid) exhibited 96-100% conversion of caprylic/myristic acid with methanol at 60 °C after 5-7 h with selective (100%) formation of ester. SZ-catalyst (SZ-1) having higher number of Brönsted acid sites could be re-used for myristic acid esterification for five cycles without significant loss in activity, whereas SZ-catalyst (SZ-2) having less number of acid sites showed a decrease in activity after five cycles *(J.Sol-Gel SciTechnol 62 (2012)13-17; Catal Sci Technol. 2 (2012) 2512).*For better catalytic performance of re-used catalyst, the reaction was studied over tungstated zirconia (WZ) with 12-20 wt% tungstate by calcining in the range of 600-900°C. WZ catalysts also exhibited similar activity as SZ showing 90-94% conversion of myristic acid with methanol at 60ºC and also good re-usability for four cycles.

Synthesis of di-octyl phthalate over solid acid catalysts

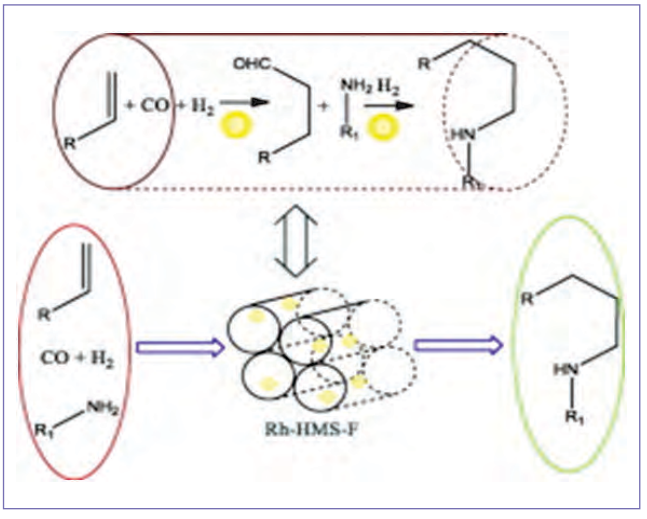


For di-octyl phthalate (DOP) synthesis, the conventional liquid acid catalyst was replaced by solid acid catalysts, wherein 92-93 wt% selectivity and 75-77 wt% yield of DOP at 160°C after 6h was obtained.

The comparison of various solid acid and conventional liquid acid catalysts showed that one of the solid acid catalyst resulted into similar conversion and selectivity of DOP as was observed with conventional benchmark H_2SO_4 and *p*-toluene sulfonic acid indicating the potential of solid acid catalyst for the synthesis of DOP.

Rhodium complex encapsulated amino functionalised hexagonal mesoporous silica catalysed effective heterogeneous hydroaminomethylation

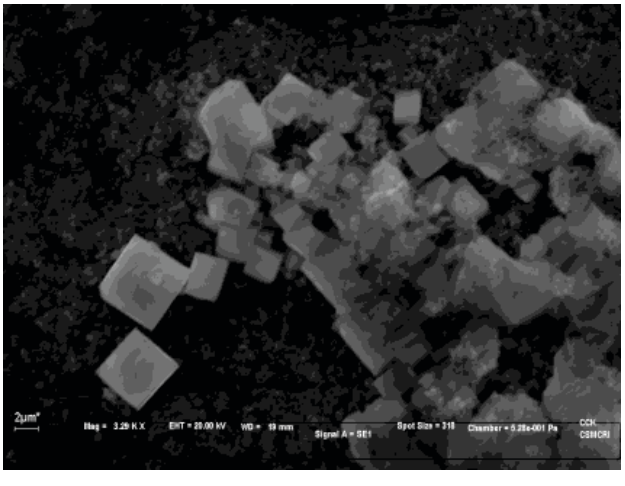
A $HRh(CO)(PPh_3)_3$ complex encapsulated into the pores of amino functionalized hexagonal mesoporous silica (HMS) synthesized, characterized and investigated as heterogeneous catalyst (Rh-HMS-F) had performed effectively for carrying out an environmentally benign atom-efficient and one-pot synthesis of amines from olefins, by hydroaminomethylation. The reaction consisted of initial hydroformylation of the olefin to an aldehyde and subsequent formation of an enamine / imine followed by hydrogenation.



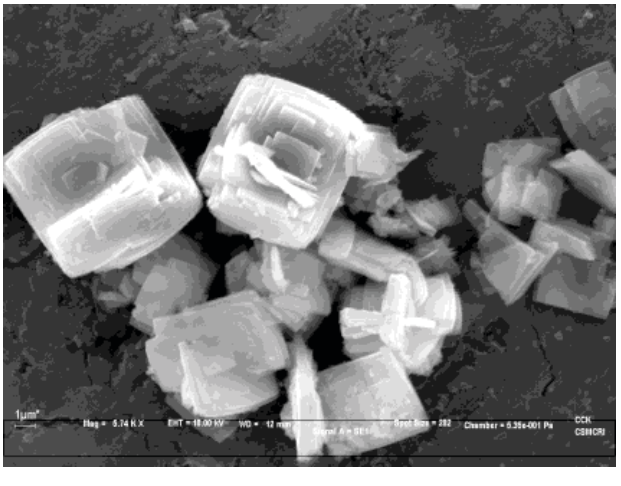
The catalyst (Rh-HMS-F) was active for hydroaminomethylation for a variety of alkenes (1-pentene, 1-hexene, cyclopentene) and amines (morpholine, hexylamine, cyclohexyl amine, pyrrolidine, diethylamine, piperidine). The catalyst afforded to achieve 100% conversion with high (>95%) selectivity to corresponding amines. Significant amounts of aldehydes and enamines were observed during the course of the reaction indicating that there could be two possible rate determining steps. The catalyst was effectively recycled up to five times without much loss in its activity and selectivity *(App Catal A Gen. (2013), 453, 159-166).*

Rhodium exchanged titanosilicates catalysed effective heterogeneous hydroaminomethylation

Rhodium exchanged titanosilicates (ETS-10 and ETS-4) catalysts were efficient and highly active and selective towards amine product within lower reaction time of 4 h in hydroaminomethylation reaction. 1-Hexene and pyrrolidine were taken as representative substrates for parametric variations using Rh-ETS-10. The increase in pyrrolidine ratio gave significant information showing a decrease in conversion with increased selectivity. The initial rate of formation of amine was double than that of isomerization of 1-hexene.

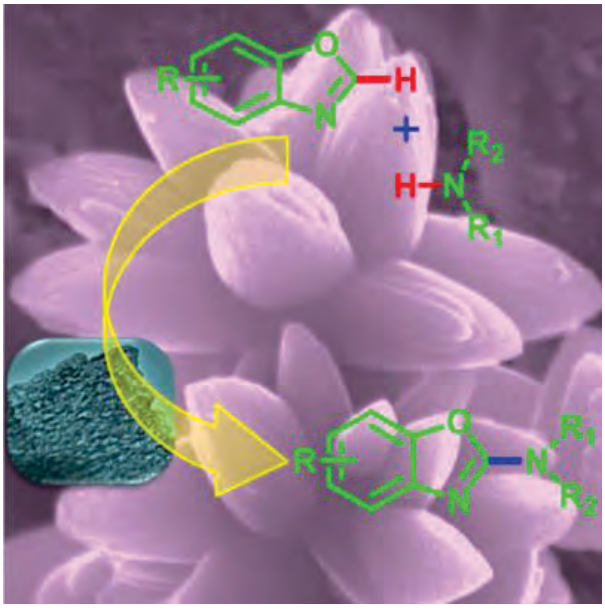


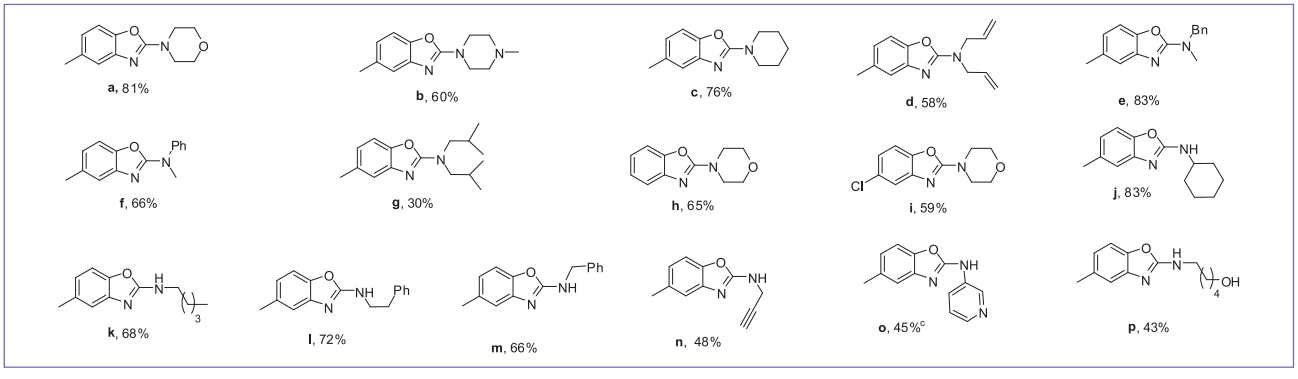
The Rh cluster like complex was formed on treating the catalyst with syn gas. A homogenous-heterogeneous dual nature of Rh was found during hydroaminomethylation. The catalyst was effectively recycled for three times without much loss in its activity and selectivity *(App Catal A Gen. (2014),473, 116-124).*



Oxidative amination of benzoxazole through C-H activation

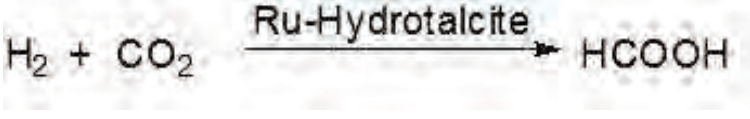
Oxidative amination of azoles through catalytic C-H bond activation are performed under homogeneous conditions, using excess reagents and additives. To address it a heterogeneously porous γ-MnO_2 catalysed direct amination of benzoxazole, wide range of primary and secondary amines are investigated under mild reaction conditions using molecular oxygen, without any additives. The reaction was well tolerated with functional group like alcohol indicating the broad applicability of this reaction.





Hydrogenation of carbon dioxide

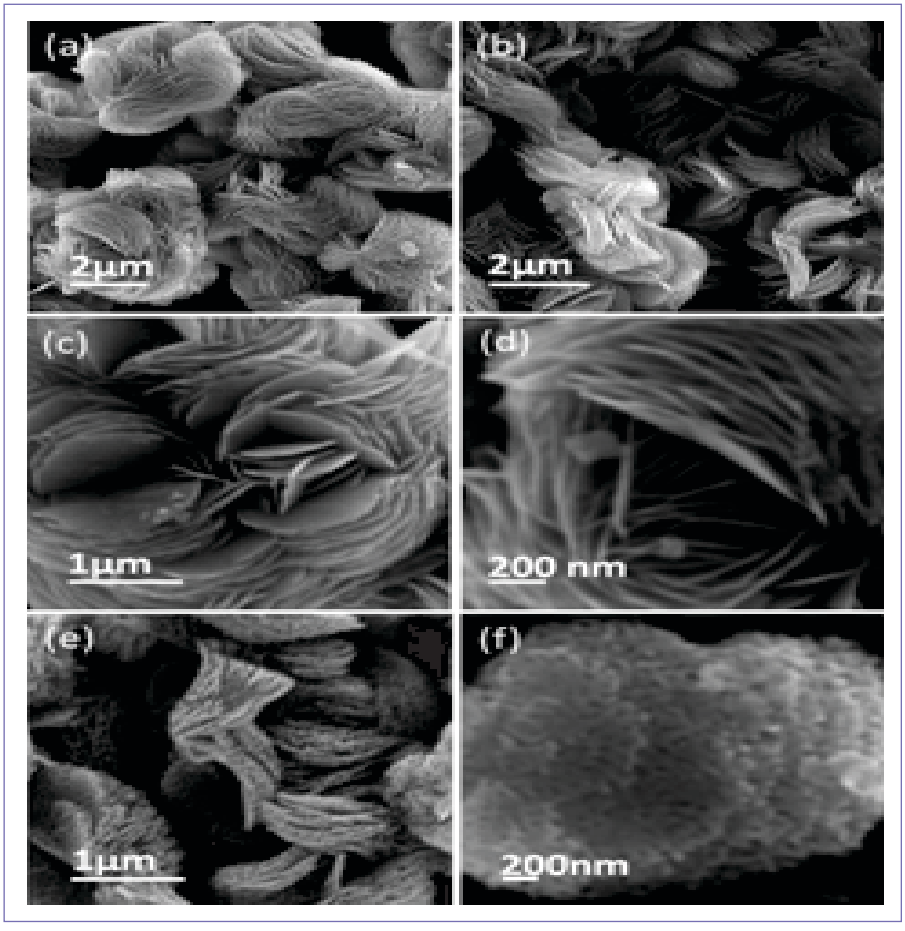
The industrial usage of CO_2 has gained increasing attention and homogeneously catalyzed hydrogenation of CO_2 to formic acid has been extensively studied, however economic separation of formic acid and catalyst remain the concern. In view of this for investigating heterogeneous catalyst system a ruthenium hydrotalcite based catalyst of Mg/Al molar ratio 3.5 was synthesized, characterized and evaluated for hydrogenation of CO_2 to formic acid. The performance of the catalyst was evaluated as a function of the amount of the catalyst in the range of 50 to 400 mg at 50 bar (H_2:CO_2=1:1 (p/p)), temp. 60°C, for 6 h. Yield of formic acid and conversion of CO_2 were increased on increasing the catalyst amount up to 300 mg and on further increasing the amount the conversion and yield could not be influenced and 7.5 mmol formic acid was formed.



A rapid and green synthetic approach for hierarchically assembled porous ZnO nanoflakes with enhanced catalytic activity

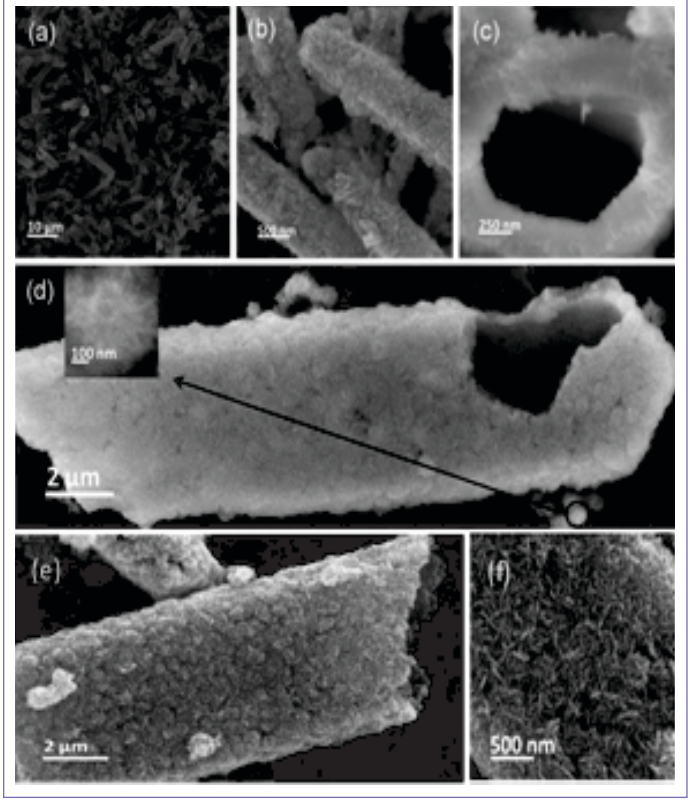
Controlled synthesis of 3D hierarchically porous ZnO architectures constructed of 2D nano-sheets through the calcination of a hydrozincite $[Zn_5(CO_3)_2(OH)_6]$ intermediate, was done. The intermediate 3D hierarchical hydrozincite had been synthesized by a novel organic surfactant

and solvent free aqueous protocol at RT using an aqueous solution of ammonium carbonate and laboratory grade bulk ZnO in a short time (20–30 min). On decomposition a porous structure of 44 $m^2 g^{-1}$ surface area was obtained. The synthesized hierarchical ZnO morphology exhibited an improved catalytic activity for the synthesis of 5-substituted-1H-tetrazoles with different nitriles and sodium azide than that of nanocrystalline ZnO and bulk ZnO, as well as other developed solid catalysts. *(JMater Chem. (2012),22, 17227-17235).*



Porous ZnO microtubes with excellent cholesterol sensing and catalytic properties

Porous ZnO microtubes were synthesised via the formation of tubular hydrozincite under ambient conditions from bulk ZnO followed by calcination at 500 °C for 2 h. The tubular structure is a hierarchical assembly of ZnO flowers to form uniform tubes, with ~30 mm length, ~2 to7 mm width and ~400 to 500 nm wall thickness, where the flowers are made of 3D assembled porous ZnO flakes. Its surface area was 58 $m^2 g^{-1}$. A novel biosensor based on this synthesized porous tubular ZnO exhibited high sensitivity (54.5 mA M^{-1} cm^{-2}) and low limit of detection, 0.2 mM (S/N = 3)) of cholesterol at RT, superior to that of sensors made of other porous ZnO shapes synthesized by varying the conditions, as well as other reported sensors. It is superior even in comparison with a nano gold modified sensor. The tubular ZnO structure also showed superior catalytic activity (92%) for the synthesis of 5-benzyl-1H-tetrazole to that of other reported solid catalysts. The synthesis from bulk ZnO makes the procedure cost effective (*J Mater Chem A.(2013), 1, 814-822).*



Porous cesium impregnated MgO (Cs–MgO) nanoflakes with excellent catalytic activity for highly selective rapid synthesis of flavanone

Porous cesium impregnated MgO (Cs–MgO) nano flakes, with enhanced surface area (156 m^2/g), basic properties and improved catalytic activity were synthesised through impregnation of $CsNO_3$ on a nesquehonite [$Mg(HCO_3)OH \cdot 2H_2O$] rod, followed by calcination. During impregnation the metastable nesquehonite rod rehabilitated to hydromagnesite [4 $MgCO_3$. $Mg(OH)_2 \cdot 4H_2O$] flakes. These porous Cs–MgO nanoflakes showed significant improvement in the yield of flavanone through the Claisen–Schmidt condensation. 90% conversion of 2-hydroxyacetophenone with 81% selectivity to flavanone. *(RSC Adv. (2013), 3, 2802-2811).*

CeO_2 nano-wires with high aspect ratio and excellent catalytic activity for selective oxidation of styrene by molecular oxygen

A simple, efficient and aqueous solution based hydrothermal synthetic route for uniform CeO_2 nano wire (NW), with high aspect ratio and surface area, using aqueous solution of cerium ammonium carbonate complex as precursor and poly ethylene glycol (PEG) as structure directing agent, is reported. The cobalt incorporated CeO_2 NW (Co-CeO_2) was also synthesized by impregnation followed by calcination. XPS and TPD analysis revealed the presence of both Ce^{3+} and Ce^{4+} with higher amount of Ce^{3+}as well as Co^{2+} and Co^{3+} species. A probable formation mechanism of wires through (110) surface is proposed. Synthesized CeO_2 shapes were employed as catalyst for selective oxidation of styrene to styrene oxide by molecular oxygen which showed excellent catalytic activity, following the Langmuir–Hinshelwood model. The catalysts were effectively recyclable *(RSC Adv. (2013), 3,10837-10847).*

Room temperature Baeyer–Villiger (BV) oxidation using O_2 over mesoporous zirconium phosphate (m-ZRP)

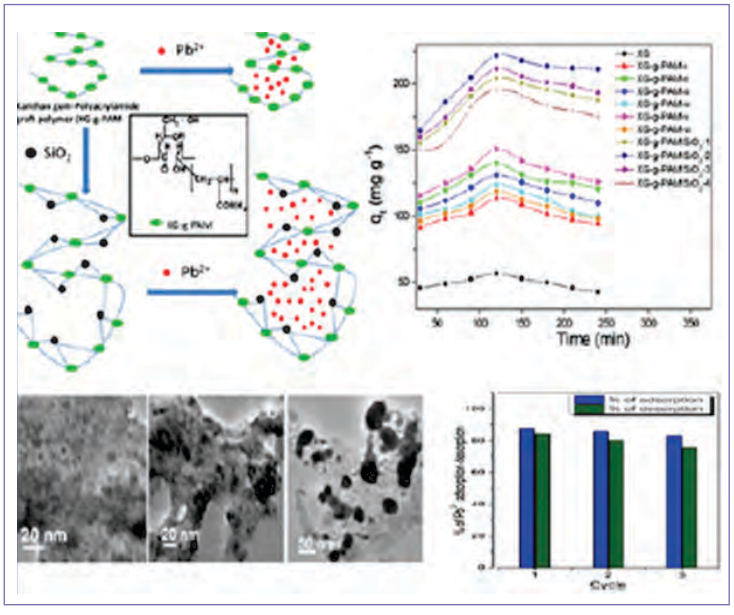
A series of lactones or esters are synthesized from their corresponding ketones employing BV oxidation at RT using m-ZrP as a solid acid catalyst, O_2/benzaldehyde as an oxidizing agent, in a solvent free reaction medium. The m-ZrP showed high catalytic activity for the BV oxidation of cyclohexanone as well as other ketones in the presence of reduced amount of benzaldehyde with 100% selectivity for the corresponding lactones/esters. The protocol is suitable even for bulkier cyclic ketones like adamantanone. The m-ZrP catalyst showed excellent reusability *(Catal Sci Technol. (2012),2, 2375-2382).*

Mesoporous borated zirconia: A solid acid–base bifunctional catalyst

A facile low temperature aqueous solution based chemical route for the synthesis of mesoporous borated zirconia, an acid–base bifunctional solid catalyst, using aqueous zirconium ammonium carbonate complex and borax in presence of CTAB is investigated. The material has a very high surface area and acidity with weak basicity. The catalytic activity of the material was investigated for the solvent-free Knoevenagel condensation reaction of benzaldehyde/substituted benzaldehyde and malononitrile/cyano ethylacetate to confirm the acid–base bifunctionality in high yield (>90%). The evidence that the high catalytic activity is a result of acid–base bifunctionality of the synthesized borated zirconia material was further supported by performing Claisen–Schmidt condensation of benzaldehyde and acetophenone. The methodology was also extended for targeted synthesis of cinnamyl ethyl ester and coumarin or coumarin ester; and resulted in a good yield *(ChemCatChem. (2013),5, 331-338).*

Novel biodegradable nanocomposite based on XG-g-PAM/SiO2: Application of an efficient adsorbent for Pb^{2+} ions from aqueous solution

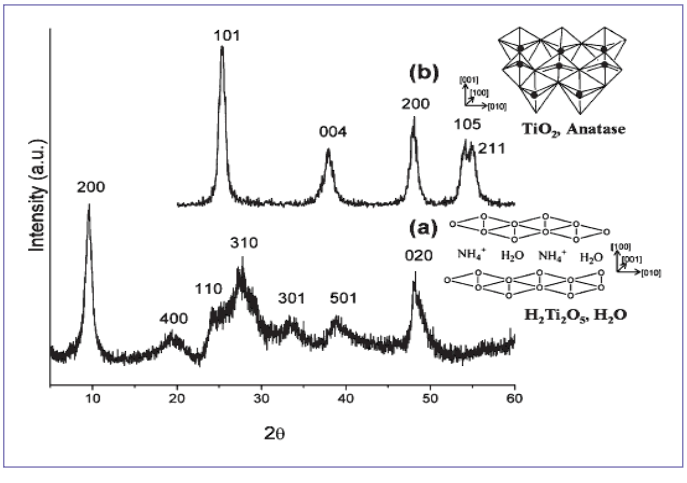
A novel nanocomposite based on nanosilica filled modified natural polymer isdeveloped for removal of Pb^{2+} ions from aqueous solution. The chemical, structural, textural, and rheological characteristics of the nanocomposite (XG-g-PAM/SiO_2) revealed stronger interaction of silica nanoparticles with polymer matrix and showed maximum adsorption capacity (Qmax = 537.634 mg g^{-1}) of Pb^{2+} ion, which is significantly higher than other reported adsorbents. The thermodynamics confirm that the adsorption is spontaneous and endothermic. Desorption studies affirmed the regenerative efficacy of loaded Pb^{2+} *(Bioresour Technol. (2012),119, 181-190).*



Organic free low temperature direct synthesis of hierarchical protonated layered titanates/ anatase TiO_2 hollow spheres and their task-specific applications

Direct synthesis of 3D arranged hierarchical hollow spheres of protonated layered dititanate ($H_2Ti_2O_5H_2O$) giving surface area as high as 334 m^2 g^{-1} were prepared through hydrothermal treatment of freshly prepared peroxo titanium carbonate. These spheres showed very high removal capacity for toxic heavy metals like Pb^{2+} and methylene blue from aqueous solution. Corresponding anatase TiO_2 spheres manifested as a brilliant anode material for lithium ion batteries with excellent cyclability. TiO_2 spheres also showed good photocatalytic activity *(J. Mater Chem A. (2013),1, 9122-9131).*

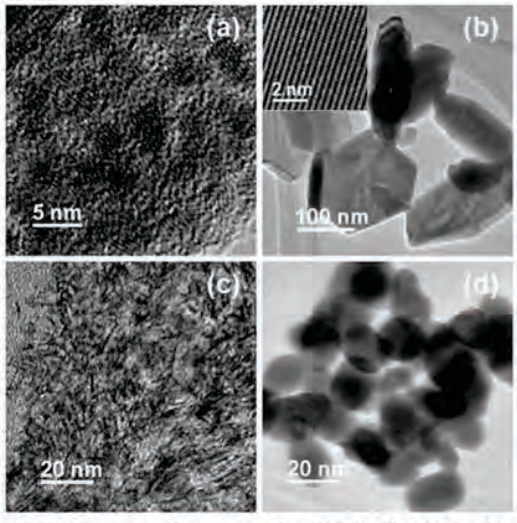
Hierarchically order porous lotus shaped nano-structured MnO_2 through $MnCO_3$: chelate mediated growth and shape dependent improved catalytic activity



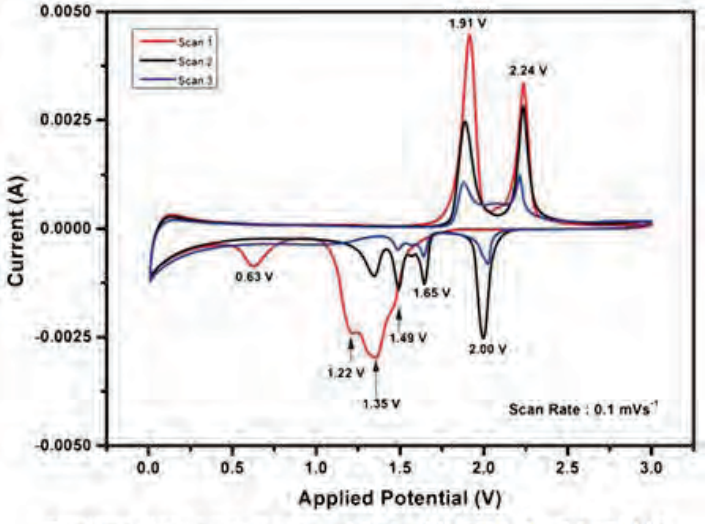
3D hierarchically assembled lotus shaped porous MnO_2 synthesized using a simple aqueous solution based chelating agent (citric acid) mediated growth of $MnCO_3$ followed by calcination at 350 °C. $MnCO_3$ in other shapes: rods, spheres and nano aggregates, are also synthesized just by varying the chelating agents. The synthesized porous MnO_2 shapes exhibit excellent shape dependent catalytic oxidation of alpha-pinene to verbenone with O_2. The lotus shaped porous MnO_2 showed superior activity, with 94% conversion of alpha-pinene and 87% selectivity of verbenone, to that of other MnO_2 shapes. The lotus shaped MnO_2 also showed good catalytic activity towards oxidation of allylic compounds to corresponding ene–ones with O_2 and is reusable *(J Mater Chem A.(2013), 1, 10251-10258)*

An alternative hydrolytic synthesis route for uniform metal selenide nanoparticles

A generalized size selective synthetic protocol for uniform metal (Cd, Zn, Pb, Cu, In) selenide nanoparticles in hydrothermal conditions, using decanoic acid (C10) as a ligand, aqueous metalammonium/ammonium carbonate complex and sodium hydrogen selenide (NaHSe), is developed. The materials show improvement in size dependent properties and hold promise for various practical applications *(RSC Adv. (2013), 3, 16322-16325).*

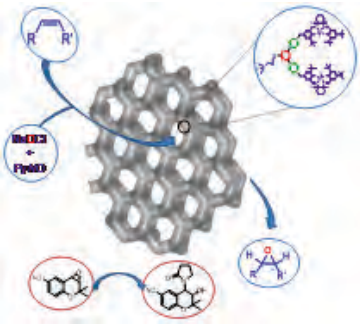


TEM images of the synthesized (a) ZnSe, (b) CuSe (inset: corresponding HTTEM), (c) In2Se3 and (d) PbSe nanoparticles



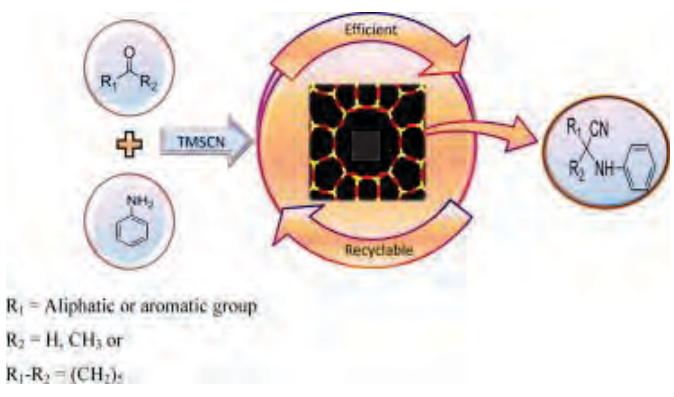
Cyclic voltammograms of CuSe//LiPF6-EC:DMC)//Li coin cell

Immobilized dimeric chiral Mn(III) salen complex for the epoxidation of non-functionalized alkenes



The chiral dimeric Mn(III) salen complex was immobilised with *(1R,2R)*-(-)-diaminocyclohexane collar on short channel large pore sized silica through a linker, {$(CH_2)_3$-NH-melamine-piperazine}. The enantioselective epoxidation of several olefins with aqueous NaOCl gave high turnover frequency (TOF) and enantio-selective formation of products. This protocol was also used to synthesize *(S)*-Levchromakalim (ee, 98%) and antihypertensive drug at 1 g scale *(Tetrahedron. (2012)68, 6314-6322).*

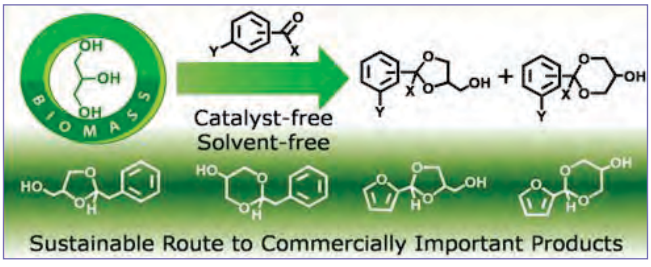
Tin exchanged zeolite as catalyst for direct synthesis of α-amino nitriles under solvent-free conditions



Sn exchanged HBeta zeolite was highly efficient catalyst for the direct synthesis of α-amino nitrile from various ketones and aldehydes with amine and trimethylsilylcyanide (TMSCN) under solvent-free conditions. Excellent yield of α-amino nitrile (up to 96%) was achieved within 10–120 min at RT. The Sn exchanged HBeta zeolite was recovered and effectively reused for several times for its performance (*Appl Cat A: Gen. (2012), 419-420, 22-30).*

Microwave-assisted rapid valorization of glycerol towards acetals and ketals

Catalyst and solvent free protocol for the microwave assisted acetalization of glycerol and carbonyl compounds to achieve high yields of cyclic acetals or ketals including commercially valuable hyacinth fragrance and fuel additive precursors was demonstrated*(Chem Eng J. (2014)235, 61-66).*



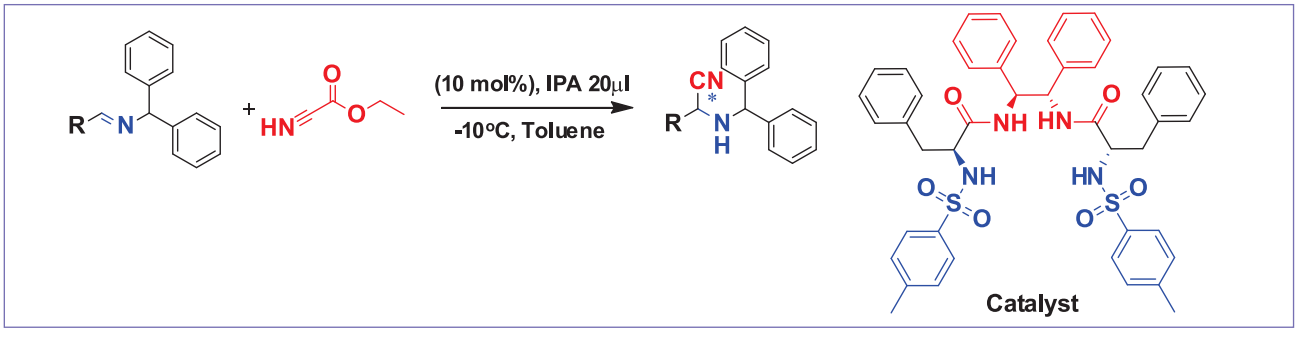
Homogeneous catalysis

Chiral catalysis

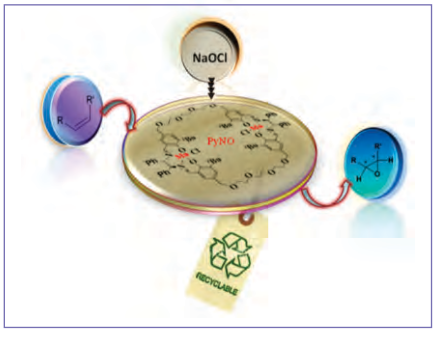
Asymmetric catalysis is an excellent strategy for achieving enantiopure pharmaceutically important molecule using chiral metal complexes/organo-catalyst. The chiral drugs in single enantiomer have market about 100 billion $. As the cost of chiral ligands is very high, their reusability is highly desirable for industrial exploitation. Recyclable chiral metal complexes were designed and used for the synthesis of various intermediates via asymmetric Strecker reaction, cyanation of aldehydes with different sources of cyanide, asymmetric ring opening reaction, kinetic resolution of racemic epoxides with amines, water and CO_2 as nucleophile, asymmetric Henry & Aza Henry reaction, asymmetric Fridel Craft alkylation and allylation reaction of carbonyl compounds.

C_2-symmetric recyclable organocatalyst for enantioselective Strecker reaction for the synthesis of α-amino acid and chiral 3 diamine- an intermediate for APN inhibitor

Several recyclable chiral amide-based organo-catalysts were synthesized and used for the asymmetric Strecker reaction of various aromatic and aliphatic N-benzhydrylimines with ethyl cyanoformate as cyanide source. These catalysts gave α-aminonitriles upto 95% yield and 99%ee. This protocol was extended for the synthesis of (*R*)-phenylalanine and (*R*)-3-phenylpropane-1, 2-diamine*(J Org Chem. (2012),77, 4375-4384).*



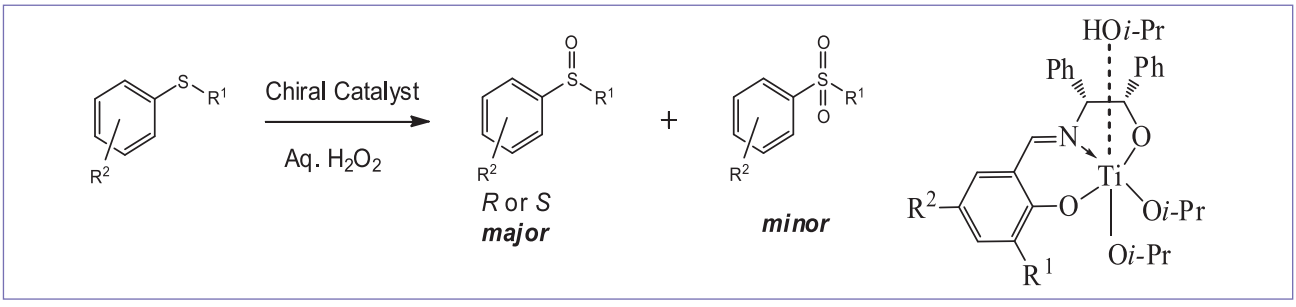
Reusable chiral macrocyclic Mn (III) salen complexes for enantioselective epoxidation of nonfunctionalized alkenes



A series of chiral macrocyclic Mn(III) salen complexes with monomeric and dimeric chiral macrocyclic salen ligands with trigol linker were prepared. With the chiral dimeric macrocyclic catalysts (5 mol %) enantio-pure epoxides were achieved in excellent yields (>99%) and ee >96%. The recycling was demonstrated with dimeric complex (recyclable up to six cycles studied with retention of enantioselectivity) in the asymmetric epoxidation of styrene *(J Catal. (2012),286, 41-50).*

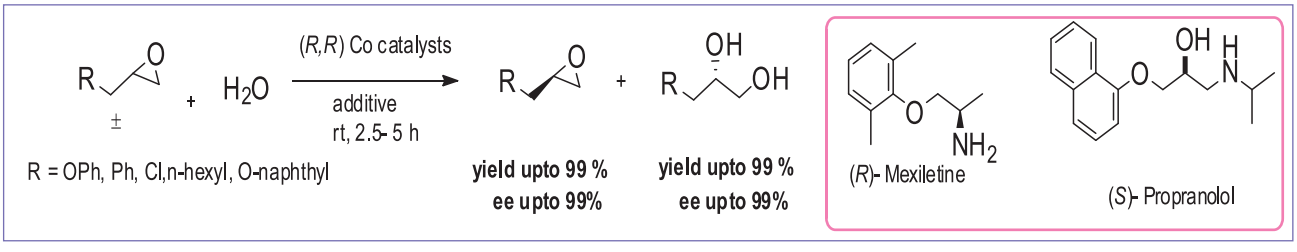
Asymmetric sulfoxidation of sulfides with hydrogen peroxide using titanium aminoalcohol derived Schiff base complexes

Aminoalcohol based Schiff bases were synthesized by condensation of (1*S*,2*R*)(+)-2-amino-1,2-diphenylethanol with various salicylaldehyde derivatives. The *in situ* generated complexes of Ti(O*i*-Pr)$_4$ with these ligands were used for asymmetric sulfoxidation of pro-chiral sulfides with 30% H_2O_2 at 0 °C in 10 h (conversion, 93%; *ee* up to 98%)*(J Mol Catal. A: Chem. (2012), 361-362, 36-44).*

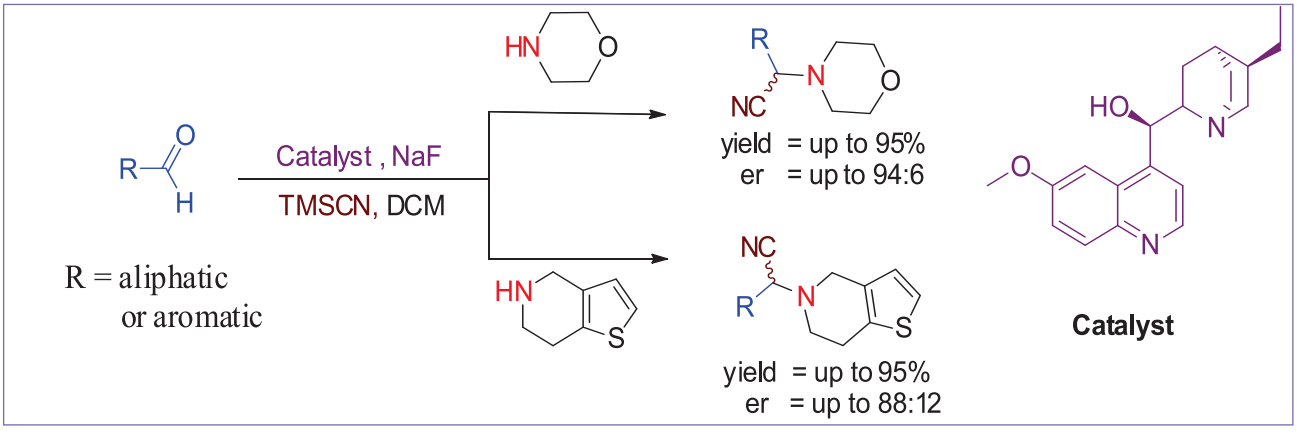


Asymmetric hydrolytic kinetic resolution (HKR) with recyclable macrocylic Co(III)-salen complexes

Recyclable chiral Co(III) macrocyclic salen complexes were used in HKR of racemic epichlorohydrin, propene oxide, styrene oxide and glycidyl ethers to give enantio-pure epoxide and diol in >42% yield (theoretical yield is 50%) with enantiomeric excess >99%. With this protocol chiral drug molecules (*R*)-mexiletine and (*S*)- propranolol were synthesized in good yield and enantio-selectivity*(Chem Eur J. (2012),18, 5256-5260).*

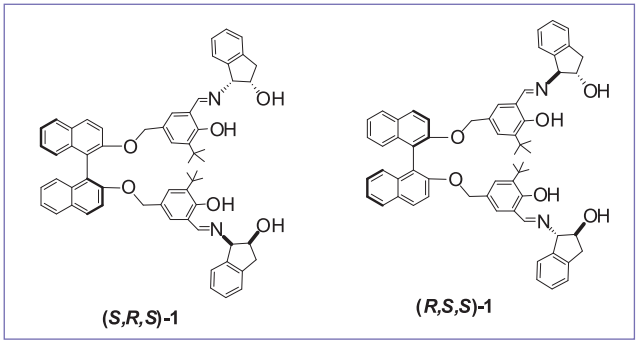


Modified asymmetric Strecker reaction of aldehyde with secondary amine: A protocol for the synthesis of *S*-clopidogrel (An antiplatelet agent)



A first approach for catalytic asymmetric Strecker reaction of aldehydes with a secondary amine in the presence of sodium fluoride using hydroquinine as chiral catalyst was developed. The catalytic system gave α-aminonitriles in excellent yields (up to 95%) and high ee (up to 94:6). The efficacy of the chiral product was successfully fulfilled in the improved synthesis of (*S*)-Clopidogrel (an antiplatelet agent)*(J Org Chem. (2012),77, 7076-7080).*

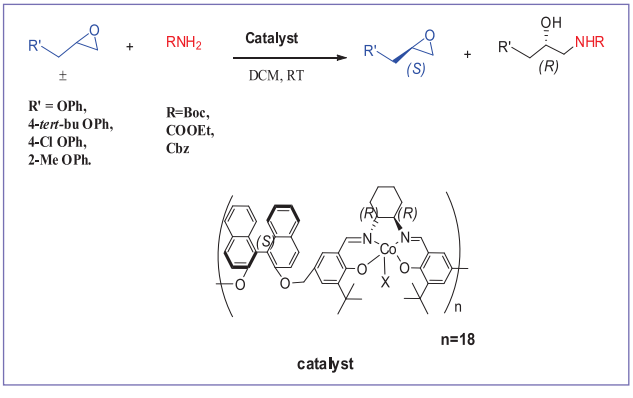
Synthesis of chiral ligands with multiple stereogenic centers and their application in titanium (IV) catalyzed enantioselective desymmetrization of *meso*-epoxides



New chiral ligands having diverse stereogenic centers arising from various diastereomeric combinations of aminoalcohol functionality with (*R*)- and (*S*)-Binol were synthesied. The catalytically active Ti complexes were generated *in situ* in the presence of water for the enantioselective ring opening reaction of *meso*-stilbene oxide, cyclohexene oxide, cyclopentene oxide, and *cis*-butene oxide with different anilines as nucleophile. Significantly, catalysts **Ti-(*S,R,S*)-1** and **Ti-(*R,S,S*)-1**(15 mol%) produced *syn*-*β*-amino alcohols of *meso*-stilbene oxide with (1*S*,2*S*) and (1*R*,2*R*) configuration respectively in excellent yields (>98%) and enantioselectivities (*ee* >99%) in 10 h at RT. However, aliphatic/cyclic epoxides with aniline gave better performance with catalyst **Ti-(*S,R,R*)-1**. The catalyst **Ti-(*S,R,S*)-1** was successfully recovered and recycled for 6 times in the ARO of *meso*-stilbene oxide *(ChemCatchem (2013),5, 2336-2342).*

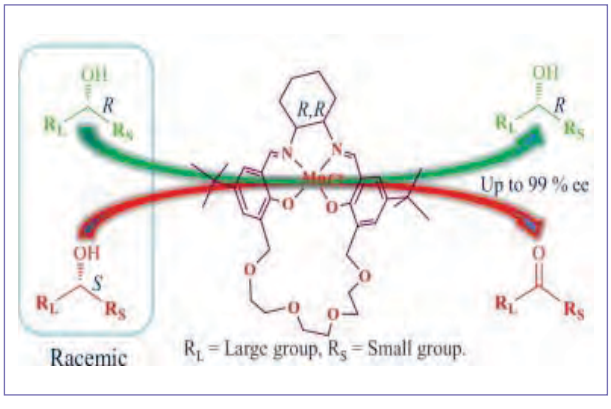
Asymmetric aminolytic kinetic resolution (AKR) of racemic epoxides using recyclable chiral polymeric Co(III)-salen complexes: A protocol for total utilization of racemic epoxide in the synthesis of (*R*)-naftopidil and (*S*)-propranolol

Chiral polymeric Co (III) salen complexes with chiral ((*R*)/(*S*)-Binol, diethyl tartrate) and achiral (piperazine and trigol) linkers with varying-stereogenic centres were synthesised for the first time and used as catalysts for AKR of a variety of terminal epoxides and glycidyl ethers to get enantio-pure epoxides (ee, 99%) and *N*-protected *β*-aminoalcohols (ee, 99%) with quantitative yield in 16 h at RT under optimized reaction conditions. This protocol is also used for the synthesis of two enantiomerically pure drug molecules (*R*)-Naftopidil (α-blocker) and (*S*)-Propranolol (β-blocker) as a key step via AKR of single racemic naphthyl glycidyl ether with Boc-protected isoproylamine with 100% epoxide utilization at 1 gram level. The catalyst was successfully recycled for a number of times *(J Org Chem. (2013), 78, 9076-9084)*

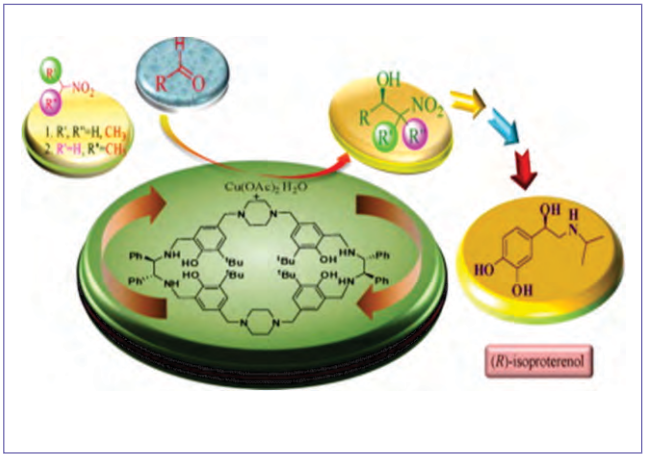


Macrocyclic Mn(III) salen complexes as recyclable catalyst for oxidative kinetic resolution (OKR) of secondary alcohols

New macrocyclic chiral Mn(III) salen complexes were synthesized and used as catalysts for OKR of secondary alcohols with diacetoxyiodobenzene ($PhI(OAc)_2$) and N-bromosuccinimide (NBS). Good to excellent enantioselectivities were achieved with catalyst for several secondary alcohols having different steric environment. In general with catalyst, NBS as a co-oxidant showed better enantioselectivity than $PhI(OAc)_2$ in OKR. *(Appl Catal. A: Gen.(2013),467, 542-551).*



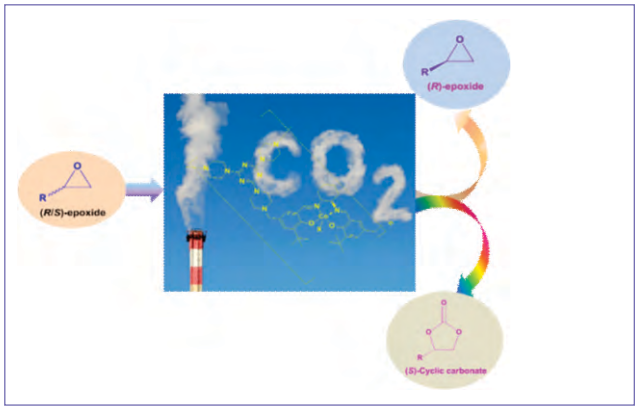
Chiral recyclable Cu(II)-catalysts in nitroaldol reaction of aldehydes with various nitroalkanes and its application in the synthesis of a valuable drug (*R*)-isoproterenol



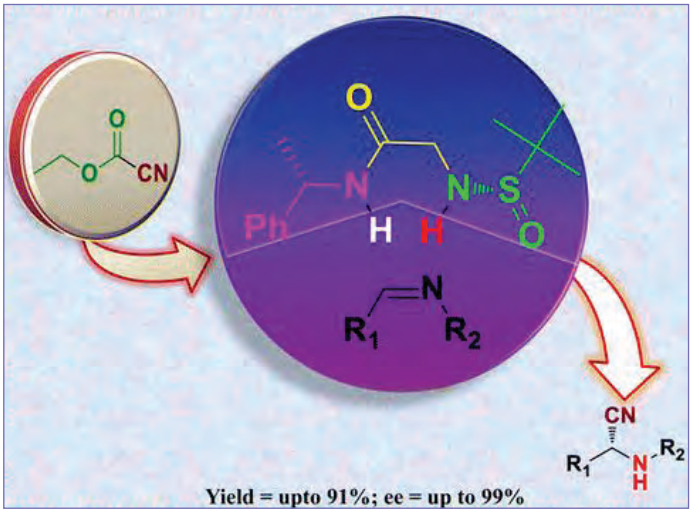
Chiral Cu(II) macrocyclic complexes were designed and used for the asymmetric nitroaldol reaction of aldehydes. Various nitroalkanes were utilized for asymmetric nitroaldol reaction with high yield (up to 98%) with ee up to 99% at RT. Kinetic investigations were done to evaluate the possible reaction mechanism. This protocol is used for the synthesis of (*R*)-isoproterenol in high yield and ee. The catalyst worked well up to 8 cycles with retention of catalyst performance *(Appl Catal A: Gen. (2013),459, 97-105).*

Asymmetric cycloaddition of CO_2 and an epoxide using recyclable bifunctional polymeric Co(III) salen complexes under mild conditions

Bifunctional polymeric Co (III) salen complexes derived from (1*R*,2*R*)-(−)-1,2-diaminocyclohexane and a triazine–piperazine core were synthesized and screened for the asymmetric cycloaddition reaction of CO_2 and an epoxide under mild conditions. A moderate K_{rel} value of 11.2 for the product propylene carbonate (ee = 74%) was obtained with catalyst without requiring any external base as the co-catalyst. The polymeric Co(III)–CCl_3COO was efficiently recycled ten times *(Catal Sci Technol. (2013),3, 2661-2667).*

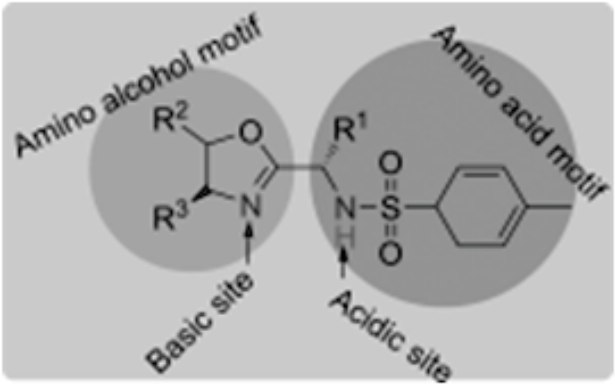


Small molecule as a chiral organocatalyst for asymmetric Strecker reaction



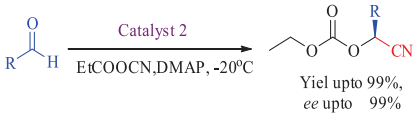
A simple and novel chiral amide-based organocatalyst was synthesized from readily available starting materials for the asymmetric Strecker reaction. A variety of *N*-benzhydryl- and *N*-tosyl-substituted imines were found to be suitable substrates with *i*-PrOH as an additive in the presence of chiral organocatalyst at 0 °C with ethylcyanoformate as a source of cyanide for the synthesis of chiral α-amino nitriles. High yield (up to 91%) with excellent ee up to 99% of product were achieved in 24–30 h for both *N*-benzhydryl- and *N*-tosyl-substituted imines. Study was extended with chiral α-amino nitriles [2-(benzhydrylamino)-2-(pyridin-3-yl)acetonitrile] for the synthesis of chiral amino amide and hydantoin in high yield and enantioselectivity (*ACS Catal. (2013),3 2873-2880).*

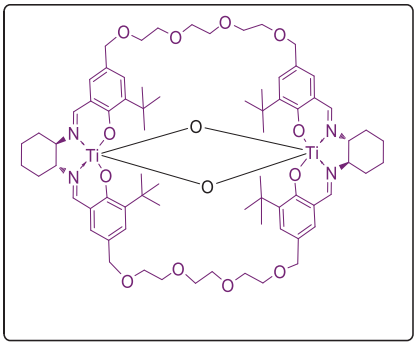
Oxazoline-based organocatalyst for enantioselective Strecker reactions: A protocol for the synthesis of levamisole



A chiral oxazoline-based organocatalyst catalysed the asymmetric Strecker reactions of various aromatic and aliphatic N-benzhydrylimines with trimethylsilyl cyanide (TMSCN) as a cyanide source at −20 °C to give α-aminonitriles in high yield (96 %) with excellent chiral induction (up to 98 % ee). DFT calculations have been performed to rationalize the enantioselective formation of the product. This protocol has been extended to the synthesis of the pharmaceutically important drug molecule levamisole in high yield and enantioselectivity*(Chem Eur J. (2013),19, 14224-14232).*

Asymmetric cyanoethoxy carbonylation reaction of aldehydes catalyzed by a Ti^{IV} macrocyclic complex: An efficient synthetic protocol for β-blocker and α_1-adrenergic receptor agonists

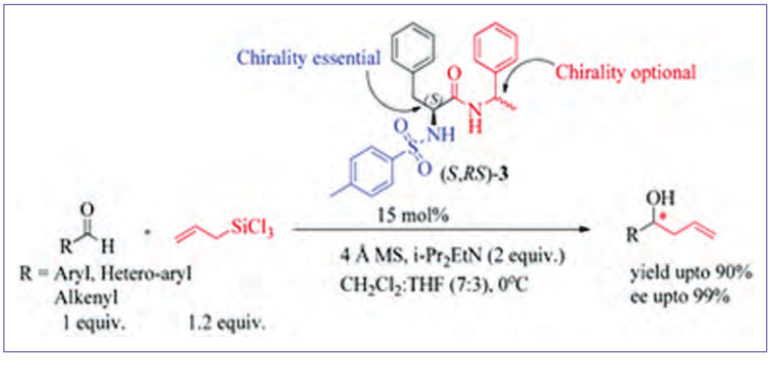




Chiral macrocyclic Ti(IV)–salen complexes were used as efficient catalysts in the asymmetric cyanoethoxy carbonylation of aldehydes. The Ti(IV) catalysts demonstrated excellent performance (product yields and ee values up to 99 %) with ethyl cyanoformate as the cyanide source and a catalyst loading of 0.5 mol %, which is the lowest known. The macrocyclic Ti(IV)–salen complex retained its performance at multigram level and was conveniently recycled for a number of times. The product obtained was straightforwardly transformed to the pharmaceutically important chiral drugs (*R*)-proethalol (β-blocker) and (R)-phenylephrine (α1-adrenergic receptor agonist) in good yields. (*ChemcatChem. (2013),5, 1441-1448).*

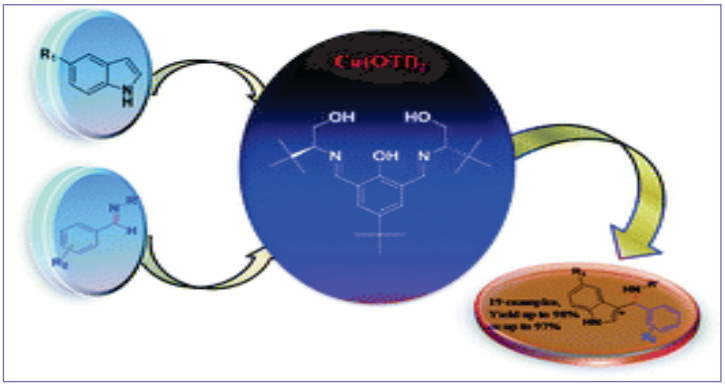
Synthetically amenable amide derivatives of tosylated-amino acids as organocatalysts for enantioselective allylation of aldehydes: computational rationale for enantioselectivity

Chiral macrocyclic Ti(IV)–salen complexes were used as efficient catalysts in the asymmetric cyanoethoxy carbonylation of aldehydes. The Ti(IV) catalysts demonstrated excellent performance (product yields and ee values up to 99 %) with ethyl cyanoformate as the cyanide source and a catalyst loading of 0.5 mol %, which is the lowest known. The macrocyclic Ti(IV)–salen complex retained its performance at multigram level and was conveniently recycled for a number of times. The product obtained was straightforwardly transformed to the pharmaceutically important chiral drugs (*R*)-proethalol (β-blocker) and (R)-phenylephrine (α1-adrenergic receptor agonist) in good yields. (*ChemcatChem. (2013),5, 1441-1448).*

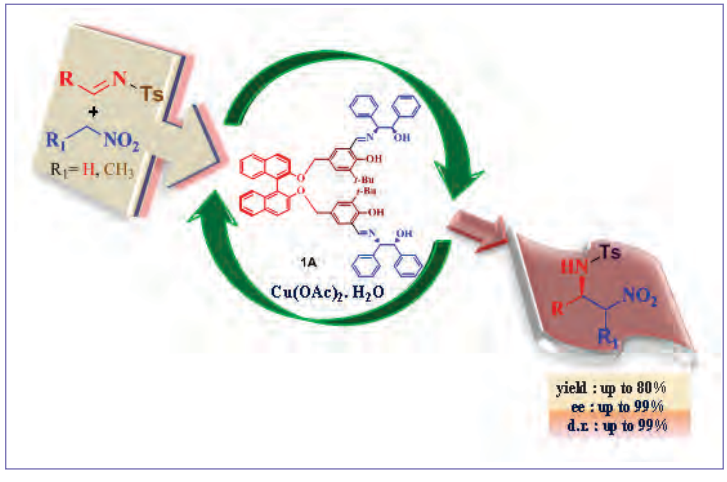


Asymmetric Friedel - Crafts addition of indoles to N-sulfonylaldimines catalyzed by Cu(II) chiral amino alcohols based Schiff base complexes

The recyclable copper(II) chiral amino alcohol based Schiff base complexes smoothly catalysed the Friedel-Crafts alkylation of indole with aryl aldimine with good yields (98%) and enantioselectivity up to 97%. *(Catal Sci Technol. (2014),4, 563-568).*

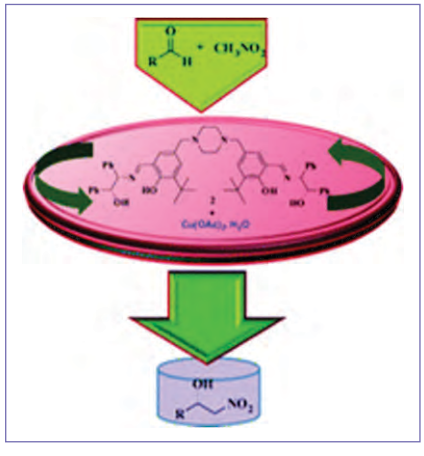


Chiral Cu(II)- amino alcohol based complexes for asymmetric Aza-Henry reaction of *N*-Ts imines



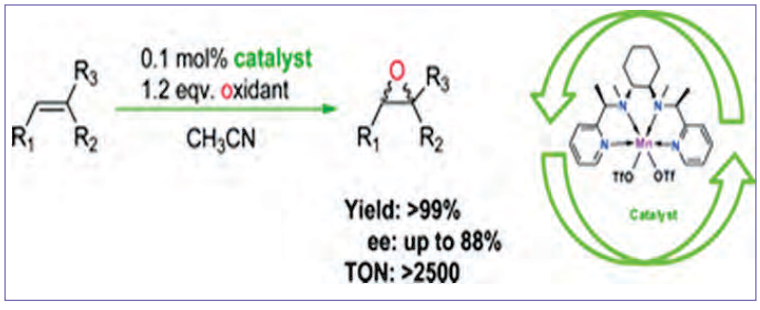
A series of chiral dimeric ligands derived from (*S*)/(*R*) 1,1'-bi(2-naphthol)-bis-aldehyde/ piperazine-bis-aldehyde and various aminoalcohols viz., (1*R*,2*S*)-(–)-2-aminodiphenylethanol, (1*S*,2*R*)-(–)-2-aminodiphenylethanol, (1*R*,2*S*)-1-amino-2,3-dihydro-1H-inden-2-ol and (*R*)-valinol were synthesized. *In situ* generated copper complexes of dimeric chiral ligands with different copper salts were used as catalyst for asymmetric Aza-Henry reaction of a variety of *N*-tosylimines as substrates with different nitroalkanes at RT to afford good yields of Aza-Henry products (80% with respect to the imines) with excellent ee (>99%) in 24 h with nitromethane and high *syn* selective products with excellent ee with nitroethane *(Cata. Sci Technol. (2014), 4, 548-555).*

Synthesis and characterization of chiral recyclable dimeric copper (II)–salen complexes and their catalytic application in asymmetric nitroaldol (Henry) reaction



Six new chiral tridentate ditopic ligands with ONO donors possessing different linkers (either achiral or chiral) were synthesized. These ligands have been treated with a series of metal ions *viz.*, Cu(II), Cu(I), Co(III) and Zn(II), affording varieties of new chiral metal complexes, and were screened for catalytic asymmetric nitroaldol reaction using benzaldehyde as a model substrate. The reaction conditions were optimized and 79% yield with good ee (88%) was achieved at RT with the *in situ* generated catalyst having a piperazine linker and (1*R*,2*S*)-2-amino-1,2-diphenylethanol collar in combination with cupric acetate as the metal source. By applying other aromatic and aliphatic aldehydes, similar yields of β-nitroalcohols with improved ee (up to 93%) were achieved. The catalytic system worked very well for four cycles *(Catal Sci Technol. (2014), 4, 411-418).*

Manganese complexes with non-porphyrin N_4 ligands as recyclable catalyst for the asymmetric epoxidation of olefins



New chiral manganese complexes of N_4 ligands derived from 2-acetylpyridine were prepared and used as catalysts in the enantioselective epoxidation of olefins, with oxidant H_2O_2 to give epoxides, with excellent conversions (up to 99%) and ee (up to 88%) within 1 h at 0 °C. The complex (0.1 mol%) was successfully subjected to recyclability experiments over 3 cycles in the epoxidation of styrene with H_2O_2 as an oxidant and acetic acid as an additive at 0 °C with retention of performance*(Catal Sci Technol. (2014),4, 208-217)*

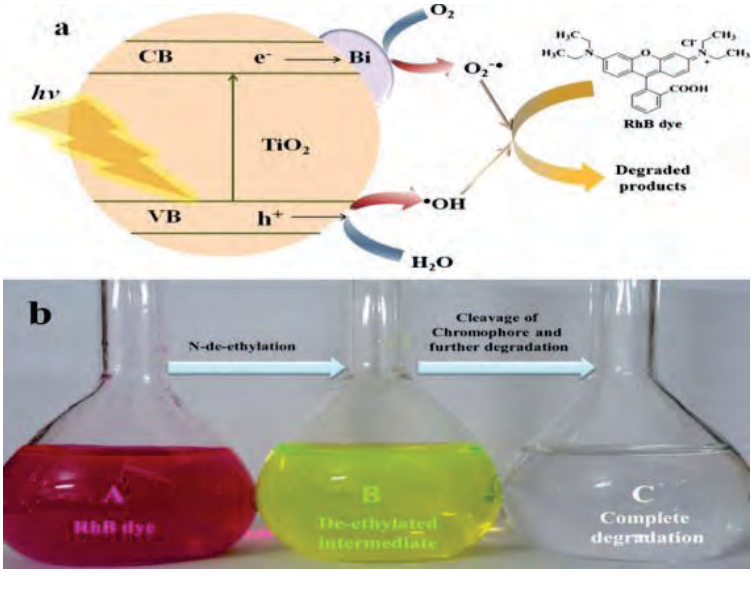
Catalysis of enantioselective Strecker reaction in the synthesis of D-homophenylalanine using recyclable, chiral, macrocyclic Mn^{III}–salencomplexes

A convenient approach to the asymmetric Strecker reaction was established by synthesizing chiral, mono- and dinuclear, macrocyclic MnII–salen complexes possessing achiral and chiral linkers (trigol, piperazine, and diethyl tartarate). The macrocylic complex with trigol linker works very well with TMSCN as a source of cyanide, using 4-phenyl pyridine N-oxide (4-PPy*N*O) as a co-catalyst in toluene at −40 °C. However, the macrocyclic complex with diethyl tartarate as a linker affected excellent chiral induction for both aromatic and aliphatic imines with a safer cyanide source (ethyl cyanoformate) in toluene at −20 °C in the presence of N,N-diisopropylimine as a co-catalyst.This protocol with catalyst having diethyl tartarate linker was further extended for the synthesis of d-homophenyl alanine, an important analogue in factor Xa inhibitors (*ChemcatChem, (2013),5, 1374-1385).*

Photocatalysis

Enhanced photocatalytic activity of bismuth-doped TiO_2 nanotubes under direct sunlight irradiation for degradation of rhodamine B dye

Bismuth-doped TiO_2 nanotubes (Bi-TNT) photocatalyst was efficiently used for degradation of Rhodamine B (RhB) dye under direct sunlight irradiation. The degradation studies revealed that initial rate of photocatalytic degradation of RhB dye using Bi-TNT was 5.56, 4.16, 1.30 and 2.38 times higher as compared to TNP, Bi-TNP, TNT and Degussa P-25 TiO_2 (P-25), respectively, under direct sunlight irradiation. *(J Nanopart Res. (2013), 15, 1-18*).

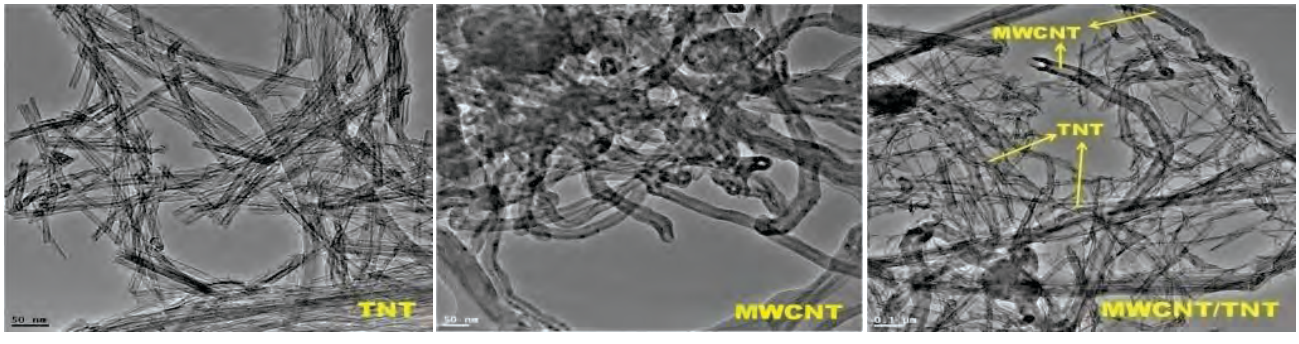


Study on identification of leather industry wastewater constituents and its photocatalytic treatment

Organic compounds present in leather industry wastewater were separated by solvent extraction. Nonadec-1-ene, 2-phenylethanol, 2, 4-di-*tert*-butylphenol and other organic compounds in the leather industry wastewater were identified. Among them, 2-phenylethanol was photo catalytically degraded using standard Degussa P-25 TiO_2 (100 mg) photocatalyst under UV light irradiation. *(Int J Environ Sci Tech. (2013),10, 855-864).*

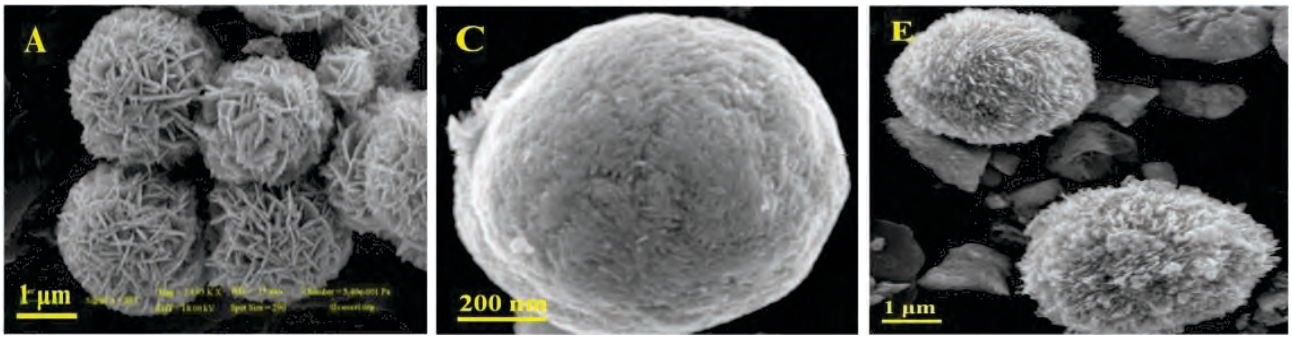
Multiwall carbon nanotube-TiO_2 nanotube composite material

Multiwall carbon nanotube-TiO_2 nanotube (MWCNT/TNT) composite material was synthesized by hydrothermal method with *in-situ* addition of activated MWCNT. Initially the raw MWCNT was activated and used for the preparation of MWCNT/TNT composite by hydrothermal method.



Synthesis of Bi_2WO_6 with sphere/flower morphology

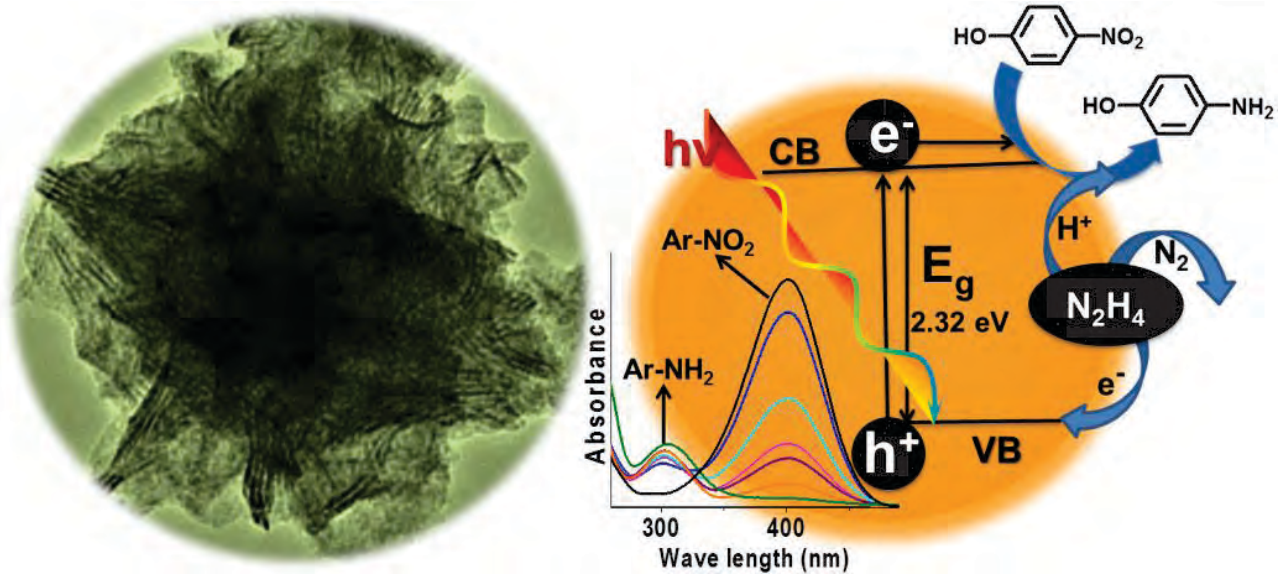
Visible light active bismuth tungstate (Bi_2WO_6) photocatalyst with sphere (BW-F) and flower morphology was synthesized by hydrothermal method with and without addition of tetraethyl orthosilicate (TEOS). SEM images clearly demonstrated the uniform flower morphology of Bi_2WO_6(A), whereas addition of TEOS leads to formation of spherical morphology of SiO_2 coated Bi_2WO_6 (BW-S-BSE, B). Subsequently the outer silica layer was etched by treating with NaOH solution in different time intervals and characterized by various physicochemical techniques. SEM and EDX analysis demonstrated that after 1h etching, SiO_2 layer was completely removed with retaining of sphere morphology of Bi_2WO_6 (BW-S-ASE-1h, D). Whereas increase in the etching time to 1.5h (BW-S-ASE-1.5h), the uniform sphere morphology was completely collapsed (E and F). The synthesized Bi_2WO_6 photocatalytic materials were utilized for degradation of reactive black 5 dye under direct sunlight irradiation.



SEM images of (A) BW-F, (B) BW-S-BSE and silica etching of BW-S-BSE samples at different time intervals (C) BW-S-ASE-0.5h, (D) BW-S-ASE-1h (Inset: Single sphere) and (E and F) BW-S-ASE-1.5h

Photo-catalytic reduction of nitroarenes under visible light

Semiconductor metal chalcogenides (CdS, CdSe, PbS, PbSe, CuSe) are advantageous because of their tuneable photo response in the visible region. CdS nanoparticle is an excellent choice of photo catalytic transformation of organic molecules in the presence of sacrificial reagents (such as S^{2-},SO_3^{2-}, EtOH etc.), which prevents the metal sulphides from anodic photo corrosion by providing sacrificial electron to the photo generated hole of the semiconductor molecules. Reduction of p-nitrophenol to p-amino phenol was carried out using hydrazine or sodium borohydride as a reducing agent and ethanol as solvent. Impregnation of Pt (2 wt%) in CdS improve the reactivity significantly and >99% conversion was observed in 15 min.



प्रकरण 2
CHAPTER



मेम्ब्रेन विज्ञान
MEMBRANE SCIENCES

रिवर्स ऑस्मोसिस एंव इंजीनियरिंग वैद्युत मेम्ब्रेन प्रविधि

Reverse Osmosis and Engineering Electro Membrane Processes

रिवर्स ऑस्मोसिस एंव इंजीनियरिंग

विभिन्न आकारिकीयुक्त पॉलीसल्फोन मेम्ब्रेन के ऊपरी हिस्से पर एम–फेनाइलीनडाईएमीन तथा ट्राइमिजोइल क्लोराइड के बीच इन्टरफेसियल बहुलीकरण द्वारा पॉलीएमाइड पतली फिल्म संघटित मेम्ब्रेन निर्मित की गई। स्कैनिंग इलेक्ट्रान माइक्रोस्कोप (SEM) तथा एटॉमिक फोर्स माइक्रोस्कोप (AFM) अध्ययनों में हमेशा की तरह रिड्ज–वैली सरंचना वाली थिन फिल्म कम्पोजिट (टीएफसी) रिवर्स ऑस्मोसिस (आर.ओ.) मेम्ब्रेन की बहुत ही समरुप पॉलीएमाइड पतली फिल्म की संरचना का पता चला। यह देखा गया कि पॉलीएमाइड स्तरित क्षेत्र में सापेक्ष आर्द्रता का मेम्ब्रेन की, नमक अस्वीकृति तथा जलप्रवाह, दोनों के कार्य–प्रदर्शन पर बहुत बड़ा प्रभाव रहा। भौतिक गुणधर्मो तथा कार्य–प्रदर्शन पर टीएफसी मेम्ब्रेन के परा–उपचार प्रभाव का अध्ययन किया गया। SEM द्वारा परा–उपचारित मेम्ब्रेन की आकारिकी में समय अंतरालों में परिवर्तन अर्थात् पॉलीएमाइड फिल्म र्निमाण तथा उपचार के बीच की समयावधि, के साथ बहुत बड़ा अंतर देखा गया। समय में बिलंब के साथ मेम्ब्रेन के अत्यधिक खुरदुरी सतह से अपेक्षाकृत चिकनी सतह तक परिवर्तन देखा गया। इससे यह निष्कर्ष निकाला जा सकता है कि टीएफसी मेम्ब्रेन का तत्काल परा–उपचार इसके कार्य–प्रदर्शन में वृद्धि के लिये फायदेमंद है।

इन टीएफसी मेम्ब्रेन से निर्मित घरेलू मोड्यूल (2" व्यास x 12" लंबाई, 0.4वर्ग मीटर सक्रिय क्षेत्रफल)ने 1000 पीपीएम सोडियम क्लोराइड के प्रदेय घोल का 75 पीएसआई दाब पर परीक्षण करने पर 93-94% नमक अस्वीकृति के साथ 10 लीटर प्रति घण्टा जल प्रवाह उत्पादित किया। इन टीएफसी मेम्ब्रेन से निर्मित सर्पिल मोड्यूल (4040 आकार) ने लगभग 5200 पीपीएम सोडियम क्लोराइड के प्रदेय घोल का 250 पीएसआई दाब पर परीक्षण करने पर 97% नमक अस्वीकृति के साथ 4-6 लीटर प्रति मिनट जलप्रवाह उत्पादित किया। उक्त विवरण दृढ़तापूर्वक यह समर्थन करता है कि ये मेम्ब्रेन अत्यधिक खारे पानी का विलवणन करके पेय जल प्राप्त करने के लिए उपयोग में लायी जा सकती हैं।

मेम्ब्रेन के दूषण प्रतिरोध गुणधर्म में सुधार करने के उद्देश्य से सतह को उच्चतर आवेशित तथा जलस्नेही बनाने के लिए, इनसीटू रेडॉक्स बहुलीकरण प्रक्रिया द्वारा पॉलीएमाइड स्तर के ऊपरी हिस्से पर पॉलीमेथाक्राइलेट की अतिशय पतली परत तैयार की गई। यह देखा गया कि निश्चित परिस्थितियों के अंतर्गत, जलप्रवाह लगभग 50 लीटर प्रति वर्ग मीटर प्रति घण्टे से 60 लीटर प्रति वर्ग मीटर प्रति घण्टे बढ़ गया, जबकि नमक अस्वीकृति (95 – 97%) लगभग समान रही। जल प्रवाह में वृद्धि का कारण टीएफसी परत में से क्रिया न कर पायेडाइएमाइन घोल का हटना, पॉलीएमाइड सक्रिय परत के मामूली अपघटन से मोटाई का कम होना, जलस्नेही कार्बोक्सीलिक एसिड कार्यात्मक समूह का बनना जिससे पॉलीएमाइड परत आकारिकी में कुछ परिवर्तन, आदि का संयुक्त प्रभाव हो सकता है। एम–फेनाइलीनडाईएमीन (एमपीडी) और 2,4,6- पीरीडिनट्राइकार्बोक्सीलिक एसिड क्लोराइड (पीटीसी) तथा पॉलीएमाइड फिल्म बनाने के लिए टीएमसी के मिश्रण उपयोग द्वारा बढ़े उन्नत दूषण प्रतिरोध गुणधर्म वाली टीएमसी मेम्ब्रेन तैयार की गई। पीटीसी से टीएमसी के 2:3 - 1:1 आण्विक अनुपात के साथ श्रेष्ठ परिणाम प्राप्त किया गया। जलप्रवाह में बढ़ोत्तरी पायी गई परन्तु नमक अस्वीकृति दक्षता लगभग अप्रभावित रही।

पॉलीएथलीन ग्लाइकॉल के सहसंयोजी लगाव द्वारा टीएफसी आर.ओ.मेम्ब्रेन के इनसीटू जलस्नेहीकरण के लिए एक प्रक्रिया विकसित की गई। यह दृष्टिकोण, अंत–क्रियाशील पॉलीएथलीन ग्लाइकॉल (MPD-PEG-MPD या MeO-PEG-MPD) की एम–फेनाइलीनडाईएमीन (एमपीडी) की संरचना के समान अंत समूह संरचना जो कि टीएफसी मेम्ब्रेन बनाने के लिए आमतौर पर प्रयुक्त होने वाला मोनोमर है, के आधार पर था। टीएफसीपीइजी-0 (एमपीडी तथा टीएमसी की बनी हुई) की सतह SEM छवि में एकसमान "नेटवर्क की तरह" संरचना के साथ लाक्षणिक सतह आकारिकी पायी गयी। इसके विपरीत पॉलीएथलीनग्लाइलेटेड मेम्ब्रेन के सतह की आकारिकी में प्रभावी अंतर था। गैरपॉलीएथलीनग्लाइलेटेड मेम्ब्रेन की तुलना में पॉलीएथलीनग्लाइलेटेड मेम्ब्रेन ने निस्यंदन के 20 घण्टे बाद प्रवाह में कमी के अनुपात (एफआर%), प्रवाह पुनर्प्राप्ति अनुपात (एफआरआर%) तथा सोडियम क्लोराइड अस्वीकृति दक्षता के मामले में उन्नत दूषण प्रतिरोध लक्षण दर्शाया।

जल को मृदु बनाने के लिए पॉली (पाइपरेजीन–ट्राइमेसामाइड) तथा पूर्ण सुगन्धित पॉलीएस्टर आधारित पतली फिल्म संघटित नैनो निस्यंदन मेम्ब्रेन तैयार की गई। पॉली (पाइपरेजीन–ट्राइमेसामाइड)

तथा पूर्ण सुगन्धित पॉलीएस्टर आधारित पतली फिल्म संघटित नैनो निस्पंदन मेम्ब्रेन तैयार की गई। पॉली (पाइपरेजीन–ट्राइमेसामाइड) आधारित एनएफ मेम्ब्रेन से 4"×14" तथा 2"×10" के सर्पिल मोड्युल तैयार किए गए। निर्माण की परिस्थितियों के आधार पर $MgSO_4$ की 70-98%अस्वीकृति के साथ जलप्रवाह का परिवर्तन 32–73 लीटर प्रति वर्ग मीटर प्रति घण्टे तक रहा। एनएफ-8, एनएफ-15 तथा एनएफ-16 नामक भिन्न अस्वीकृति तथा जलप्रवाह प्रदर्शित करने वाले तीन अलग–अलग एनएफ मोड्युल को विशेष अध्ययन हेतु चयनित किया गया। तीनों मेम्ब्रेनों में से एनएफ-8 ने $MgSO_4$ की लगभग 98% अस्वीकृति के साथ उच्चतम नकारात्मक सतह विभव तथा द्विसंयोजक और एकल संयोजक ऋणायनों के बीच 4:1 का अस्वीकृति अनुपात प्रदर्शित किया। तीनों चयनित मोड्युल में से एनएफ-8 ने दबाव के व्यापक विस्तार तथा 50% पुनर्प्राप्ति पर उच्चतम रंजक अस्वीकृति प्रदर्शित की।

जल अघुलनशील PDMA-PMMA-PDMA-1 (Mw 26000-28000 g/mol) संश्लेषित किये गये और परानिस्यंदन मेम्ब्रेन के उपरी हिस्से पर उनका लेप किया गया। इसतरह से परिवर्तित मेम्ब्रेन ने प्रोटीन के बीएसए परानिस्यंदन के दौरान विशुद्ध मेम्ब्रेन की तुलना में बेहतर दूषण प्रतिरोधी लक्षण प्रदर्शित किया। विशुद्ध मेम्ब्रेन द्वारा 66% प्रोटीन (बीएसए) की अस्वीकृति की तुलना में परिवर्तित मेम्ब्रेन द्वारा प्रोटीन की 92-97% की अस्वीकृति पाई गई।

पॉलीस्टर के बिना बुने हुए कपड़े की सहायता से विभिन्न बहुलक मात्राओं (16, 18, 20, and 22 % w/w) वाले कास्टिंग घोल से औसत 1 माइक्रोमीटर आकार के छिद्रवाली पीवीडीएफ आधारित फ्लेट शीट मेम्ब्रेन बनाई गई। आकारकीय अध्ययन में तरल–तरल अमिश्रण प्रक्रिया के दौरान उत्पन्न फेस उत्क्रमण के परिणाम स्वरुप, मेम्ब्रेन ने विषमदैशिकता प्रकृति का संकेत दिया।मेम्ब्रेन आसवन प्रक्रिया में इन मेम्ब्रेनों ने 30,000 से 100,000 पीपीएम कृत्रिम समुद्रीजल के अलवणीकरण की क्षमता दर्शायी। इन मेम्ब्रेनों ने, छिद्र की सरंचना, प्रदाय जल की सांद्रता तथा प्रौद्योगिकी के मानदण्डों के आधार पर 99% नमक अस्वीकृति दक्षता के साथ 2 से 12 लीटर प्रति वर्गमीटर प्रति घण्टे की रेंज पर जलप्रवाह दर्शाया। सभी मेम्ब्रेन ने सभी प्रदाय जल की सांद्रता की रेंज में समान व्यवहारिक कार्य–प्रदर्शन किया जिससे पता चला कि प्रदाय जल में खारेपन की वृद्धि का मेम्ब्रेन के कार्य–प्रदर्शन में किसी भी प्रकार का विपरीत प्रभाव नहीं पड़ता।

हाईड्रॉक्सिल निलंबित पॉली (हाइमिथाइलसीलोक्जेन) के बड़े अणुओं का पॉलीमिथाइलहाइड्रोसीलोक्जेन (पीडीएमएस) तथा एन–ओक्टाडेसाइलट्रई–क्लोरोसाइलेन (ओटीएस) के साथ क्रॉस–बंधन द्वारा वर्धित जल–विरोधी पॉली (डाइमिथाइलसीलोक्जेन) (पीडीएमएस) मेम्ब्रेन तैयार की गई। अद्वितीय, द्वि–क्रियाशील पीडीएमएस मेम्ब्रेन ने पानी में से जैविक उड़नशील अवशेषों को हटाने के लिए बेहतर कार्य–प्रदर्शन किया और इसतरह जैविक प्रदूषित जल के शोधन हेतु उच्च क्षमता दर्शायी। ओटीएस की 1 wt % मात्रायुक्त मेम्ब्रेन ने पानी पर बेन्ज़ीन या डाइक्लोरोमीथेन की उच्च स्थायी चयनात्मकता के मामले में उत्तम कार्य–प्रदर्शन किया।

विभिन्न पदार्थों से काईरल पृथक्करण मेम्ब्रेन तैयार की गई। एसटिक एसिड में चिटोसन घोल से फेज उत्क्रमण विधि द्वारा ग्लूटारेलडिहाइड से क्रॉस–बंधित करके ग्लूटारेलडिहाइड क्रॉस–बंधन चिटोसन मेम्ब्रेन (जीसीसीएम) तैयार की गई। इसी प्रकार β-साइक्लोडेकसट्रीन ग्लूटारेलडिहाइड क्रॉस–बंधन पॉलीसल्फोन मेम्ब्रेन (β-सीडीएक्सएम) तैयार की गई। इन मेम्ब्रेनों का उनकी फेनिलएलनिन, ट्राइप्टोफान तथा (आर,एस)-2-एमिनो-1-बुटानॉल के प्रति एनान्शियो चयनात्मकता का अध्ययन किया गया।

जल से फिनाइल यूरिया तृणनाशक और फिनॉलिक कीटनाशकों को अलग करने के लिए संघटित आर.ओ. मेम्ब्रेन के उपयोग का मूल्यांकन किया गया। विलेय की अस्वीकृति, विलेय की प्रकृति, टीडीएस तथा पानी के पीएच पर निर्भर थी। विलेय अस्वीकृति विस्तार 90-95% पायी गई। मेम्ब्रेन का दूषित होना तथा प्रवाहित प्रवाह में कमी भी जल के प्रकार पर निर्भर है। प्रदेय पानी में स्थित एकल और द्विसंयोजी आयनों का मेम्ब्रेन के कार्य–प्रदर्शन पर प्रभाव होता है।

इथायलीन ग्लाइकॉल डाइमिथाक्रिलेट, N,N' मेथाइलीन बिस एक्राइलैमाइड एवं डाइवेबाइल बेंजीन जैसे विभिन्न तिर्यकबंध एजेन्टों के साथ अलग–अलग मिथाएक्रेलिक एसिड और एक्रेलिक एसिड के सहबहुलीकरण द्वारा कार्बोक्सीलिक एसिड कार्यात्मक समूहयुक्त दुर्बल एसिड ऋणायन रेज़िन की दो भिन्न श्रृंखलायें तैयार की गईं। रेजिन्स की संरचना की पुष्टि हेतु उनके भौतिक रासायनिक गुणधर्मों का परीक्षण और FTIR, SEM, PXRD तथा DSC जैसे विभिन्न उपकरणों द्वारा विश्लेषण किया गया।

जीवाणुनाशक सिप्रोफ्लोसौसिन के कड़वे स्वाद को आवरित करने के लिए चयनित रेजिन्स के ड्रग रेजिन्स यौगिक (डीआरसी) तैयार किये गये। विभिन्न उपकरणों द्वारा विश्लेषण करके डीआरसी का पैटर्न प्रमाणीकृत किया गया। मानक पद्धतियों तथा नियमों के अनुसार प्राकृतिक (इन विवो) तथा कृत्रिम (इन विट्रो) परिक्षण में डीआरसी के स्वाद आवरण के कार्यप्रदर्शन का परीक्षण किया गया। लार तथा अमाशयी pH पर डीआरसी का तीव्र अवमुक्तन देखा गया। इसके नेटवर्क अनुप्रवेश समस्या को सुलझाने के लिए, कैल्शियम क्लोराइड तिर्यंकबंध एजेन्ट की उपस्थिति में सोडियम आल्जीनेट (AL), चिटोसन (CS) तथा के–केरागीनान का उपयोग करके डीआरसी के बीड्स तैयार किये गए। तैयार किये गए आइपीएन बीड्स का संपूर्ण गुण निर्धारण किया गया और दोनों प्रकार के आयन विनिमय रेजिन्स के लिए दोनों pH अर्थात् लार और अमाशय में, औषधि अवमुक्त होने का समय 10 घण्टे तक बढ़ाया गया।

सामाजिक कार्यों की भागीदारी जैसे आर्सेनिकयुक्त जल में से आर्सेनिक हटाने के लिए सामुदायिक स्तर के आर्सेनिकविहीनीकरण यूनिट्स की डिजाइन तैयार कर उन्हें आर्सेनिक प्रभावी क्षेत्र में स्थापित करना, जल में 10 PPb स्तर तक आर्सेनिक का पता लगाने के लिए आर्सेनिक परीक्षण किट का निर्माण आदि में विभाग ने व्यापक कार्य किया है जिसका वर्णन प्रकरण–7 में किया गया है।

वैद्युत मेम्ब्रेन प्रविधि

विद्युत अपोहन एक व्यापक पृथक्करण प्रक्रिया है जिसमें विद्युत आवेशित मेम्ब्रेन तथा विद्युत विभवान्तर के उपयोग द्वारा जलीय विलयनों तथा अन्य अनावेशित घटकों से आयनिक स्पेशीज़ को अलग किया जाता है। विद्युत अपोहन का खारे जल के विलवणीकरण में व्यापक रुप से उपयोग किया जाता है। बेहतर चयनशीलता, कम विद्युत प्रतिरोध तथा उन्नत उष्मीय, रासायनिक तथा यांत्रिक गुणों युक्त नवीन आयन विनिमय मेम्ब्रेन से प्रेरित होकर हाल में विद्युत अपोहन के अन्य उपयोगों ने खाद्य, औषधि तथा रासायनिक प्रक्रिया उद्योगों के साथ साथ जैवप्रौद्योगिकी तथा अपशिष्ट जलशोधन में विस्तृत रुचि प्राप्त की है। इसके अलावा विसरण, डायलिसिस, डोनैन डायलिसिस, इलेक्ट्रोडायलिटिक जल वियोजन, विद्युत–आयनविहीनीकरण इत्यादि जैसी अन्य निकट संबंधित प्रक्रियाओं में बड़े पैमाने पर इसके संभावित उपयोग हैं।

ये प्रक्रियायें आयन विनिमय मेम्ब्रेनों को मुख्य अवयव के रुप में उपयोग कर रहीं है जो कि अभी तक विकास के प्रारंभिक चरण में हैं परन्तु वे भी तेजी से वाणिज्यिक और तकनीकी प्रासंगिकता प्राप्त कर रही हैं। आयन विनिमय मेम्ब्रेन का ऊर्जा भंडारण या रुपांतरण तंत्रों जैसे बैटरी और ईंधन सेलों तथा क्लोरीन–आल्कलाइन इलेक्ट्रोलिसिस तथा विभिन्न इलेक्ट्रो मेम्ब्रेन प्रक्रियाओं जैसी विद्युत रासायनिक प्रक्रियाओं में बड़े पैमाने पर उपयोग किया जाता है।

पॉलीइथायलीन, स्टाइरीन तथा डीविनाइलबेन्ज़ीन द्वारा उचित बहुलीकरण तथा प्रसंस्करण फिल्म बहिर्वेधी तथा प्रक्रियाकरण के माध्यम से इन्टरपॉलीमर आयन–विनिमय मेम्ब्रेन तैयार की गईं। ये आयन–विनिमय मेम्ब्रेन जल के लिए अभेद्य हैं और विद्युत आवेशित समूहों (सल्फोनिक एसिड तथा अमोनियम चतुर्थ) युक्त होती हैं जो विद्युत विभव के अंतर्गत लवण आयनों को पारित होने की अनुमति देती हैं। खारे जल के विलवणीकरण के अलावा पिछले दस वर्षों के दौरान औद्योगिक तरल पदार्थ प्रसंस्करण के लिए भी विद्युत अपोहन तकनीक का सफलतापूर्वक उपयोग किया गया।

विद्युत–आयनविहीनीकरण, आयन–विनिमय तथा विद्युत अपोहन संयोजित एक महत्वपूर्ण पृथक्करण प्रक्रिया है, परिणाम स्वरुप इस संकर प्रक्रिया में रेज़िन के पुनःउत्पादन की आवश्यकता नहीं होती है। ध्रुवीकरण के सांद्रण के कारण ऊर्जा हानि तथा अपनी उच्च विद्युत प्रतिरोधकता की वजह से तनु विलयनों के शोधन के लिए विद्युत अपोहन एक किफायती प्रक्रिया नहीं है। इस समस्याओं के निराकरण के लिए, विद्युत अपोहन के आयन क्षीण कक्षों में आयन–विनिमय रेज़िन स्थापित किये गये। अब हम प्रक्रिया की डिज़ाइन और दक्षता में सुधार करने के प्रयास कर रहे हैं। हालमें, हमने वर्तमान प्रणाली के साथ 12 LPH तक उत्पादन प्राप्त किया है और आगे, कम ऊर्जा आवश्यकता के साथ 50 LPH उत्पादन क्षमता प्रस्तुत करने जा रहे हैं।

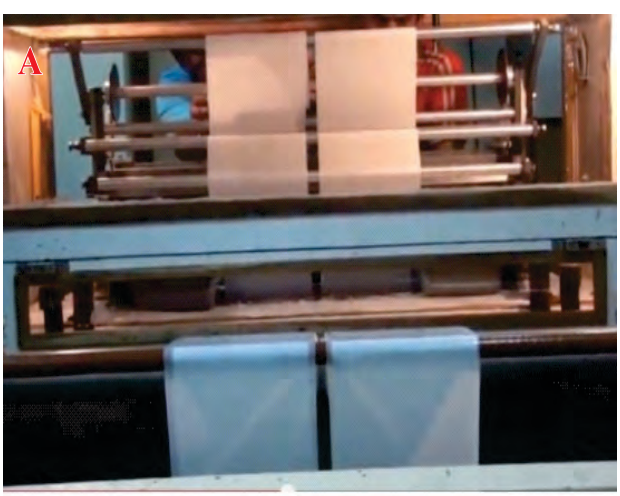
आने वाले वर्षों में, विलवणीकरण, स्वच्छ प्रौद्योगिकी तथा अन्य उभरते विद्युत मेम्ब्रेन उपयोगों पर विशेष ध्यान के कारण आयन–विनिमय मेम्ब्रेनों की मांग बढ़ रही है। आमतौर पर हेलोमेथाइलेशन विशेष रुप से क्लोरोमिथाइलेशन माध्यम से पोस्ट–प्रक्रियाकरण द्वारा तथा उसके तुरंत बाद क्वाटरनाइजेशन द्वारा एनायन विनिमय मेम्ब्रेन बनाई जाती है।

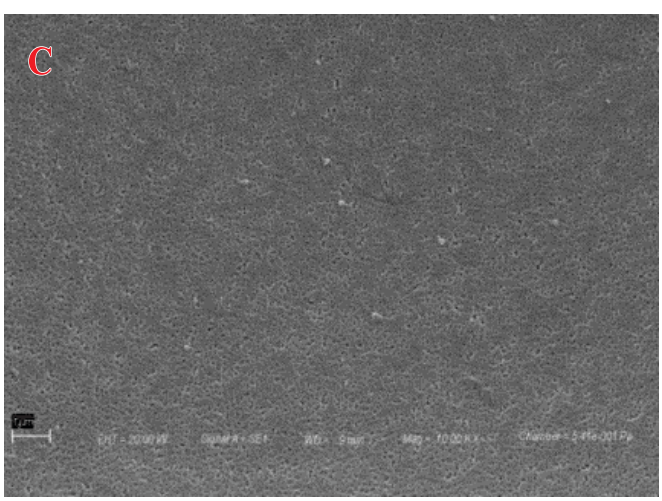
क्लोरोमिथाइलेशन प्रतिक्रिया के लिए पारंपरिक रुप से क्लोरोमिथाइलइथर (CME) का उपयोग किया जाता है। दुर्भाग्य से CME, कैंसर कारक तथा खतरनाक है और इसका उपयोग प्रतिबंधित है। वर्तमान लेख में स्टाइरीन–को–डाइवेनिलबेंजीन (Sty-*co*-DVB) के स्थान पर पी–मिथाइलस्टाइरीन–को–डाइवेनिलबेंजीन (*p*-MS-*co*-DVB) के उपयोग द्वारा इन्टरपॉलीमर एनायन विनिमय मेम्ब्रेन (AEMs) तैयार करने के लिए हरित मार्ग का वर्णन है। बंधक तथा फिल्म के रुप में उपयोग में लिए गये PMS तथा पॉलीइथायलीन को इन्टरपॉलीमर्स में से गलन बहिर्वेधी प्रक्रियाओं द्वारा बनाया गया। फिल्म की कार्यात्मकता बेंजाइलिक मोनो ब्रोमीनेशन तथा बाद में ट्राइमिथाइलेमाइन के साथ चतुष्कन संगठन से प्रभावित थी। इस वैकल्पिक प्रक्रिया द्वारा CME का उपयोग खत्म कर दिया गया। इसने उत्कृष्ट यांत्रिक शक्ति तथा स्थिरता का भी प्रदर्शन किया। विलवणीकरण तथा ऊर्जा के अनुप्रयोगों के लिए कुछ नये धनायन तथा ऋणायन विनिमय मेम्ब्रेनों को भी विकसित किया गया है।

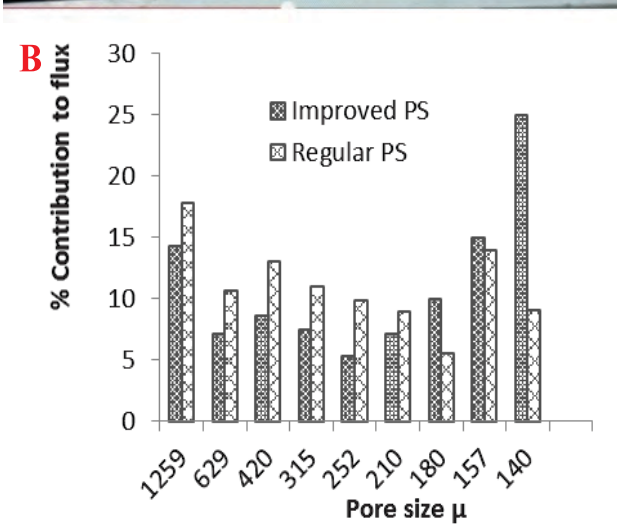
REVERSE OSMOSIS AND ENGINEERING

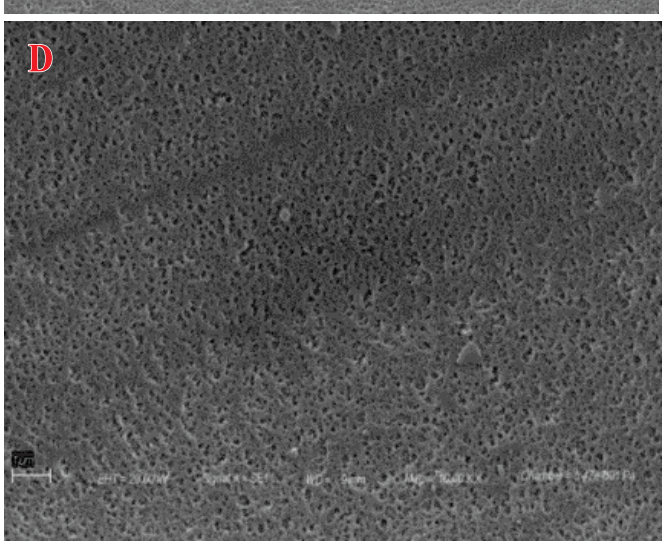
Improvements in large scale preparation of thin-film composite reverse osmosis membrane: preparation and structure-performance relationship

Efforts have been made to improve the quality of polysulfone (PS) support membrane by modifying the casting unit and process parameters like casting speed, polymer solution, contact time before gelation, change in the non-woven fabric, etc (Pic-A). The variation in PS support membrane thickness has been minimized to within ±5 µm at 1m width. The present PS support membrane is highly porous (bar diagram B) and exhibits water flux of 700-800 $Lm^{-2}hr^{-1}$ at 50 psig pressure. The difference in properties could be observed in pore size distribution of support membranes (SEM images). Polyamide thin film was fabricated by the interfacial polymerization between *m*-phenylenediamine and trimesoyl chloride on top of such support membrane. SEM and AFM studies revealed very uniform polyamide thin film structure of the TFC reverse osmosis (RO) membrane with usual ridge-valley structure. The domestic modules (2" dia x 12" length, 0.4 m^2 active area) made from these TFC membranes produced water flux of about 10 LPH with salt rejection of about 93-94% when tested at 75 psig with 1000 ppm sodium chloride feed solution.

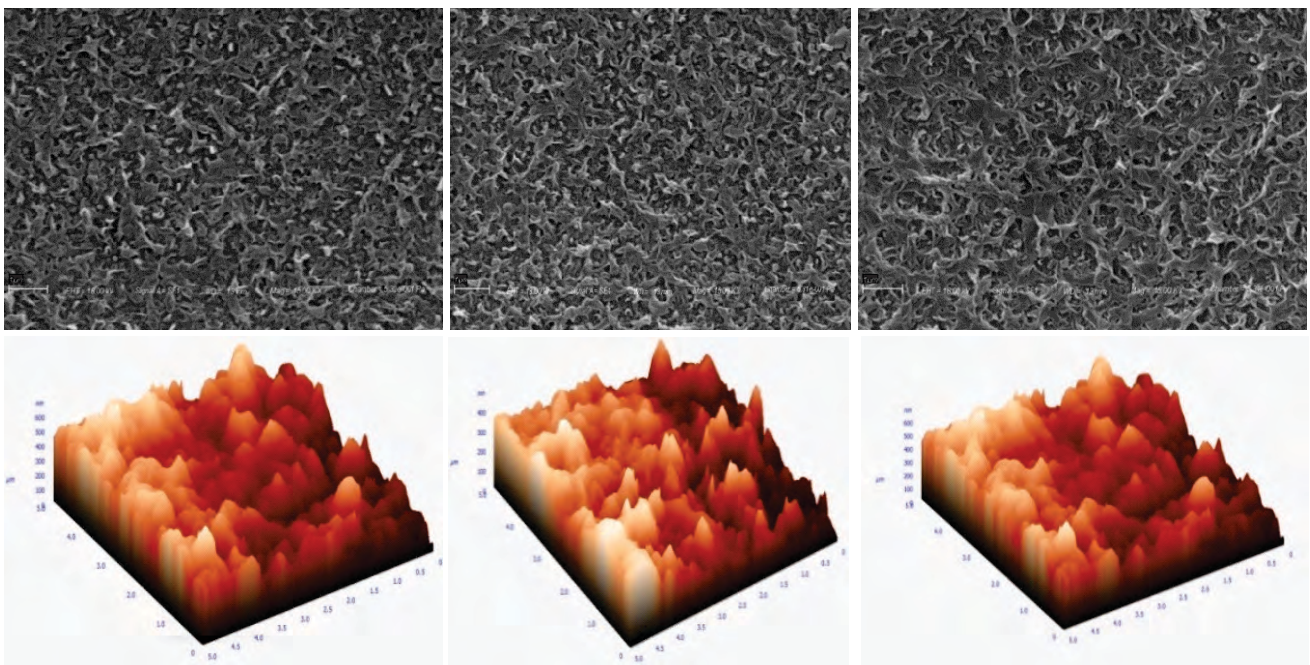








(A) Picture of membrane casting displaying parallel casting process under same conditions using two different fabrics, (B) Contribution of pore size distribution towards pure water flux of the support PS membranes at 50 psig applied pressure. (C) and (D): SEM images of PS supports made on two different types of fabrics.

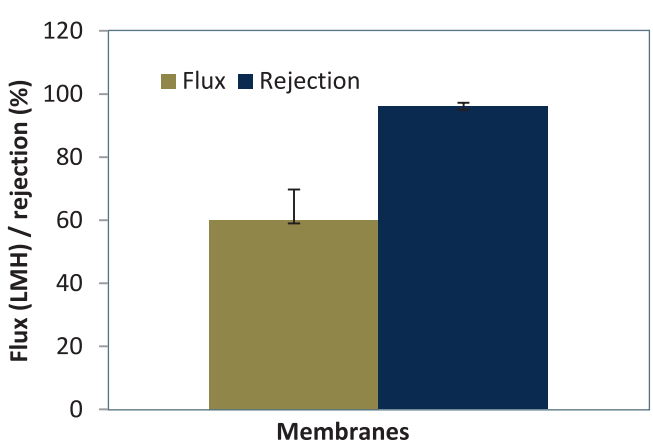


Representative SEM (top) and AFM (bottom) images of three different batches of TFC membranes showing similar surface morphology.

Following table summarizes the surface roughness, contact angle, characteristic IR band ratio (Amide-I/PS) of four different batches of TFC membranes prepared under similar experimental conditions and figure below presents the average performance of 15 batches of TFC membranes made at 1m width × 100 m length for brackish water desalination.

Characteristic properties of TFC membranes

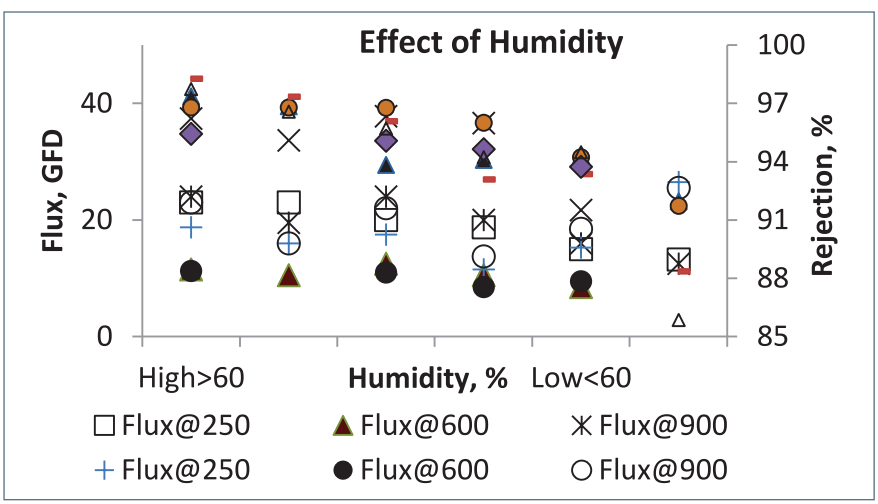
TFC Membrane Batch No.	Contact Angle (average, degree)	Avg. Roughness (nm)	I_{1660}/I_{1585}
NM-324	61 ± 2	120	0.95 (±0.02)
NM-325	63 ± 3	110	0.94 (±0.6)
NM-327	61 ± 3	136	1.10 (±0.10)
NM-328	64 ± 2	127	0.98 (±0.8)



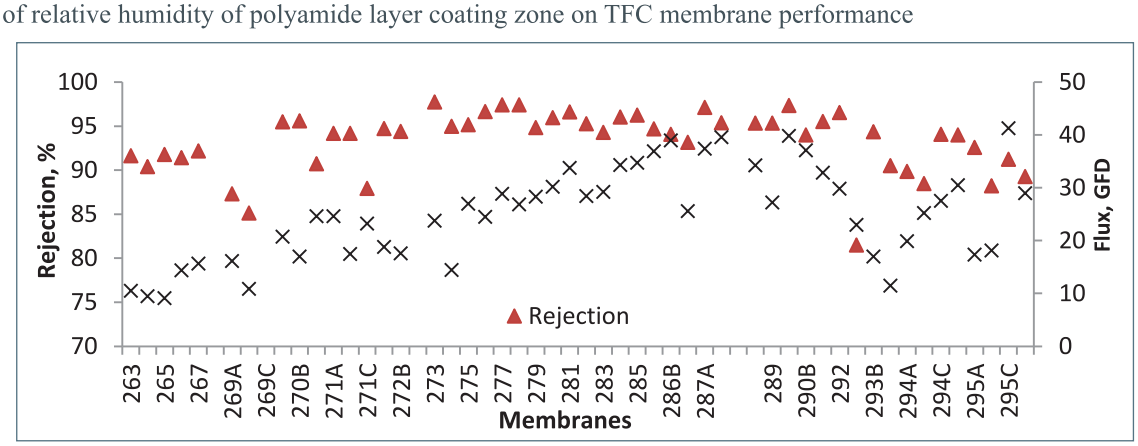
Average performances of 15 batches of membrane under brackish water desalination condition (@ 250 psig, 2000 ppm sodium chloride solution).

Effect of preparation conditions (1 m × 100 m) of polyamide layer on the performance of TFC membranes

It was observed that the relative humidity in the polyamide layer coating zone has a great effect on membrane performance for both water flux as well as salt rejection and TFC membranes with 55-65 LMH water flux and 95-97% salt rejection could be achieved under some optimised conditions as shown below.



Effect of relative humidity of polyamide layer coating zone on TFC membrane performance



Performance of TFC membranes prepared under optimised conditions

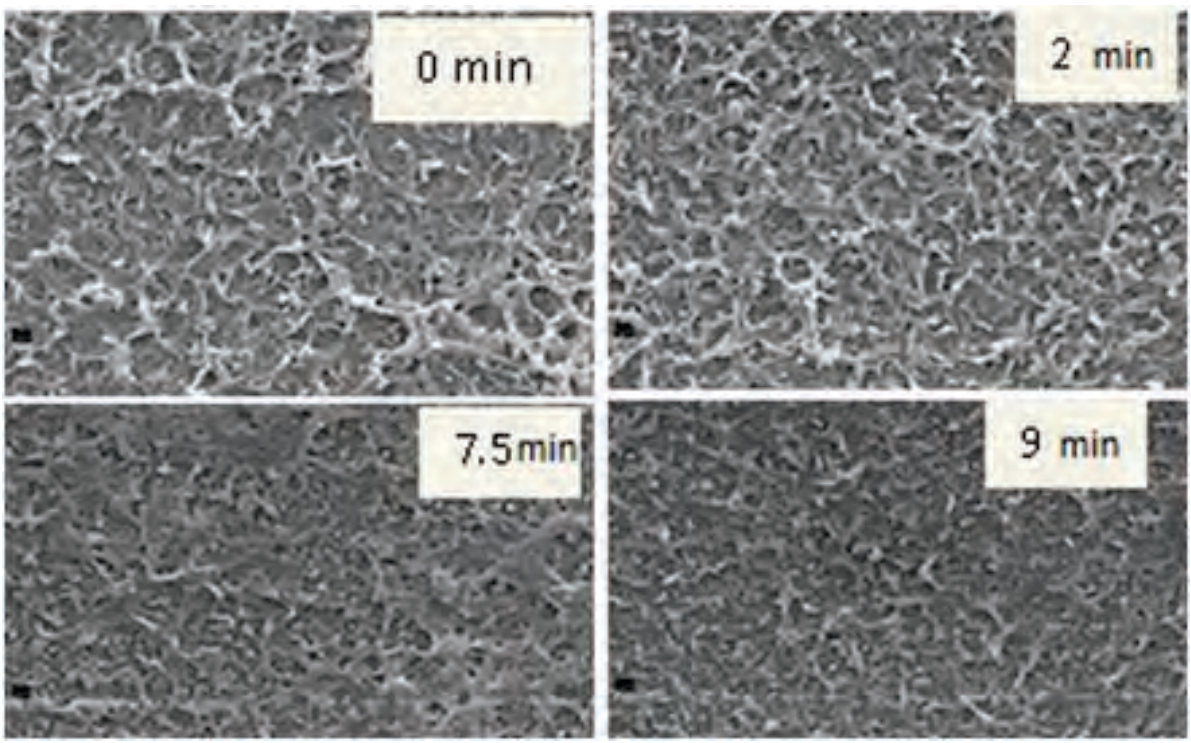
Spiral modules (4040 size) made from these TFC membranes exhibited salt rejection of about 97% with water flux of about 4.4 L/min when tested at the operating pressure of 250 psi for feed water containing about 5200 ppm NaCl. The representative examples are given in the following table. The data strongly supports that the membranes can be applied for the desalination of highly saline waters to obtain drinking water.

4040 TFC module performance for desalination of saline water at 250 psi

TFC Module no.	Product rate L/min	Feed (NaCl), ppm	Product, ppm	%SR
166	4.4	5124	133	97.40
167	4.4	5434	129	97.62
168	4.4	5276	234	95.56
169	3.6	5296	225	95.75

Effect of post-treatment of TFC membrane on structure and performance

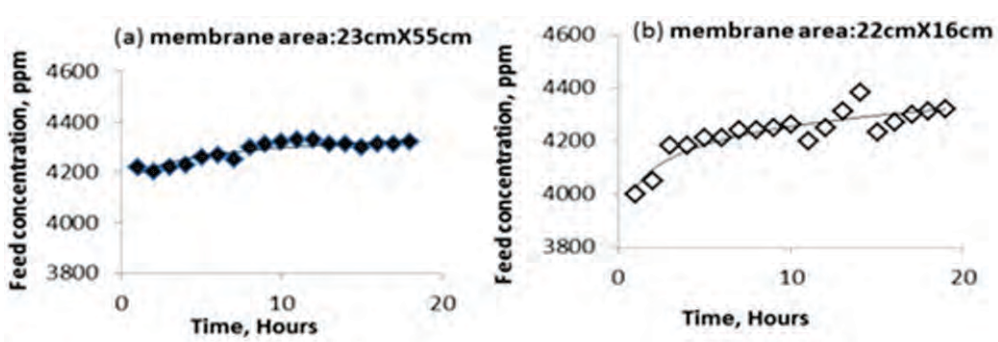
So far, there has been no detailed report on the effect of post treatment on membrane performance and membrane physical characteristics. The initial results indicated a slight decrease in salt rejection and permeate flux with the increase in time gap between membrane preparation and post treatment. A large difference in the post treated membranes morphology by SEM was noticed with variation in time gap (below). From highly rough surface to somewhat smoother surface was noticed with delay time. It may be concluded that immediate post treatment of TFC membrane is beneficial for enhancement of performance of the membrane.



Effect of time gap between film curing and post-treatment on membrane morphology

Use of polyamide TFC membranes prepared under improved conditions for RO and forwardosmosis for water recovery

The combined leather or textile effluent is generally treated with RO in different stages to obtain up to 80% reusable water. In order to decrease the multistage RO energy consumption, it has been envisaged that membrane based integrated processes may be the best solution. In this regard, treatment of the diluted leather effluent was carried out in forward osmosis (FO) set-up using different TFC membranes prepared in the department. NaCl solution of about 30000 ppm was used as draw solution. The FO performance of regular TFC membrane and modified TFC membrane is compared in the following figure.



Concentration of leather effluent by TFC membranes in FO arrangement: (a) regular TFC (b) modified TFC.

Though, it appears that both the membranes performed similar it is important to note that the modified TFC membrane area is only 27.83% that of regular TFC membrane. Within a limited period of filtration, in both the cases feed concentration increased initially fast and then attained a slow and steady rate. Further, the effluent was also treated with low pressure RO membranes and was found to able to recover colourless water for further processing. Further experiments are in progress.

Surface modification for the enhancement of antifouling property of TFC RO membranes for brackish/sea water desalination

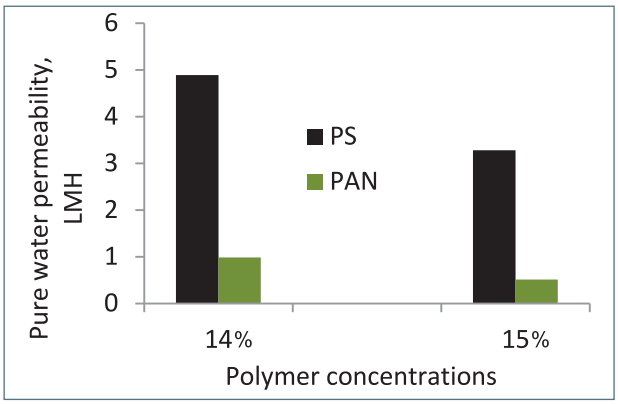
With a view to impart higher surface charge and hydrophilicity for improvement of fouling resistance behaviour of the membranes, it was planned to fabricate an ultrathin layer of polymethacrylate over the top of the polyamide layer. Before subjecting the membranes for surface modification, the TFC membrane was treated with different primary solutions under different conditions. It was observed that under certain conditions, the water flux was increased from about 30 gfd to 35 gfd (by about 17% increase) while the salt rejection remained almost unaffected (95.86 – 96.51%), as shown in table. The increase in water flux may be due to the combined effects such as the removal of un-reacted diamine solution from the TFC layer, slight decomposition of polyamide active layer leading to the reduced thickness and formation of hydrophilic carboxylic acid functional group all of which are likely to cause some changes in the polyamide layer morphology. Experiments are underway for elucidating the reasons for these changes.

Treatment no	Flux (GFD	Rejection, %
T 0 (Unmodified)	29.5	96.51
T 1	22.5	95.87
T 2	34.0	95.86
T 3	26.0	96.91
T 4	14.7	96.57
T 5	19.8	96.41
T 6	19.0	95.82
T 7	24.0	96.36
T 8	30.5	95.68
T 9	35.0	95.86

Effect of treatment on TFC membranes performance (Feed: 2000 ppm NaCl solution; Pressure: 250 psi).

Development of RO membrane using PAN as the support for TFC membrane

Polyacrylonitrile (PAN) membrane was considered as substitute for PS as TFC support. PAN membranes were prepared from cast solution of different concentrations (10-15%) occasionally mixed with polyvinylpyrrolidone. Performance of PAN and PS membranes as TFC support are compared and depicted below.



Comparison of the productivity of membranes prepared from PS and Polyacrylonitrile

PS membranes prepared from 14 and15% polymer concentration displayed much better water permeability at 75 psi pressure compared to PAN membranes. It has also been observed that PS membranes prepared using NTS as fabric support showed promising results. Furthermore, modification in polymer fabric contact time in the casting zone before entering gelation bath resulted in improved membrane anchoring properties. Few observations are summarized in following table. Further experiments are in progress to improve the flux and consistency.

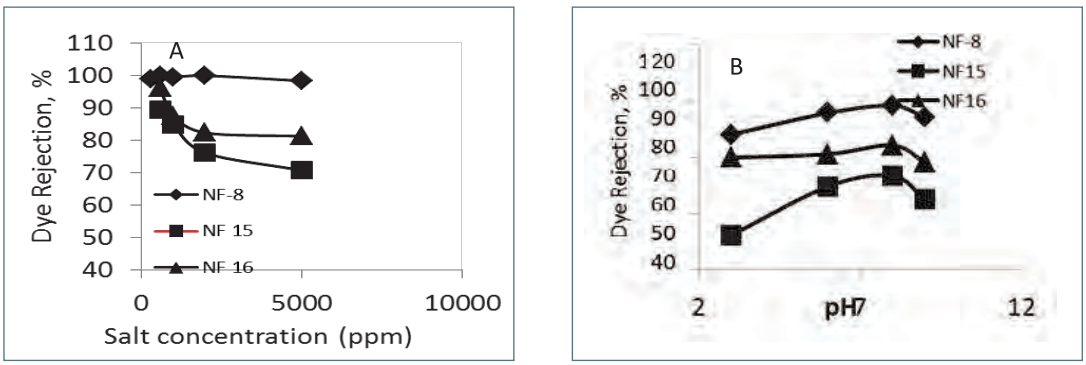
Membrane	Pure water flux, ($LM^{-2}h^{-1}$)	Salt Water Flux, ($LM^{-2}h^{-1}$)	Salt rejection (%)
1	20	17	93
2	15	14	94
3	17	15	91

Performance study of different TFC membranes for domestic desalination application. Experiment conditions: Flux measured at 75 psi pressure, 1000 ppm NaCl solution.

Preparation and testing of nanofiltration membranes for the treatment of dye solutions

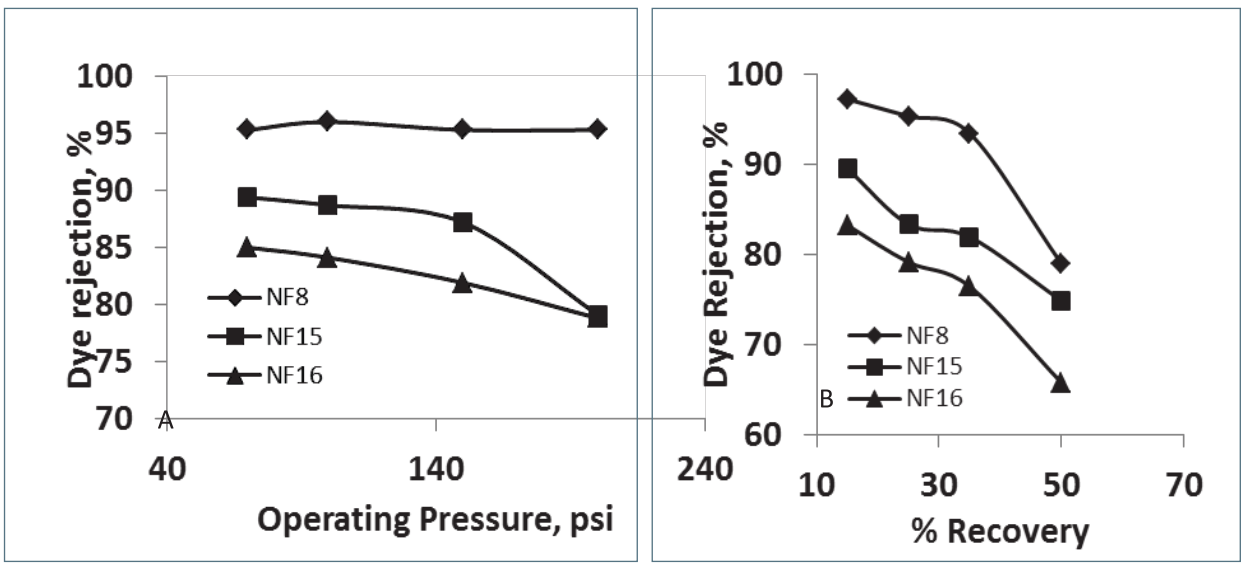
Spiral modules of 4"×14" and 2"×10" were made from poly(piperazine-trimesamide)-based NF membranes. The membrane flux was varied from 32–73 $LM^{-2}h^{-1}$ with $MgSO_4$ rejection of 70-98% depending on preparation conditions. Three different NF modules namely NF8, NF15 and NF16 varying in their rejection and flux profile have been selected for further studies for the treatment of dye solutions. Among the three membranes NF8 membrane exhibited highest negative surface potential with $MgSO_4$ rejection 98% and showed rejection ratio of 4.1 between divalent and monovalent anions.

Following figures showed the dye rejection ability of modules with variation of salt concentration and pH of the feed solutions (containing dye) respectively. Among the three selected modules, NF8 exhibited highest dye rejection at wide range of pressure and at a recovery of 50%.



Effect of variation of (A) salt concentration and (B) pH on the dye rejection for different NF membrane modules.

The performance of these membrane modules were also tested in the separation of dyes at different operating pressures.



Effects of the variation of (A) operating pressure and (B) %recovery on the reactive Black 5 dye rejection for different membrane modules.

Concentration of tea polyphenols and the post-effects (i.e. fouling) of membranes

The possibility of separation of polymeric carbohydrate by the ultrafiltration membranes has been studied. We have experimented the fouling of ultrafiltration hollow fibres and flat sheet membranes during tea extract filtration under different conditions. Initial results suggest that the polyphenol components are not separated by the ultrafiltration membranes used for this study. The performances of different hollow fibre modules during tea-extract filtrationsare summarized in the following table. The flux recovery ratio (FRR %) results show that the fouling phenomenon is occurred in the system. After washing with citric acid, the FRR did not improve much whereas with NaOCl showed better effect.

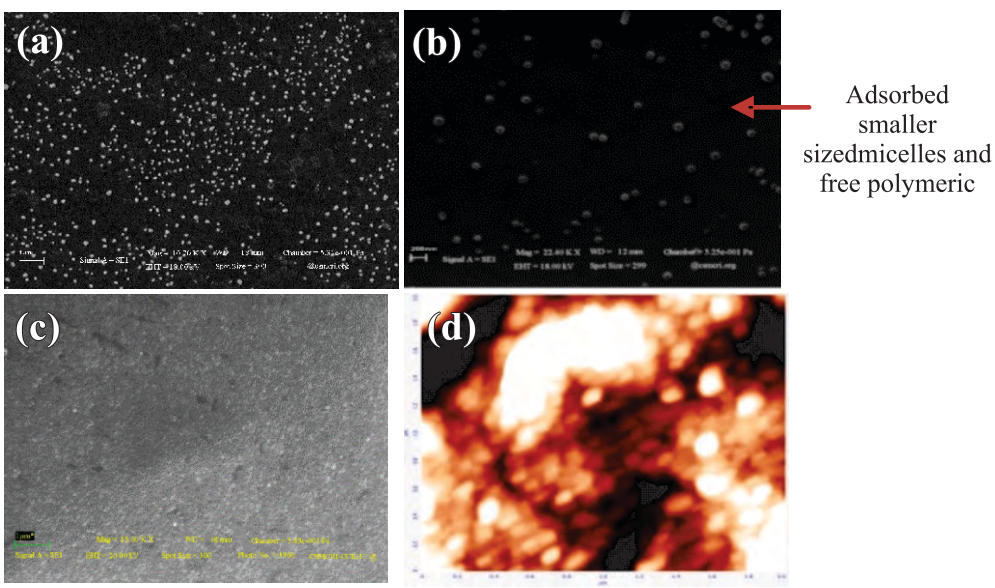
Summary of water flux (ml/min), flux during tea extract filtration and FRR (%).

Sr. N.	Modules No.	Pure water flux (Avg.) (ml/min)	Flux during Tea extract filtration (Avg.) (ml/min)	FRR (%) (after water washing)	FRR (%) (after washing with 2 wt% citric acid solution)	FRR (%) (after washing with 1 wt% NaOCl solution)
1	L-3	44	9	45	52	-
2	HF-61	67	11	22	26	40
3	Flat sheet	175	12	31	33	40

The main reason of ultrafiltration of tea extract is for the removal of polymeric impurities such as carbohydrate and undissolved particles if any. The filtration experiment showed that the flux during filtration of tea extract substantially decreases.

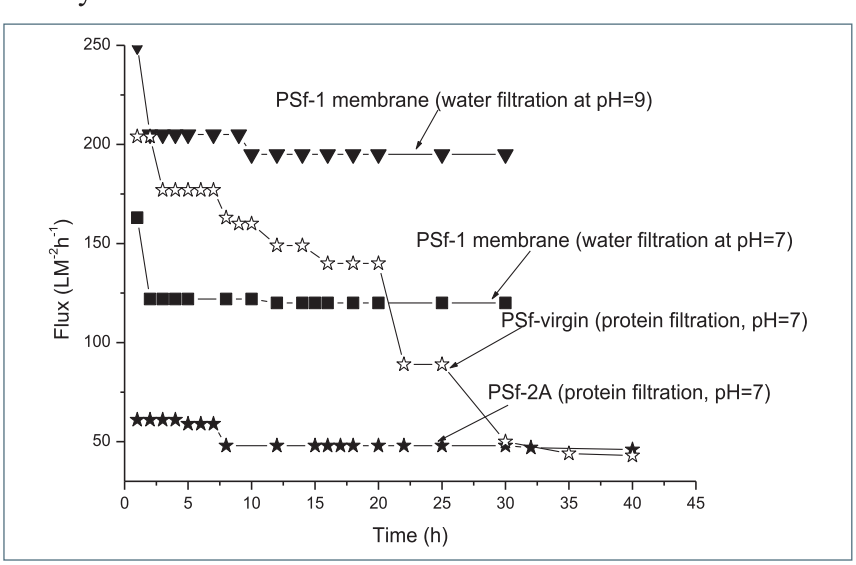
Surface modification of ultrafiltration membranes by block copolymer micelles and gels

Water insoluble PDMA-PMMA-PDMA-1 of molecular weight 26000 g/mol, containing 38 wt% PDMA, and water soluble (dispersible) PDMA-PMMA-PDMA-2 of molecular weight 28000 g/mol, containing 79 wt% of PDMA were synthesized. Figures shown below are the SEM and AFM images of ultrafiltration membranes modified by the copolymer micelles and gels. The block copolymer micelles and gel modified membranes showed superior antifouling properties than that of virgin membrane during ultrafiltration of protein (BSA). The rejection of BSA by the modified membranes varies from 92 to 97% compared to 66% protein rejections for the virgin membranes.



SEM images: (a) gel modified membrane (PSf-2A), (b) micelles modified membrane (PS-1) and (c) PS-virgin. (d) AFM image of PS-1.

Following figure shows the flux vs. time plots for modified PSf-1 and PSf-2A membranes during water and protein ultrafiltration. It is apparent that for long-term water and protein filtration ca. for ~30-40 h the performance of modified membrane remained almost steady after initial decline. In contrast, the flux of PS-virgin gradually decreased with filtration time. Besides filtration operation, the long-term stability of the deposited micelles and gel particles was also confirmed by IR spectra.



Flux vs. time plots during water and protein filtrations. The modified membranes were submerged in water at room temperature for 45 days and then used for filtration experiments.

In situ preparation of novel antifouling thin film composite membranes

Anti-biofouling RO membrane

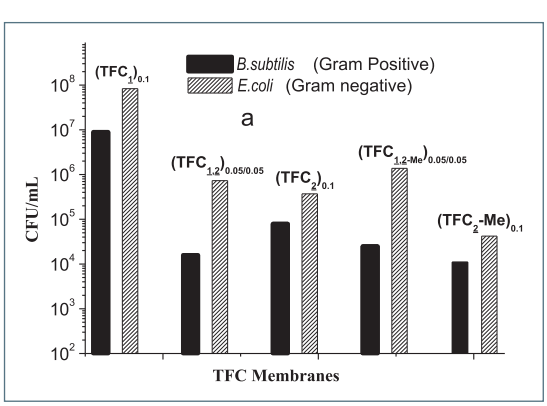
Novel TFC membranes with enhanced antifouling property were prepared by reacting *m*-phenylene diamine (MPD) and mixture of 2,4,6-pyridinetricarboxylic acid chloride (PTC) and trimesoyl chloride (TMC). The best results were obtained with 2:3-1:1 molar ratio of PTC to TMC, in as much as the flux was also enhanced and the salt rejection efficiency remained almost unaffected. The performances of different TFC membranes were evaluated. The data in table reveals that the $(TFC_2)_{0.1}$ membrane prepared with PTC alone exhibited poorer flux and rejection efficiency compared to conventional TFC membrane prepared with TMC [$(TFC_1)_{0.1}$]. We ascribe this to the non-uniformity of the membrane as observed by SEM (Figure not shown). On the other hand, when PTC was taken in combination with TMC in the weight ratio of 3:2 to 1:1 of TMC: PTC, [membranes $(TFC_{1,2})_{0.06/0.04}$ and $(TFC_{1,2})_{0.05/0.05}$] the results were nearly at par with that of (TFC1)0.1 (prepared with MPD and TMC) in so far as rejection efficiency was concerned, and superior to (TFC1)0.1 from the perspective of membrane flux.

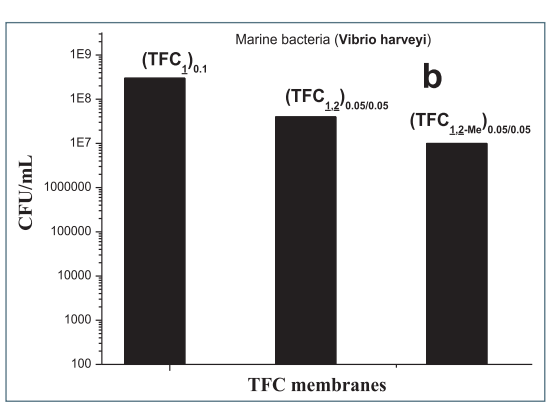
Flux and rejection efficiency of different TFC membranes measured during water desalination (2000 ppm NaCl) at pressure 200 psi.

Sl. Nos	Membrane designation	Flux ($LM^{-2}h^{-1}$)[b]	Rejection[b] (%)
1	$(TFC_1)_{0.1}$	42.5 (±3.2)	94 (±2)
3	$(TFC_{1,2})_{0.06/0.04}$	52.7 (±7)	93 (±1.5)
4	$(TFC_{1,2})_{0.05/0.05}$	48 (±3)	92 (±1.4)
5	$(TFC_{1,2})_{0.03/0.07}$	37.4 (±2)	81 (±2)
6	$(TFC_2)_{0.1}$	36 (±4)	73 (±3.5)
7	$(TFC_{2\text{-Me}})_{0.1}$	32 (±5)	74 (±3)

Bacterial resistance or antibacterial activity of various TFC membranes and correlation with surface charge and roughness

As can be seen from the figure (a), all PTC containing membranes showed superior antimicrobial activity towards both Gram Negative and Gram Positive bacteria compared to the $(TFC_1)_{0.1}$ control, with 102-104 times greater activity when tested with normal broth culture solutions. The bacterial attachment results specifically followed the order, (TFC2-Me) 0.1<(TFC2)0.1<(TFC1,2)0.05/0.05<(TFC1)0.1. We further extended the study to actual seawater with the representative marine bacteria, *Vibrio harveyi* (Fig. b). The membranes containing PTC once again exhibited superior activity.



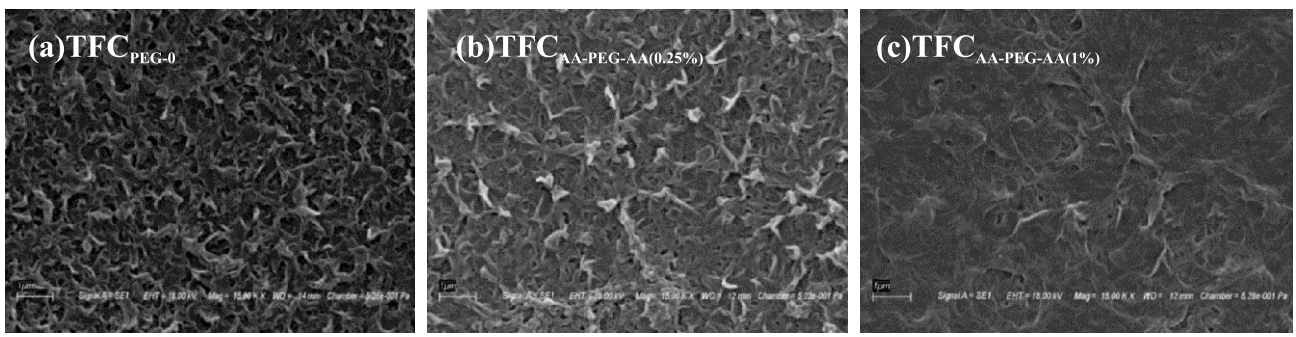


Quantification of bacterial attachment on the surface of various membranes by submerging the membranes in (a) normal broth culture solution containing *B.subtilis* and *E.coli* and (b) natural sea water solution (30000 ppm salinity) containing the Gram negative marine bacteria *Vibrio harveyi*.

Hydrophilization of TFC reverses osmosis membranes by PEGylation approach

A process for *in situ* hydrophilization of TFC RO membranes by covalent attachment of polyethylene glycol was developed. The approach was based on use of end-functionalized polyethylene glycol (MPD-PEG-MPD or MeO-PEG-MPD) with end group's structure resembling the structure of MPD, commonly used for preparation of TFC membrane.

Surface SEM image of TFC_{PEG-0} (prepared with MPD and TMC) membrane exhibited typical surface morphology with uniform "network-like" structure (image a). In contrast, the PEGylated membranes exhibited significant different surface morphologies (images b and c).



SEM images of TFC membranes showing surface morphology. Images: (a) TFC-0 prepared by MPD and TMC, (b) $TFC_{AA-PEG-AA(0.25\%)}$, prepared by addition of 0.25% (w/w) AA-PEG-AA to the MPD solution and (c) $TFC_{AA-PEG-AA(1\%)}$, prepared byaddition of 0.5% of (w/w) AA-PEG-AA to the MPD solution.

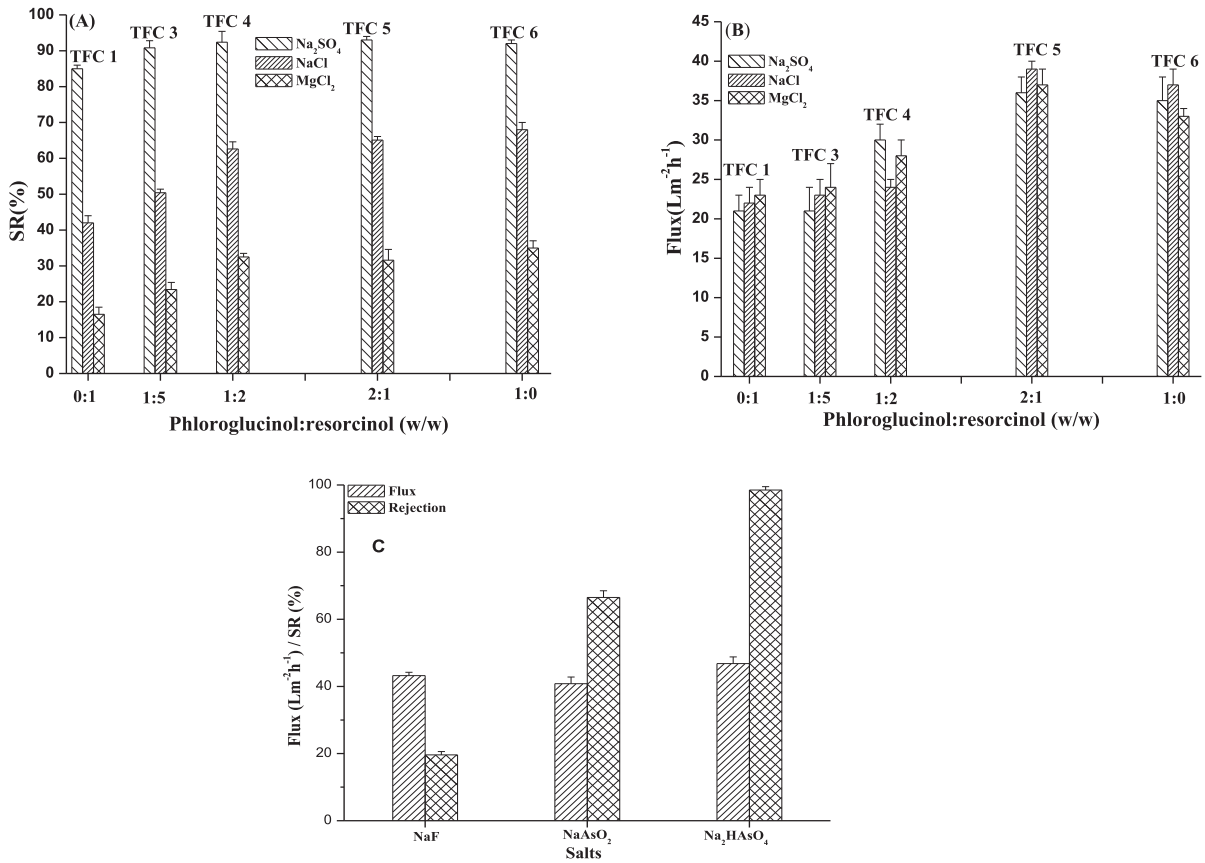
Table (below) summarizes the antifouling properties of various TFC membranes in terms of flux reduction ratio (FR), FRR and NaCl rejection efficiency after 20 h of filtration operation. As tabulated, the PEGylated membranes exhibited improved antifouling property compared to non-PEGyylated membrane. The performance of PEGylated membranes is also comparable to that of conventional non-PEGylated TFC membrane prepared under similar conditions.

Summary of antifouling properties of different TFC membranes after filtration of water (containing 2000 ppm NaCl and 300 ppm BSA) for 20 h.

Membrane	FR (%)	FRR (%)	NaCl Rejection (%)	
			before	after 20h
TFC_{PEG-0}	43±3	71	97±1	97±1
$TFC_{AA-PEG-AA(0.25\%)}$	13±2	95	94±1	95±1
$TFC_{AA-PE-AA(0.5\%)}$	15±3	94	97±1	96±1
$TFC_{MeO-PEG-AA(0.5\%)}$	16±3	91	95±1	95±0.5
$TFC_{MeO-PEG-AA(1\%)}$	17±2	95	93±1	94±1

Preparation of fully aromatic polyester-based thin film composite nanofiltration membranes for water softening

New phenol based monomers were used for the interfacial polymerization (IP) along with widely used TMC for the preparation of fully aromatic polyester-based TFC NF membranes on the porous PS support. Membranes (TFC-3 to TFC 5) prepared with mixture of phloroglucinol and resorcinol or fluoroglucinol (TFC 6) exhibited higher salt rejection efficiency compared to membrane prepared with resorcinol (TFC 1). Figures (A) and (B) provide comparative data of SR and permeate flux, respectively, of 1500 ppm NaCl, $MgCl_2$ and Na_2SO_4 recorded for TFC 1, TFC 3, TFC 4, TFC 5 and TFC 6 PE membranes. The NaF, $NaAsO_2$ and Na_2HAsO_4 rejections efficiency of a representative TFC 6 and corresponding permeate fluxes are also provided in figure(C).

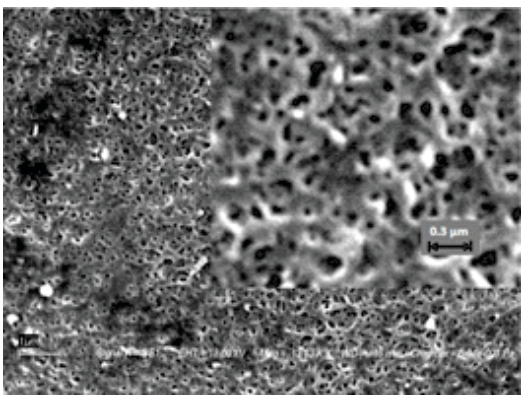


SR data (bar diagram A) and fluxes (bar diagram B) of the membranes (Operating pressure 0.52 MPa, feed solution concentration 1500 ppm and pH~7). Bar diagram (C) diagrams showing rejection and flux data of TFC 6 for experiments conducted with aqueous feed solutions of NaF, $NaAsO_2$ and Na_2HAsO_4 (Feed concentration: ~5 ppm; pH~7; operating pressure: 0.52 MPa; feed solution temperature: 27 ^{0}C).

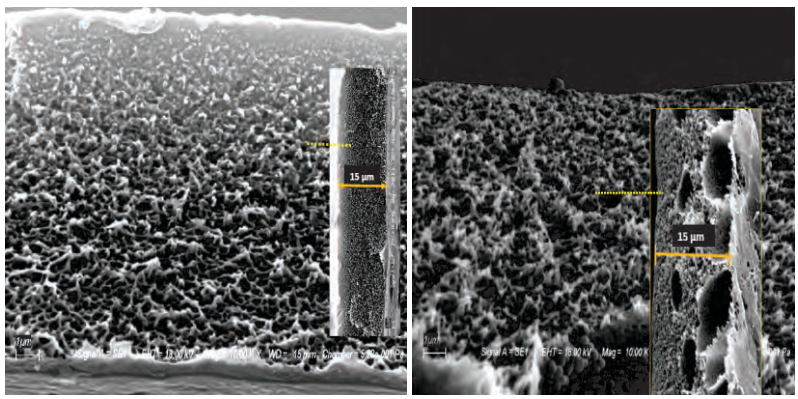
Preparation of membrane supports for development of functional polymeric membranes

Generally, porous membranes supports are asymmetric in nature and are prepared according to phase inversion technique. Both the thermodynamic and the kinetic factors control the phase inversion process. Temperature and composition of the casting solution and non-solvent bath, substrate fabric wetting, gate height of the casting blade etc., have great influence on membrane morphology and are crucial for development of membranes with improved properties.

PS support membranes (0.3 m x 30 m sizes)having the pore size of 0.1-0.2 µm were prepared according to the usual phase inversion process using a semi-automated membrane casting unit. Two types of thin porous supports of about 15 µm thickness differing in the nature of pore asymmetry were casted on a non-woven polyester fabric to achieve maximum permeability while providing sufficient mechanical strength since the permeability is inversely proportional to the barrier layer thickness. Figure given below shows the cross-sectional SEM images of the two supports. The SEM images were taken on the sample that was removed from the polyester fabric. As shown in the figure, the difference between the support is in terms of pore asymmetry. In one case, there are smaller pores in the top and larger pores underneath which also consist of very large macrovoids while in the other case there is gradient pores – small pores at the top and larger pores at the bottom without any large macrovoids.



Surface SEM image of a porous polysulfone support of pore size ~0.1-0.2 µm

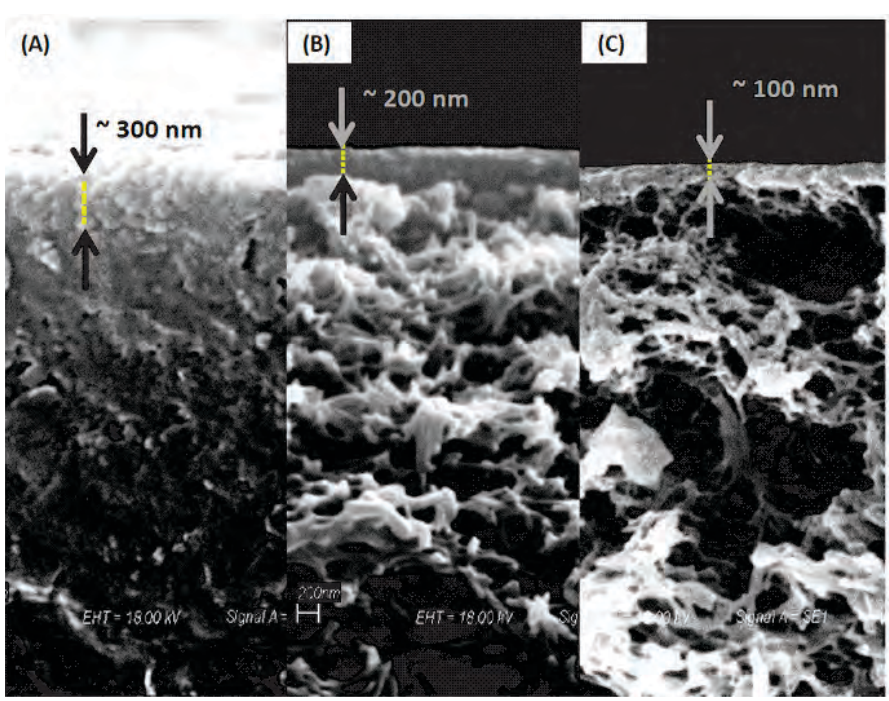


Two types the asymmetric porous supports of 15 µm thickness. Gradient pores without macrovoids (left image) and with macrovoids (right image).

SEM images of membranes

Low pressure high-flux membranes for hardness removal and water purification

A systematic study was carried out to explore limiting thickness of the state-of-art nanofiltration membrane. The interfacial polymerization between aqueous solution of piperazine and organic solution of trimesoyl chloride over PS ultrafiltration supports of average pore size 20, 100 and 200 nm, respectively had been performed to vary the membrane thickness and properties. The prepared membranes were designated as TFC-12, TFC-15 and TFC-24, respectively. Influence of the supports on membrane thickness, surface roughness and zeta potential was observed by SEM, AFM, ATR-IR and zeta-potential measurements. The membrane thickness and surface roughness were found in increasing order of TFC-12 < TFC-15 < TFC-24. When tested for desalination of brackish water of 2000 ppm NaCl or 1000 ppm $MgSO_4$ at 150 psig, TFC-24 exhibited the highest salt rejection efficiency but the least flux of 26 $l \cdot m^{-2} \cdot h^{-1}$ while the flux was enhanced to about 94 $l \cdot m^{-2} \cdot h^{-1}$ but with lower salt rejection for TFC-12 which was in agreement with the differences in membrane thickness and roughness. The results indicated a trade-off performance relationship for the nanofiltration membranes that the membranes of high-flux with moderate selectivity or high-selectivity with moderate flux could be prepared by varying supports from a same preparation condition.



Cross-section SEM images of the TFC membranes, TFC-24 (A), TFC-15 (B) and TFC-12 (C)

The cross-section SEM images of the membranes are shown in above figure. The TFC-NF24, TFC-NF15 and TFC-NF12 membranes had polyamide layer thickness of about 300, 200 and 100 nm, respectively over the PS supports. The observed differences in polyamide surface microstructure morphology and thickness among the TFC types from the same preparation condition indicated that the PS support of different pore size influenced on polyamide formation of piperazine–trimesoyl chloride interfacial polymerization.

Membrane treatment of highly saline water

Highly porous PVDF membranes were prepared by phase inversion method from the solutions of different concentrations at identical conditions of casting such as temperature, relative humidity and air drying time before immersion in non-solvent using motorized machine to study the microstructures formed in the resulting membrane and correlate membrane morphology to membrane performance in membrane distillation process. The PVDF flat-sheet membranes of average pore size over 1 µm were prepared from casting solution having varied polymer content (16, 18, 20, and 22 % w/w) over polyester non-woven fabric support. The membranes were extensively characterized for porosity, hydrophobicity and surface topography. Morphology study indicated an anisotropic nature of the membranes resulting from phase inversion occurred through liquid-liquid demixing process. The membrane prepared from casting solution of low polymer content is highly porous compared to those prepared from solution of higher polymer content. The membranes demonstrated potential for desalination of 30,000 to 100,000 ppm synthetic seawater through membrane distillation. The membranes exhibited 99.0+%salt rejection efficiency and varied water flux ranging from 2 to 12 liter·meter^{-2}·hour^{-1} (LMH) depending on the membrane pores structures, feed concentration and processing parameters. All the membranes exhibited practically uniform performance in all feed concentration ranges which indicated that there is no adverse effect of increased salinity in the feed on the performance of the membrane. The study concludes that membrane distillation is a suitable and promising process for desalination of highly saline water such as seawater.

The porosity analysis of the membrane samples using SEM, TEM and AFM techniques clearly indicated a microporous membrane morphology, however all the pores observed in surfaces may not be active pores, some pores may be dead-end pores in which flow do not take place. Membrane effective porosity refers to the volume fraction of the connected voids to the total sample volume and may be given by following equation:

$$\varepsilon = \frac{V^{cp}}{V^{v}}$$

Here ε is membrane effective porosity; V^{cp} and V^{v} are volume of through pores and total sample volume.

The porosity analysis of the membrane as determined on capillary flow porometer using capwin software has been given below. It is seen from the table that the porosity of the membrane decreases with the increase of polymer content in casting solution. Further, the membrane prepared from the solution containing less amount of polymer (16-18 wt. % polymer solution) contained small pores with majority of pores of about 1 µm size as compared to those prepared from solution contained more amount of polymer (20-22 wt. % polymer solution) which exhibited relatively wider pore size distribution. This indicates that polymer content in membrane casting solution strongly influences the porosity of the membrane.

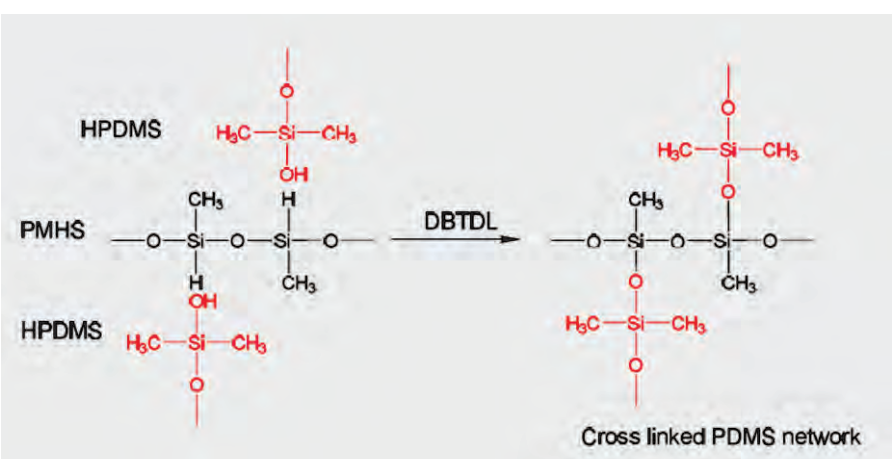
Porosity analysis of the membranes

Membrane [a]	A(16)	B(18)	C(20)	D(22)
Smallest pore diameter (µm)	1.512	1.213	1.13	1.076
Mean flow pore diameter (µm)	1.941	1.654	1.582	1.502
Bubble point diameter (µm)	2.312	2.124	2.092	2.001
% Distribution of max. pore flow	83.34	76.54	72.34	71.03
Diameter at max. pore flow (µm)	1.672	1.452	1.321	1.256
Pore count (numbers per m^2)	$12.93x10^{13}$	$33.18x10^{12}$	$15.23x10^{12}$	$28.56x10^{11}$

[a] numerical values in parenthesis is solution concentration used for making the membrane

Preparation of hydrophobic poly(dimethylsiloxane)-PS composite membranes for potential application in aqueous-organic separations

Among major applications of pervaporation membrane processes, organic separation from aqueous effluent is becoming increasingly important. For such organic permselective separation, membrane with organophillic nature is required. One such organophillic membrane material is polydimethylsiloxane (PDMS) which has an alternating –O–Si–O– unit structure and has very good stability in operation. Various types of PDMS membranes were used for the removal of volatile organic compounds (VOCs) pollutants from water, recovery of organics from aqueous streams and separation of organics from alcohol. Depending on the preparation conditions, PDMS membranes of different structures were formed. As shown in the following scheme, the cross-linking reaction for neat PDMS membrane in presence of catalyst was done by condensation reaction of terminal hydroxyl group (Si-OH) of HPDMS and the Si-H groups of PMHS liberating hydrogen.

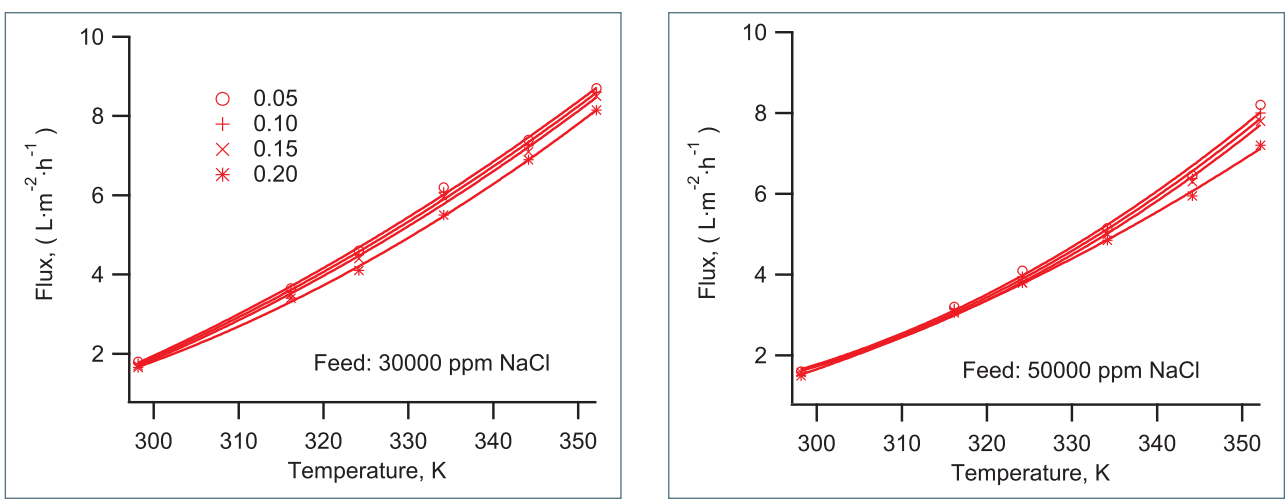


Scheme. Preparation of cross-linked PDMS-based membrane

A high-performance composite membrane comprised of cross-linked poly(dimethylsiloxane) membrane layer coated on polysulfone porous support in which the thickness of the poly(dimethylsiloxane) layer can be varied by controlled cross-linking *via* sequential sorption-reaction-evaporation, was achieved. In the preparation procedure, a desired quantity of base polymer HPDMS along with the cross-linker PMHS and catalyst dibutyltindilaurate were absorbed in the pores of the support by absorbing a required *n*-heptane solution concentration of the above reactants and catalyst. The immersion of the support in the initial *n*-heptane solution of the reactants along with the catalyst of a desired concentration for an equilibrium sorption uptake resulted in filling of the support pores with the reactants which subsequently undertook cross-linking reaction in the solvent within the pores of the support. Upon evaporation of the solvent from the surface, a lamination of dense PDMS film over the surface of porous support was resulted.

Test of hollow fiber polymer composite membranes for desalination applications

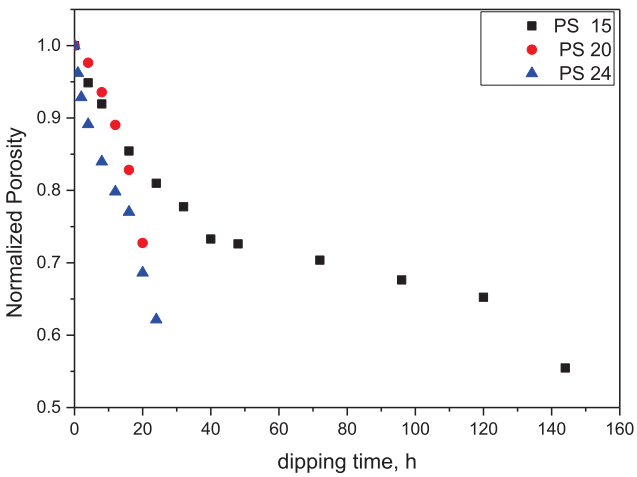
The separation characteristics of composite hollow fiber membranes for desalination of synthetic seawater through pervaporation process were studied. The conductance of produced water from desalination of saline water of 30000 – 50000 ppm NaCl concentration was observed to be about 10 – 50 µS/cm and exhibited water flux of about 8.2 – 8.7 $L \cdot m^{-2} \cdot h^{-1}$ at 352 K. The increase in water flux was also observed by operating the process at higher temperature and by using lower salt concentration of the feed (see below). The apparent activation energy of the pervaporation separation over the membrane was determined from the experiments.



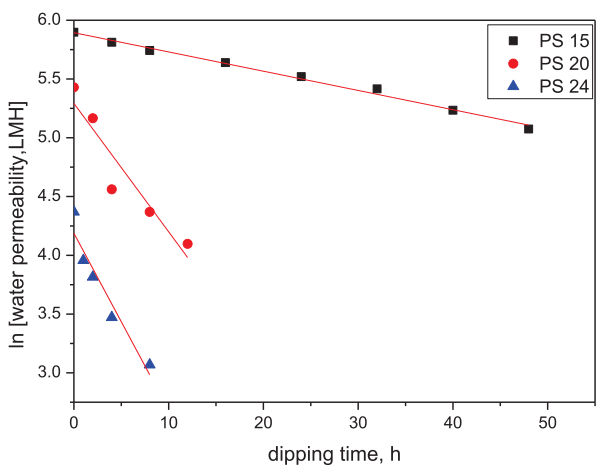
Flux vs. temperature plots from the separation experiments using saline feed of 30000 – 50000 ppm NaCl concentration for 4 membranes denoted as 0.05, 0.10, 0.15 and 0.20.

Pore structure modification of polysulfone ultrafiltration membrane by hexane treatment

Organic solvent-stable membranes are of great importance for several important industrial processes viz. vegetable oil refining, degumming process, deacidification and solvent recovery. Development of hexane-stable polymeric membrane is particularly interesting from the view point of (i) the low toxicity of hexane and (ii) common use of hexane as extracting medium for various stages of vegetable oil-refining applications. The properties of PS membrane were studied with different dipping time in hexane in static condition. This systematic screening allowed the detailed evaluation of the effect of hexane on membrane properties. The variation of normalized porosity with the dipping time in hexane in context with three membranes are given in the following figure. In order to study overall permeation properties of the asymmetric PS membrane the pure water permeability for the membranes were tested with the variation in dipping time in hexane (see below). It showed the decrease in water permeability with the dipping time of hexane. PS-15 membrane suffered a loss of 43.9% in water permeability 48 h. PS-20 suffered a loss of 26.4% in 12 h whereas PS-24 suffered a loss of 27.2% in 8 h. Fitting the data in first order rate equation it shows the rate of water permeability decrement follows PS-24 (-0.15) >PS-20 (-0.11) > PS-15(-0.016). It shows that the rate of decrement in permeability is ten times for PS-24 compared to PS-15, which suggests that the PS membrane which has maximum polymer rich phase showed the maximum rate of decrement.



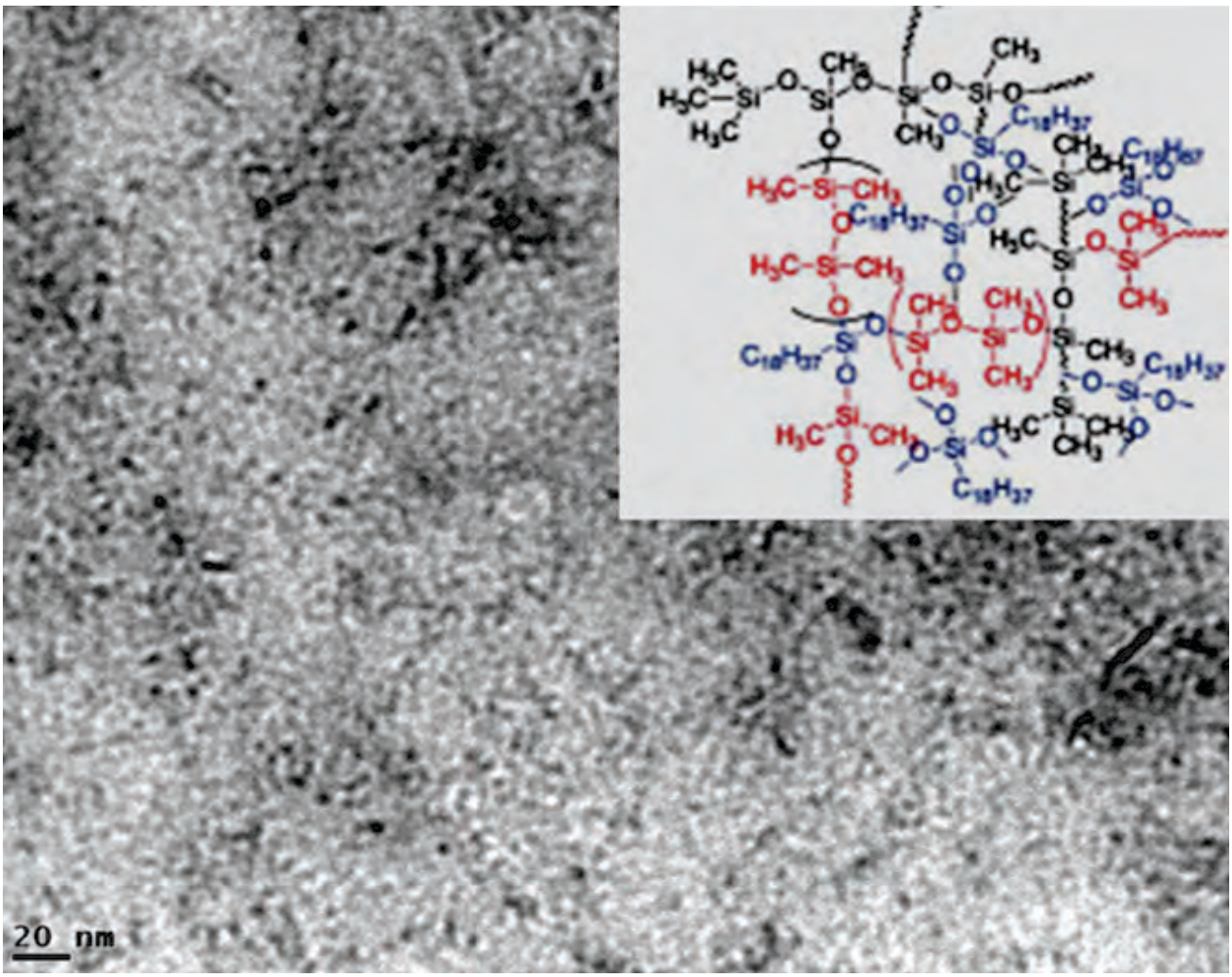
Variation of normalized Porosity of PS membranes with dipping time in hexane



Variation of water permeability of PS membranes with dipping time in hexane

Bi-functional poly(dimethylsiloxane) membrane

A new class of poly(dimethylsiloxane) (PDMS) membranes with increased hydrophobicity, in which hydroxyl terminated polydimethylsiloxane (HPDMS) cross linked concurrently with polymethylhydrosiloxane (PMHS) and n-octadecyltrichlorosilane (OTS), is reported here. The unique bifunctional PDMS membranes possess improved membrane performance for removal of trace volatile organics from water, thereby showing high potential for treatment of organic polluted water. Series of membranes with fixed HPDMS and PMHS ratios but different OTS content varying from 0.1 to 20 wt% were prepared. This resulted in the formation of two different types of bifunctional PDMS membranes. The membranes with lower OTS content (<5 wt%) resulted in formation of homogeneous structures in which OTS is X-linked molecularly, whereas nanocomposite structures with the additional presence of very small organosilica particles of about 1–2 nm size, were observed in the membrane with 5 wt. % OTS loading. In membranes with excess 10–20 wt% OTS loading, these nanoparticles were aggregated. The nanoscale structure observed by TEM was in accord with the SANS profiles. The membranes were further characterized by SEM, NMR, IR, contact angle, swelling and X-linking density measurements and correlated with their separation performances. The membrane with OTS content of 1 wt% exhibited the best performance in terms of high permselectivity of benzene or dichloromethane over water.

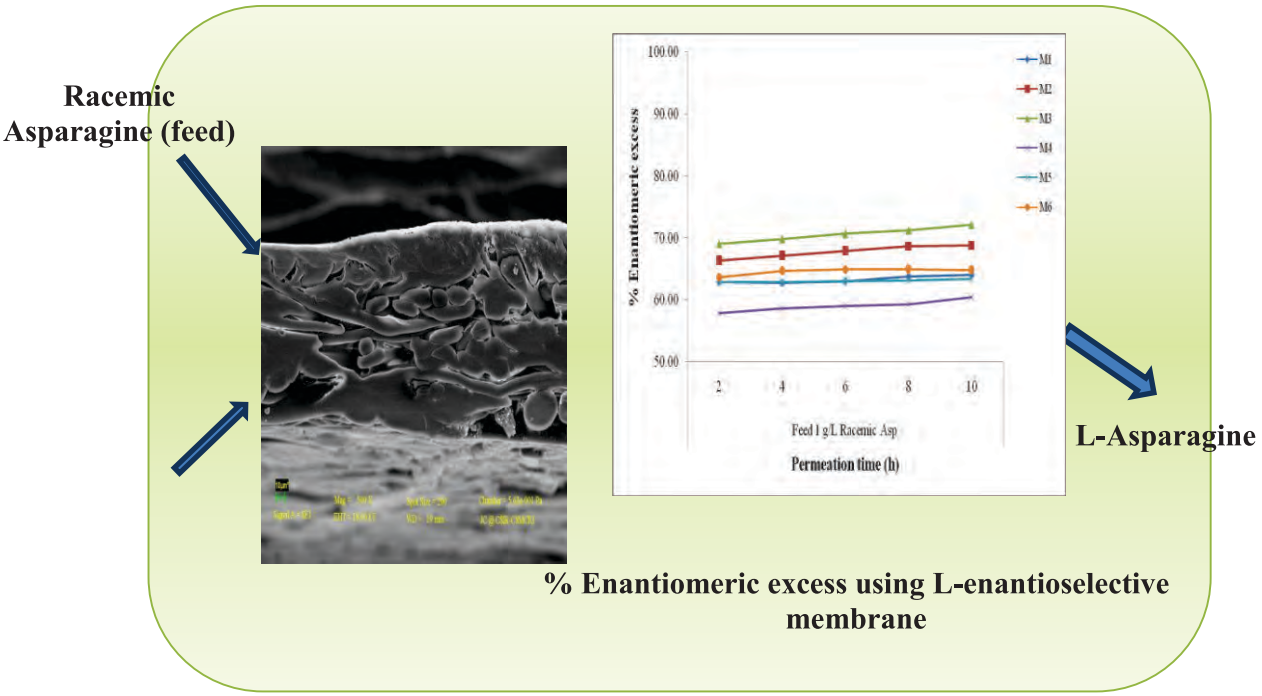


TEM image of bi-functional PDMS membrane; Inset: chemical structure

Membranes for chiral separation

Chiral separation membranes from different materials by different techniques were prepared. The details of two membranes are given here. The glutaraldehyde-cross linked chitosan membrane (GCCM) was prepared by phase inversion method from chitosan solution in acetic acid followed by cross linking with glutaraldehyde. The membrane was characterized for its chemistry and morphology by Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy (ATR-FTIR) and Scanning Electron Microscopy (SEM). The membrane was evaluated for optical resolution of (R, S)-2-amino-1-butanol and the influence of concentration of copper (II) ions in feed solution were investigated.

β-cyclodextrin was incorporated in polysulfone membrane and cross linked by gluteraldehyde to prepare β-cyclodextrin glutaraldehyde cross-linked polysulfone membrane (β-CDXM). The membranes were prepared by well-known wet phase inversion method from 15% (W/W) polysulfone, 1-2% β-cyclodextrin and 5 mL glutaraldehyde (50%) in DMF. Cyclodextrins (CDs) are torus-shaped molecules composed of cyclic 1,4 oligo-glucopyranosides possess hydrophobic cavity and hydrophilic external surface and form inclusion complex with chiral molecules. The formation of inclusion complexes with different isomers of a compound can be used for the separation of isomers. The membrane was studied for its enantioselectivity towards phenylalanine (Phe) and tryptophan (Trp). The association of β-CD with isomers of phenylalanine (Phe) and tryptophan (Trp) to form inclusion complexes was studied. The performance of the membrane is shown in the figure below.

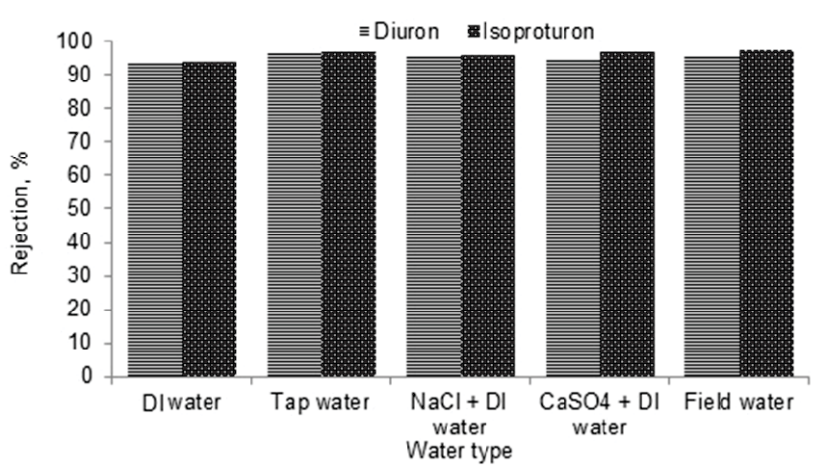


Enantiomeric excess obtained with permeation time.

Application of reverse osmosis membrane for removal of substituted phenyl urea pesticides from water

TFC polyamide RO membrane prepared in laboratory was used for filtration of phenyl urea herbicides dissolved in water. Membrane performance in removing pesticides from water was evaluated and compared with commercial membrane data. Rejection by the membranes is high (>90%) for the pesticides and depends on water type (see below figure). Membrane fouling and permeate flux decline also depends on water type. Presence of mono and bivalent ions in feed water influences membrane performance.

Similarly TFC polyamide membranes are also used for separation of phenolic pesticides from water. Rejection by the membranes varies depending upon the nature of solutes. The maximum rejection of 95% was observed. The study was also extended to show the variation of separation of pesticides depending upon the nature of water matrix (viz. pH, TDS). Time dependence study showed increasing trend in separation.

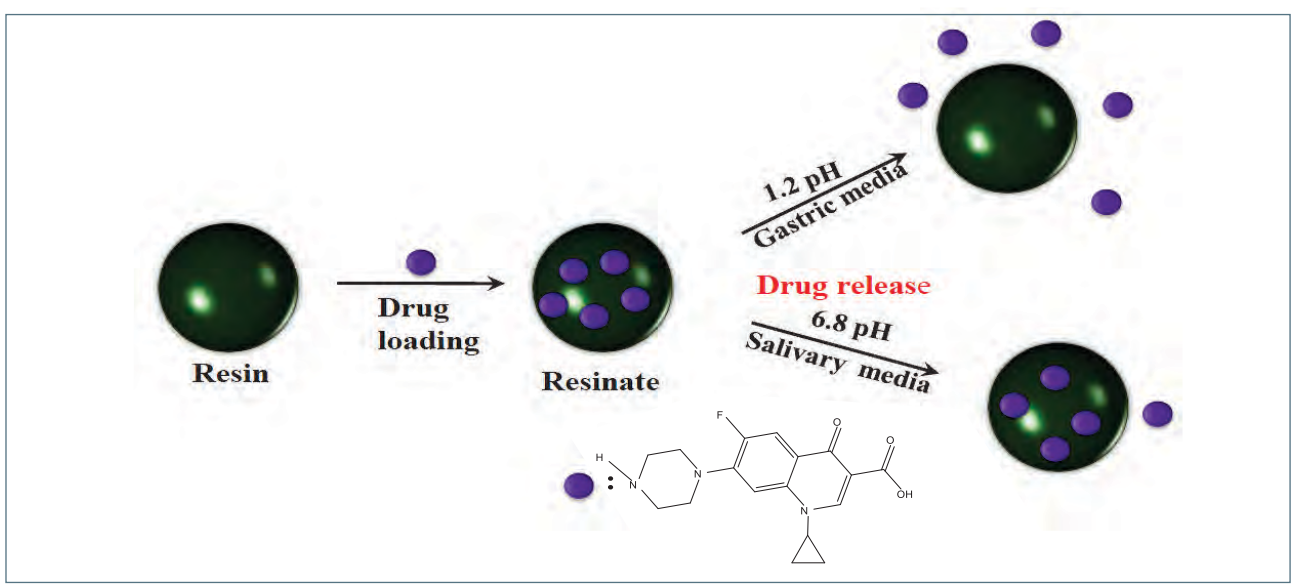


Effect of water type on pesticide rejection after 12h filtration

Development of cross linked functional copolymers and their applicability for pharmaceutically important materials

Two different series of weak acid cation exchange resins containing carboxylic acid functional groups were prepared by the copolymerization of methacrylic acid and acrylic acid with different cross linking agents like ethylene glycol dimethacrylate, N,N' methylene bis acrylamide and divinyl benzene separately. They were characterized for their physico chemical properties and instrumental analysis was also carried out by different instruments like FTIR, SEM, PXRD and DSC to confirm the formation of resins. Drug resin complexes (DRCs) of selected resins were prepared with bitter antibiotic drug Ciprofloxacin to mask the bitter taste of Ciprofloxacin. The pattern of DRCs was authenticated by analyzing them with different instruments. In vivo and In vitro taste masking performance of DRCs were performed by following standard methods and norms.

The release of drug from DRCs was observed to be fast at salivary and gastric pH. To overcome the problem Interpentrating Network (IPN) beads of DRCs were prepared by using different biopolymers like sodium aliginate (AL), Chitosan (CS) and κ-carreganeen (κ-Ca) in the presence of a crosslinking agent-calcium chloride. The IPN beads formed were characterized completely and release of drug was observed to be extended upto 10 hours at both the pH i.e. salivary and gastric for both the types of ion exchange resins.



Formation of drug resinates & release depends upon:

- **Ion-exchange capacity**
- **Particle size of resin and drugs**
- **pH and Ionic strength of the solution**
- **Degree of cross linking**
- **Solubility of drugs**
- **Temperature.**

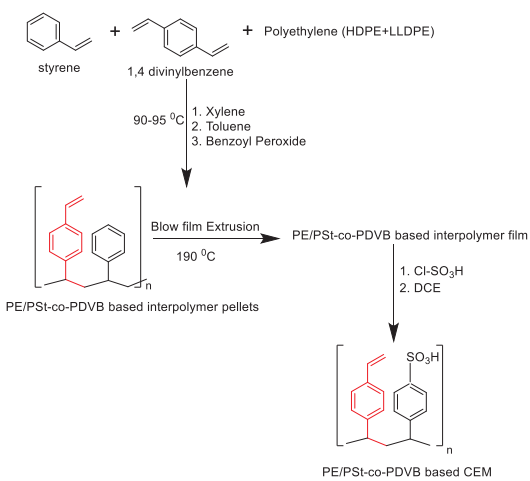
Formation of drug-resin complex and release mechanism of drug

ELECTRO MEMBRANE PROCESSES

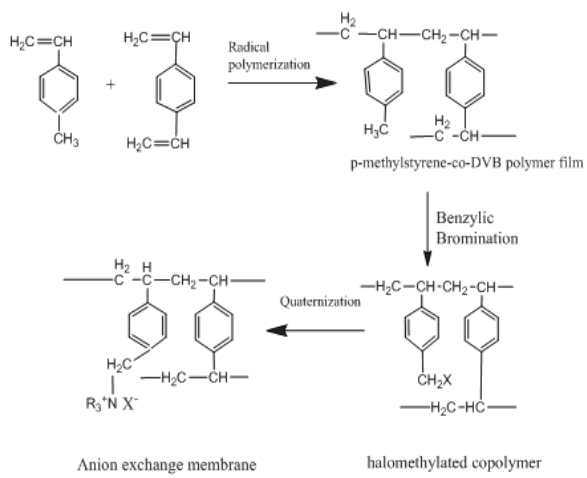
Large scale preparation of polyethylene based cation and anion exchange membrane for water desalination via electrodialysis

The Central Salt and Marine Chemicals Research Institute (CSMCRI), Bhavnagar has been working on the preparation of polyethylene/polystyrene (PE/PSt) interpolymer based cation exchange membrane (CEM) and anion exchange membrane (AEM) for the last 45 years. The mechanical and electrochemical properties of these membranes are excellent and comparable with commercial membranes like Ashahi glass, Neosepta etc. As the base material of these membranes are based on polyethylene which is very inert to acid, base or corrosive chemicals, the chemical stability of these membranes are very good. The major problem associates during the preparation of AEM from blown extruded film. During functionalization the films are exposed with chloro methyl ether (CME) in ethylene dichloride solvent in presence of lewis acid. This chloromethylated films are finally quaternized in presence of trimethylamine and AEMs are prepared. The major problem is that CME is not commercially available and highly carcinogenic. Therefore, its use has been restricted and limited to resin industries. In order to avoid the use of CME, AEMs have been prepared from polyethylene/poly*p*methylstyrene (PE/P*p*MS) based interpolymer film by benzylic bromination followed by amination with trimethyl amine.

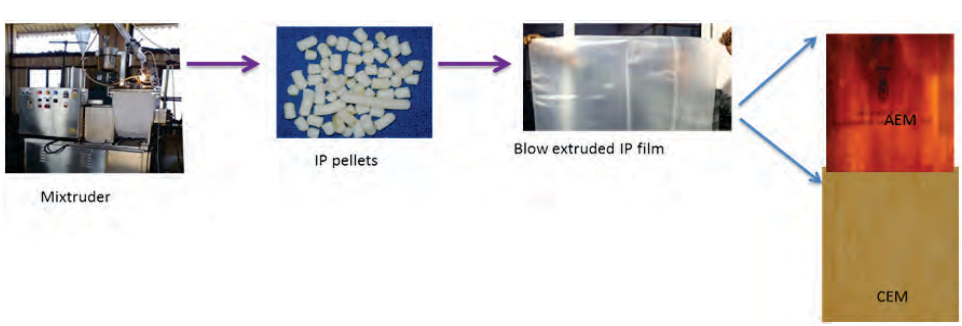
The PE/PSt and PE/PMS interpolymer based CEMs and AEMs are prepared by three steps. First step is the preparation of PE/PSt and PE/P*p*MS interpolymer pellets using a mixtruder, second step is the blow film extrusion of interpolymer pellets into the corresponding films and third step is the functionalization of blown extruded films into corresponding CEMs and AEMs. Schemesshow the synthetic strategy for the large scale preparation of CEM and AEM.



Synthetic route for the preparation of PE/PSt interpolymer based CEM



Synthetic strategy for the preparation of PE/PMS interpolymer based AEM



Electrochemical properties of the prepared CEMs and AEMs

The properties of the PE/PSt based CEM and PE/PMS based AEMs are given in the below tables. It can be seen that good, all round properties are obtained from the CEM, which is comparable with that obtained by the earlier process, with excellent mechanical strength.

Results of different batches of PE/Pst interpolymer based CEM prepared from copolymerization of Styrene, divinyl benzene and polyethylene in presence of 1 wt% benzoyl peroxide initiator

CEM abbreviation	% PSt present	Thickness (mm)	% water uptake	IEC (meq g^{-1})	R^m (ohmcm^{-1})	t^+
CEM-1	18	0.26	6	1.20	30-35	0.81
CEM-2	37	0.22	20	1.50	2-4	0.92

Results of different batches of PE/PMS interpolymer based AEM prepared from copolymerization of *p* methylstyrene, divinyl benzene and polyethylene in presence of 1.5 wt% benzoyl peroxide initiator

AEM abbreviation	% PMS present	Thickness (mm)	Br content	water uptake%	IEC (meq g^{-1})	R^m (ohmcm^{-1})	t^-
AEM-1	24	0.20	6.5	5	1.15	20-25	0.92
AEM-2	32	0.150	14	15	1.52	5-6	0.96

The water desalination efficiency of the prepared AEM-2 and CEM-2 was determined by electrodialysis (ED) using an in-house prepared ED cell (effective membrane area 20cm x 10cm) containing thirty pieces of newly prepared CEM-2 and AEM-2 under single pass mode. The applied voltage was 1.5-1.7 volts /cell pair. The feed water TDS was varied from 2000-3000 ppm. The results are summarized below.

ED unit desalination results using newly prepared AEM-2 and CEM-2 under single pass mode

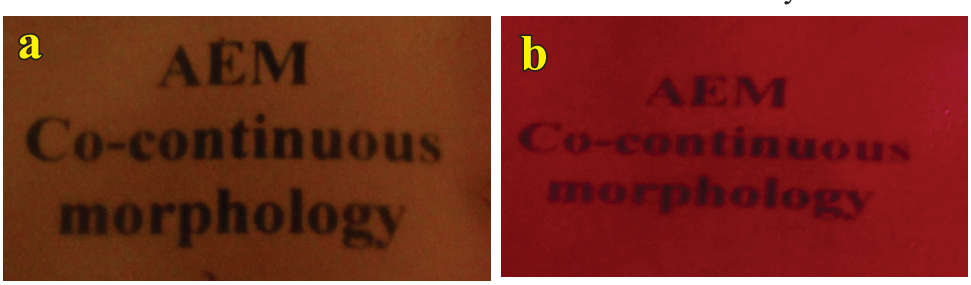
Volt/ cell pair	Current (Amp)	Feed TDS (ppm)	Output TDS (ppm)	Output flow (lt/hr)	Power consumption (W/Kg)	Current efficiency (%)
1.5	0.18	2000	550	7.0	0.798	86.10
1.5	0.18	2000	700	8.0	0.778	88.20
1.6	0.19	2000	670	8.0	0.857	88.50
1.5	0.27	2500	650	8.0	0.820	83.70
1.5	0.33	3000	850	8.4	0.822	83.57
1.6	0.34	3000	700	8.4	0.844	86.77
1.7	0.36	3000	650	8.4	0.930	83.73

Amphiphilic poly(acrylonitrile)-co-poly(2-dimethylamino) ethyl methacrylate conetwork-based anion exchange membrane for water desalination

A new cross-linked AEM from poly (acrylonitrile)-co-poly(2-dimethylamino)ethyl methacrylate(PAN-co-PDMA) copolymer by quaternizing the DMA moieties followed by cross-linking of –CN groups were designed. This process avoids the use of carcinogenic CME which is widely employed for chloromethylation reaction for the preparation of AEMs. Key

parameters evaluated via ED during water purification revealed that a copolymer containing 28 wt% PDMA possesses all the required properties of high performance AEM such as reasonable water uptake (21%), good ion-exchange capacity (IEC = 1.30 meq/g), high ionic conductivity (K^m = 2.22 mS/cm), high transport number (t^-=0.88) and good mechanical properties (9.2 MPa of tensile stress at break and 2.4 Kg/cm^2 of burst strength in water swelled state).

The AEM was directly tested in ED unit of effective area 65 cm^2 using 5 pieces of PAN/PDMA based AEM and 5 pieces of polystyrene/polyethylene based CEM under recirculation mode by varying feed NaCl concentration (2000 and 5000 mg/L) and applied potential (1-2 volts/cell pair) showing current efficiency as high as 80%. Such combination of physical and electrochemical properties of the membrane is attributed to the co-continuous morphology with low degree of phase separation as confirmed by measuring the water uptake in swelled state by Thermo Gravimetric Analysis (TGA), Differential Scanning Calorimetry (DSC), homogeneous distribution of oppositely charged dye and by transparency of the membrane in both dry and swelled states.



Photographs of PAN-co-PDMA conetwork based AEM in
(a) water wet state and (b) Rose Bengal dye adsorbed AEM in water wet state.

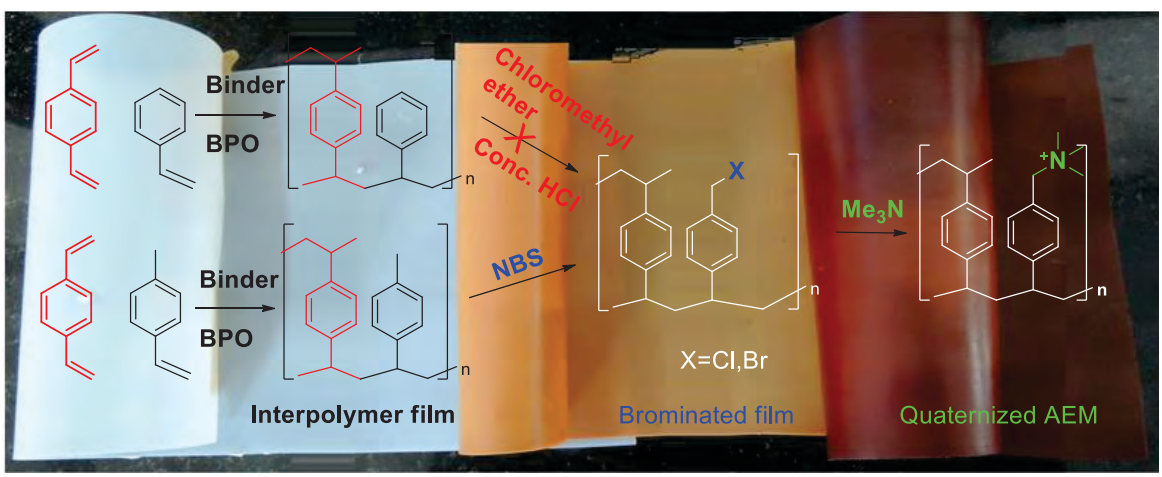
ED unit Desalination results using cross-linked PAN-Co-PDMA based AEM. a and b are the feed NaCl concentrations 2000 mg/L and 5000 mg/L. (*J. Mater Chem.* A. (2014), 2, 8396.)

Applied volt/cell pair	Concentration (mg/L) (Final)	Time (min)	Conductivity of water (mS/cm)		% reduction	Power consumption (KW.h/Kg)	Current Efficiency CE (%)	Flux for NaCl migration ($J\times10^{-4}$) (mol/m^{2}s)
			Initial	Final				
1.5[a]	506	80	4.5	1.4	75	0.94	74	1.74
2.0[a]	538	60	4.5	1.5	73	1.15	80	2.02
1.5[b]	495	150	11.0	1.4	90	1.07	65	1.60
2.0[b]	550	120	11	1.5	89	1.35	68	2.09

Safer route for preparation of anion exchange membrane from inter-polymer film and evaluation in electrodialytic application

The present work describes the safer route for the preparation of inter-polymer AEMs using *p*-methylstyrene-co-divinylbenzene (*p*-MS-co-DVB) in place of styrene-co-DVB. The polyvinyl chloride (PVC) and polyethylene (HDPE+LLDPE) were used as binders separately for the preparation of inter-polymer films of *p*-MS-co-DVB by using casting and melting extrusion method respectively. Functionalizations of developed films were carried out through benzylic mono-bromination followed by quaternization with trimethylamine. This alternative procedure avoided the use of CME required for functionalization of styrene-co-DVB based polymer films. CME is a carcinogen that is hazardous to health. The structural characterization of developed AEMs were done by Fourier transform infrared

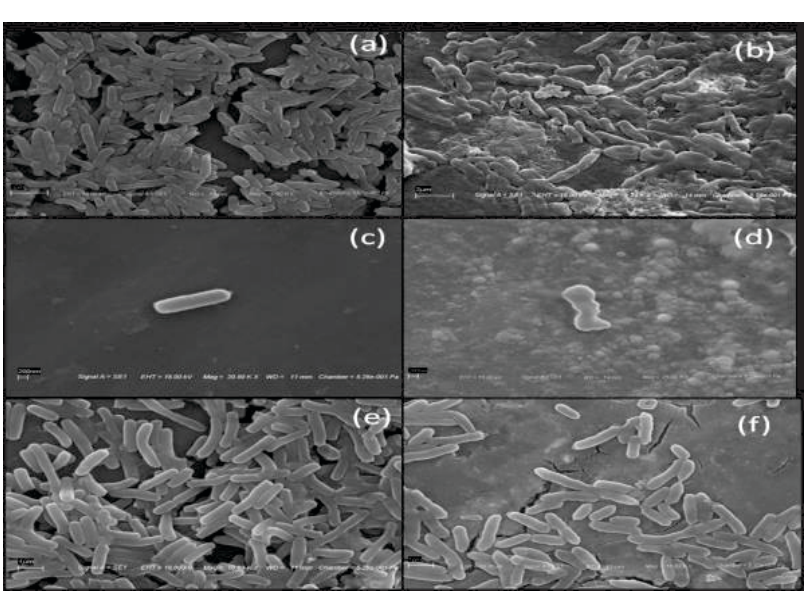
spectroscopy (FT-IR) and ^{13}C-nuclear magnetic resonance (^{13}C-NMR), while physicochemical and electrical properties were examined by ion-exchange capacity, water uptake, ionic resistance and transport number. The AEM of *p*-MS-co-DVB/PE membrane, exhibited superior performance in ED application, with higher rate of desalination, lower energy usage, higher current efficiency and high transport number compared to the *p*-MS-co-DVB/PVC based AEMs.



Patent:*Anion exchange membrane and preparation thereof, PCT Pub No-WO2014080427, May-2014,*Pushpito Kumar Ghosh, **Saroj** Sharma,Milan Dinda,Chiragkumar Rameshbhai Sharma, Uma Chatterjee, Vaibhav Kulshreshtha, Soumyadeb Ghosh, Babulal Surabhai Makwana, Sreekumaran Thampy, and Girish Rajnikant Desale. *(J. Memb. Sci., (2014) 459, 122–131.)*

Silver nanoparticle embedded novel crosslinked beaded polystyrene/polyamidoxime sequential interpenetrating polymer networks (IPNs) and its antibacterial activity

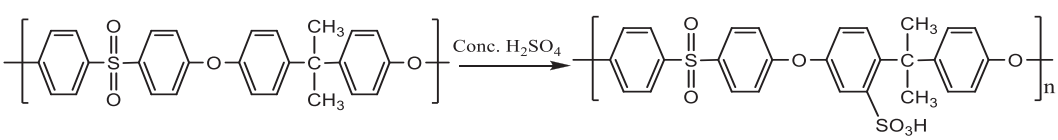
The novel crosslinked beaded polystyrene/polyamidoxime Interpenetrating Polymer Networks (PSD/PAMD-IPNs) resins impregnatated with silver nanoparticle (SNPs) was synthesized. The developed IPN was studied for the antibacterial acivity for water purification. The size of the SNPs formed on IPN were <5 nm and of [111] and [200] plane. The synthesized IPN were characterized by IR, Solid state ^{13}C-NMR, SED-EDX and XRD. The SNPs-IPN has been investigated for the antibacterial study at laboratory scale using batch and column study. The column experiments showed 99% bacterial reduction within 4–6 h and have promising antibacterial efficacy. The reusability of the SNPs-IPN beads was also tested for its repeated use for industrial application.

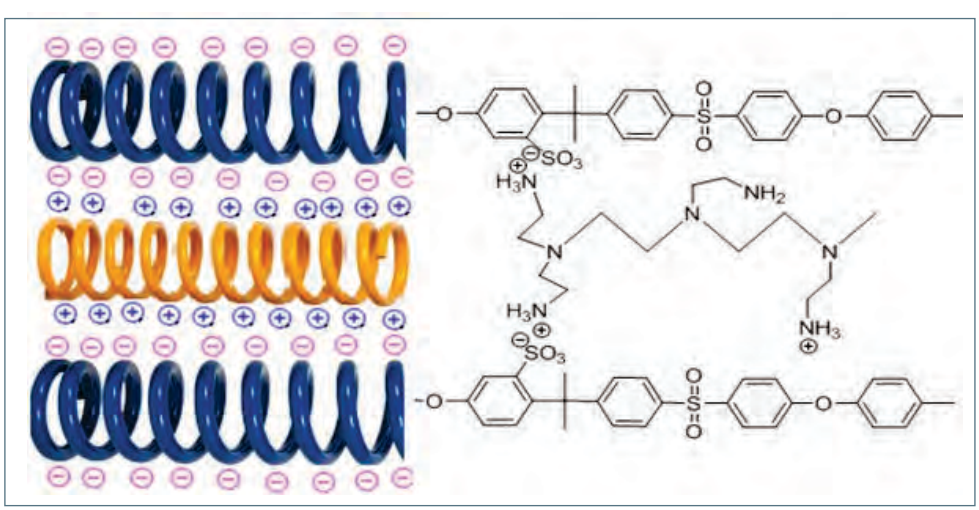


SEM images of prepared IPNs : (a), (c), (e) plates of blank IPN beads (without SNPs) shows bacterial growth, while (b), (d), (f) are SNPs-IPN beads shows no bacterial growth. (a) B. licheniformis (blank) (b) B. licheniformis (SNPs-IPN) (c) E. coli (blank). (d) E. coli, test (SNPs-IPN) (e) P. stutzeri (blank) (f) P. stutzeri, test (SNPs-IPN) (*Polym Composite. (2014), 9,1-11).*

Highly stable acid-base complex membrane for ethanol dehydration by pervaporation separation

An investigation has been made for pervaporation (PV) of water/ethanol azeotrope using sulphonated poly(ethersulphone) (SPES)/ polyethyleneimine (PEI) membranes compare to SPES membrane. SPES/PEI membranes showed high selectivity because of their alternating electrostatic deposition which yields ultrathin, water-selective polyelectrolyte membranes. Prepared membranes have been analyzed for their thermal and mechanical stabilities using DSC, TGA, DMA and structural properties by SEM. Addition of functional group has been confirmed by solid state ^{13}C and FTIR. Thermal and mechanical data showed that membranes are mechanically stable upto 250 °C. The glass transition temperature and peak sharpness increases with PEI amount which indicate the rise in molecular hybridization. FTIR spectra confirm the addition of various functional groups in SPES due to PEI addition. Membranes containing 20 % (w/w) PEI exhibited highest water/ethanol selectivity of the order of 4185 and flux (1.2 kg/m^2 h) at 30 °C *(RSC Adv. (2013),3, 22014)*.

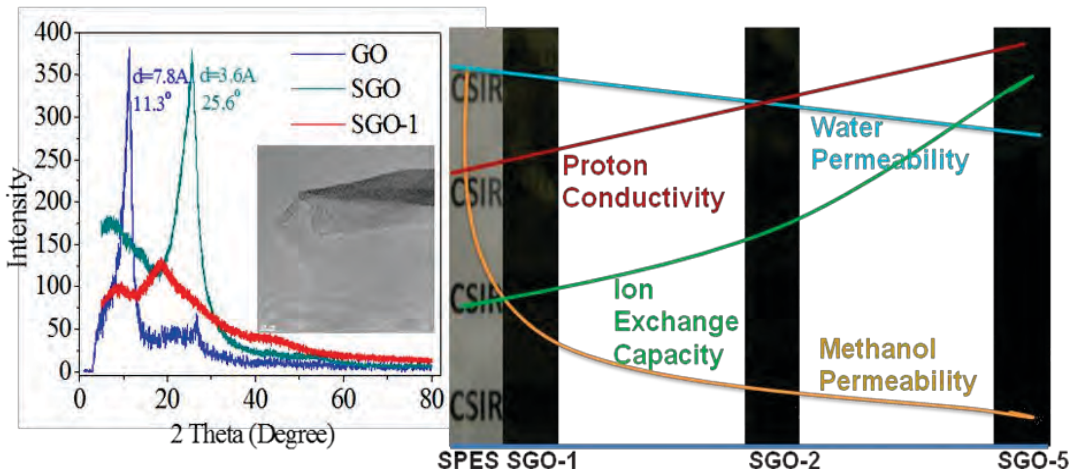




Sulfonation of Poly (ether sulphone) and their interaction with Poly (ethyleneimine)

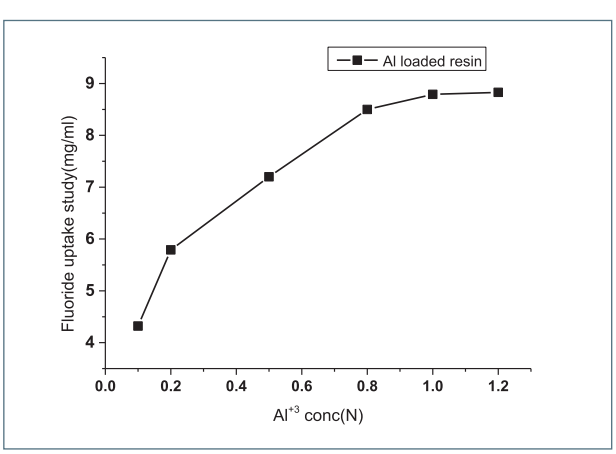
Highly conducting SGO/SPES nanocomposite polymer electrolyte membranes for high temperature applications

Proton-exchange membranes consisting of sulfonated polyether sulfone with a significant improvement of electrochemical properties are successfully prepared with different SGO content. The incorporation of SGO greatly increases the ion-exchange capacity (IEC), water retention and proton conductivity, while it reduces the methanol permeability through the SPES membrane. The prepared membranes are characterized by FTIR, XRD, DSC, SEM, TEM, and AFM techniques. Intermolecular interactions between the components in blend membranes are established by FTIR. The distribution of SGO is found to be uniform throughout the membrane matrix confirmed by SEM and TEM analysis. The proton conductivity in 5% SGO membrane is enhanced by 2 fold at 30 °C than the SPES membrane and reaches to 5 fold at 90 °C. These superior characteristics make the membranes with optimized SGO contents suitable for DMFC and the high temperature applications compared to the plain SPES*(ACS Appl Mat Interfaces. (2014), 6, 5595)*.

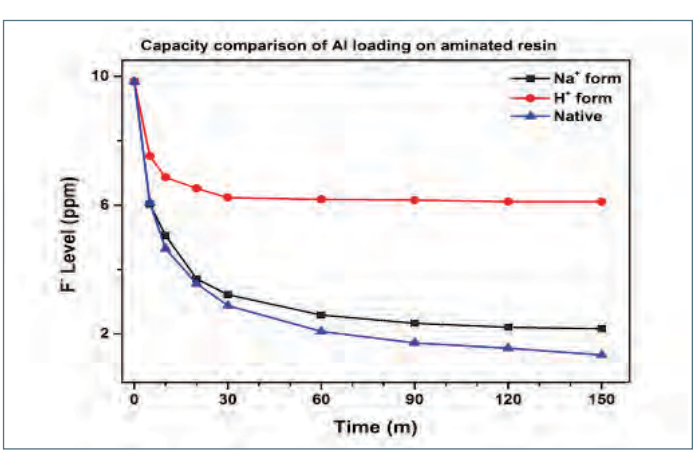


Defluoridation Employing Indigenous Fluoride Specific resin

MMA-co-EGDMA resin beads were synthesized in a single vessel RB flask using suspension polymerization method. The work was scaled up from 1L to 3 L vessel size and beads in the size range of 0.4-0.8 mm with the good yield (~95% *w/w*). The polymerization was carried out using anchor shaped in-house fabricated impeller and the controlled size-distribution was achieved by suitable chemical modification i.e use of PVA as stabilizer and low amount of salt (<1% in place of 35 % NaCl) for agglomeration control which delivers >80% *w/w* fraction in the size range of 0.3 mm to 1.2 mm. The exotherm involved, leading to sudden sharp rise in temperature, was also controlled in this manner. Amination of the beads led to 7-8 meq/mL ion-exchange capacity and this form of resin was used to lower the sulphate level in the defluoridated water. Faster defluoridation kinetics using resin beads were achieved which was comparable to activated alumina. A PCT patent entitled" a process for the defluoridation of drinking water" 2510/del/2014 is filed.



Defluoridation capacity of aminomethyl phosphonic acid resin increases with Al loading



Defluoridation efficiency using different forms of aminomethyl phosphonic acid resin beads

प्रकरण 3
CHAPTER 3



जैविक विज्ञान
Biological Sciences

समुद्री पर्यावरण अनुसंधान
प्राकृतिक उत्पाद रसायन
आण्विक जीवविज्ञान और जैवप्रौद्योगिकी

Marine Environmental Research
Natural Product Chemistry
Molecular Biology and Biotechnology

समुद्री पर्यावरण अनुसंधान

विशेष निवेश क्षेत्र धोलेरा के परिवेशी पर्यावरण की गुणवत्ता का आकलन

आधार रेखा की पर्यावरण गुणवत्ता का अध्ययन अप्रैल 2011 से मार्च 2012 के दौरान तीन मौसमों (वर्षाऋतु से पहले अप्रैल 11 से जून 2011, वर्षाऋतु के बाद सितम्बर–2011 से दिसम्बर–2011 तथा सर्दियों की ऋतु दिसम्बर 2011 से मार्च 2012) में किया गया। परिणामों का सारांश निम्नानुसार है:

परिवेशी वायु गुणवत्ता के विवरण से ज्ञात हुआ कि धोलेरा में पूरे वर्ष कणिकीय पदार्थों (10 माइक्रोमीटर से कम आकार वाले PM_{10} तथा 2.5 माइक्रोमीटर से कम $PM_{2.5}$)की मात्रा अपेक्षाकृत अधिक थी, और यह शायद भारी वाहनों के यातायात के कारण था। NO_2, SO_2, CO, ओज़ोन तथा अमोनिया जैसे मापदण्ड, स्वीकृति सीमा से नीचे थे जबकि बेंज़ीन और बेंज़ो पाइरीन संसूचन स्तर से भी नीचे पाये गये। कणिकीय धातुयें जैसे Ni एवं Pb की मात्रा स्वीकृत सीमा से नीचे पायी गयी जबकि कुछ स्थानों पर As की उपस्थिति भी चिन्हित हुई। सभी मौसम में वायु गुणवत्ता सूचकांक से ज्ञात हुआ कि अध्ययन में आवरित क्षेत्रों के किसी भी स्थल पर गंभीर वायु प्रदूषण नहीं पाया गया। विशेष निवेश क्षेत्र के निर्माण के दौरान निलंबित ठोस कणों का नियंत्रण जल के छिड़काव तथा निर्माण क्षेत्रक बाड़ों द्वारा स्थिर करके किया जाना चाहिए। निर्माण स्थल तक पहुँचने का मार्ग पक्का होना चाहिए जिससे उड़ने वाली धूल उत्पन्न न हो।

नमूने के स्थलों में कुछ को छोड़कर ज्यादातर स्थलों पर शोर का स्तर, केन्द्रीय प्रदूषण नियंत्रण बोर्ड (सीपीसीबी) के आवासीय क्षेत्रों के दिन के समय के शोर मानक की तुलना में अधिक था। यद्यपि अध्ययन क्षेत्रों में अपेक्षित शोर का प्रभाव कम था। निर्माणकार्य के दौरान आसपास के लोगों पर शोर के प्रभाव को कम करने के लिए, ज्यादा से ज्यादा कार्य दिन में तथा रात के दौरान कार्य कम किये जाने चाहिए। ज्यादा शोर करने वाले उपकरणों का एक साथ उपयोग नहीं किया जाना चाहिए और इस तरह के उपकरणों का उपयोग रात के दौरान नहीं करना चाहिए।

धोलेरा विशेष निवेश क्षेत्र के कई भूजल स्रोतों से प्राप्त जल पीने तथा घरेलू अनुप्रयोगों के लिए उपयुक्त नहीं है। सभी नमूने के स्थलों के भूजल में कुल निलंबित ठोस (टीएसएस) स्वीकार्य सीमा (यूएसईपीए: 0-5 मिलीग्राम प्रति लीटर तथा डब्ल्युएचओ: 5 मिलीग्राम प्रति लीटर) से अधिक थी। लगभग सभी जल के नमूनों में कुल घुलित ठोस(टीडीएस) का स्तर उच्च पाया गया। ज्यादातर स्थलों पर बॉयोकेमिकल ऑक्सीजन डिमांड (बीओडी) तथा डिजाल्वड ऑक्सीजन (डीओ) मान अनुशंसित मानों की तुलना में क्रमशः उच्च और कम पाये गये। जल की पेयता जांचने के लिए किये गये सूक्ष्मजैविकी विश्लेषण से ज्ञात हुआ कि ज्यादातर जल के नमूनों में ई. कोलाई की प्रति 100 मिली में संभावित मात्रा 1600 या 1600 से अधिक पाई गई जिससे पता चलता है कि ये जल सूक्ष्मजैविकी की दृष्टि से न तो पीने योग्य हैं और नही घरेलू उपयोग के लिए उचित हैं। इस तरह अध्ययन क्षेत्र के भूजल की गुणवत्ता मल संदूषण, उच्च खारेपन तथा उच्च कार्बनिक भार के कारण खराब है। ऐसे जल संसाधनों का पेयजल के रुप में उपयोग स्वास्थ्य के लिए हानिकारक है। निर्माण कार्य के दौरान पानी के छिड़काव अथवा अन्य सफाई क्रियाओं से उत्पन्न अपशिष्ट जल में सीमेंट और अन्य संदूषकों की अत्यधिक मात्रा रहती है। ऐसे पानी को विसर्जन से पहले उचित रुप से निथार कर निष्प्रभावित किया जाना चाहिए। निर्माण कार्य के दौरान मजदूरों को उचित सफाई सुविधा उपलब्ध कराई जानी चाहिए तथा सिवेज़ को सेप्टिक टैंक तथा सॉकपिट प्रणाली द्वारा प्रशोधित किया जाना चाहिए। जिससे प्रस्तावित विशेष निवेश क्षेत्र के निर्माण कार्य के कारण भूजल पर्यावरण पर समग्र प्रभाव अल्पकालिक तथा प्रभावहीन हो।

अध्ययन क्षेत्र की मिट्टी की धनायन विनिमय क्षमता (सीईसी) निर्धारित सीमा से अधिक थी। इसके अलावा सभी स्थलों पर तीनों मौसम के दौरान सोडियम अवशोषण अनुपात (एसएआर) में भी व्यापक रुप से विभिन्नता पायी गईं। स्पष्ट है कि इस क्षेत्र में उच्च सोडियम अवशोषण अनुपात, लवणता के कारण है। इसके अतिरिक्त अनुशंसित मानों से अधिक चालकता, मिट्टी में लवण के प्रभाव को दर्शाती है। सभी स्थलों की मिट्टी के विश्लेषण ने मिट्टी में उपलब्ध नाइट्रोजन की मध्यम तथा फोस्फरस की क्षीण मात्रा दर्शाया। इस तरह अध्ययन क्षेत्र, विशेष रुप से तटीय क्षेत्र के पास की मिट्टी लवण तथा पोषकों की कमी से प्रभावित है। अतः कृषि प्रयोजन के लिए वर्तमान स्वरुप में यह जमीन उपयुक्त नहीं है। चूंकि प्रस्तावित विशेष निवेश क्षेत्र गैर–कृषि भूमि पर है इसलिए निर्माण के दौरान फसल उत्पादन

यदि कोई है तो, उसमें परिवर्तन करने की आवश्यकता नहीं है।

तटीय पानी और तलछट के भौतिक रासायनिक विश्लेषण से पता चला कि तटों के सभी मापदण्ड सामान्य थे। सामान्यतः समुद्र जल में भारी धातु की सांद्रता, सीपीसीबी के प्राथमिक जल की गुणवत्ता के लिए स्वीकार्य सीमा के भीतर थी। अध्ययन के क्षेत्र में पादप–प्लवकों तथा प्राणी –प्लवकों की क्रमशः 25 तथा 15 जातियाँ पायी गईं। पादप–प्लवकों में सुरीरेल्ला, कोसाइनोडिस्कस तथा निट्स्चिया जातियाँ बहुतायत में थीं जबकि प्राणी–प्लवकों में फोरामीनीफेरा प्रभावी समूह के रुप में था। पादप तथा प्राणी–प्लवकों की विविधता के सूचकांक से ज्ञात होता है कि इस क्षेत्र के समुद्रीजल गुणवत्ता अच्छी से बहुत अच्छी के बीच है जो दर्शाती है कि समुद्रजल प्रदूषण रहित है। हालांकि समुद्रीजल के जीवाणु–विश्लेषण से पता चलता है कि धोलेरा तथा राहतलाव के तटीय क्षेत्र तुलनात्मक रुप से सीवेज़ संदूषण से प्रभावित हैं। धोलेरा विशेष निवेश क्षेत्र के निर्माण तथा परिचालन कार्य के दौरान सीवेज़ सहित सभी अपशिष्ट जल का प्रशोधन गुजरात प्रदूषण नियंत्रण बोर्ड के निर्धारित मापदण्डों के अनुसार किया जाना चाहिए।

जीपीसीबी, गांधीनगर द्वारा वित्तपोषित परामर्श परियोजना के अंतर्गत गुजरात के विभिन्न तटों पर प्रदूषण स्तर का अध्ययन

इस परियोजना अंतर्गत पर्यटन विकास के संबंध में 13 समुद्रतटों का एक मौसम में स्वास्थ्य संबंधी अध्ययन किया जाएगा। ये समुद्रतट हैं–

1. अहमदपुर–मांडवी, जिला–जूनागढ़
2. सोमनाथ, जिला–जूनागढ़
3. भवानी समुद्रतट–महुआ, जिला–भावनगर
4. द्वारका, जिला–जामनगर
5. मांडवी, जिला–कच्छ
6. पोरबंदर
7. नारगोल, जिला–वलसाड
8. तिथल, जिला–वलसाड
9. उमरगांव, जिला–वलसाड
10. सुलतानबाद–डुमस,जिला–सूरत
11. सुवाली–हजीरा, जिला–सूरत
12. दांडी, जिला–नवसारी
13. उभराट, जिला–नवसारी

प्रत्येक समुद्रतट की लंबाई तथा प्रदूषित एवं प्रदूषणरहित क्षेत्रों को ध्यान में रखते हुए स्थलों की संख्या निर्धारित की गई है। प्रत्येक स्थल से एकत्रित किये गये समुद्रीजल तथा तलछट के नमूनों का कीटनाशकों सहित भौतिक रासायनिक मापदण्डों तथा पादप–प्लवक, प्राणी–प्लवक, प्रोटोज़ोआ और विभिन्न प्रकार के रोगजनक तथा अरोगजनक जीवाणुओं सहित जैविक मापदण्डों के लिए विश्लेषण किया जायेगा। प्रत्येक तट का पर्यावरणीय स्वास्थ्य आकलन तथा तट के कूड़े का मापन भी किया जाएगा। तट पर कचरे का होना तटीय पर्यावरण में मानवीय गतिविधियों का स्पष्ट संकेत है। यह क्रमवार अनेक पर्यावरणीय परिणामों वाला महत्वपूर्ण प्रदूषण मसला है। जैविक रुप से समुद्रतट का कचरा वन्य जीवोंको नष्ट तथा उनके आवासों को खत्म कर सकता है। इससे आर्थिक रुप से मत्स्य उद्योग तथा शौकिया मछुआरों, दोनों पर नकारात्मक एवं व्यापक प्रभाव पड़ता है। सौंदर्य मूल्यों की हानि तथा मानव स्वास्थ्य पर इसका संभावित प्रभाव भी चिंता का विषय है।

समुद्रीजल के नमूनों का जैविक मापदण्डों के साथ पीएच, तापमान, मैलापन, लवणता, डीओ,बीओडी,तेल और स्नेहक, कुल जैविक कार्बन (टीओसी), NO_2-N, NO_3-N, PO_4-P तथा अवशेष धातुओं (Zn, Pb, Cd, Co, Cr, Cu, Ni, As, Mn) तथा खर–पतवार नाशकों/कीटनाशकों के लिए विश्लेषण तथा तलक्षट नमूनों का संरचना, कुल जैविक कार्बन तथा भारी धातु (Al, As, Cr, Mn, Fe, Co, Cd, Pb, Ni, Cu, Zn) तथा नितल जीव समूहों के लिये विश्लेषण किया जाएगा। नमूने एकत्रित करने तथा उनके विश्लेषण का कार्य प्रगति पर है।

खंभात की खाड़ी, गुजरात के भूजल में चुनिंदा भारी धातुओं तथा बोरॉन की उपस्थिति एवं वितरण

एक वर्ष में वर्षाऋतु के बाद, सर्दी और पूर्व वर्षाऋतु के मौसम के दौरान गुजरात राज्य में अरब सागर की प्रदेशिका, खंभात की खाड़ी के विभिन्न स्थलों से एकत्रित किये गये भूजल के नमूनों का इंडक्टीवली कपुल्ड प्लाज्मा–ऑप्टीकल इमीशन स्पेक्ट्रोमेट्री द्वारा As, Co, Cr, Cu, Fe, Mn, Ni, Pb तथा Zn जैसी धातुओं की सांद्रता मापी गई। ज्यादातर भारी तत्वों का गुण निर्धारण कम क्षारीय तथा अपचयित दशाओं में निम्न गतिशीलता द्वारा किया गया, जलवाही स्तर में इनकी सांद्रता पेयजल के स्वीकृत मानों के भीतर है। अस्थायी परिवर्तनों से संकेत मिलता है कि वर्षाऋतु के दौरान अधिकतर धातुएं इसमें मिलती हैं। भारी धातुओं के मुख्य घटकों के विश्लेषण बताते हैं कि अध्ययन क्षेत्र में Co, Cu, Cd तथा Zn एक दूसरे से परस्पर संबंधित हैं तथा उल्लेखनीय रुप से मानव–उद्भित हैं, जबकि Pb और Cr वायुमंडलीय जमाव के कारण हैं। चट्टानों के क्षरण तथा मानवीय निवेशों को भूजल में तत्वों की उपस्थिति का मुख्य स्रोत पाया गया। कुछ युरोपीय तथा एशियाई क्षेत्रों की तुलना में खम्भात की खाड़ी के भूजलों में भारी धातु का स्तर उच्चतर पाया गया, हालांकि इन धातुओं का स्तर विश्व के कुछ शहरी स्थलों के साथ तुलनीय पाया गया।

रियायती जैव सामग्रियों के जलीय घोल से अमोनीकृत नाइट्रोजन का जैवशोषणः गतिकी तथा संपर्क समय का इष्टतमीकरण

भूरी समुद्री शैवाल सिस्टोसेरिया इंडिका के मृत बायोमॉस तथा जेट्रोफा के बीज़ से बॉयोडीज़ल के उत्पादन के दौरान उत्पन्न तेल–केक के जलीय घोलों द्वारा अमोनीकृत नाइट्रोजन $N\text{-}NH_4^+$ के जैवशोषण का अध्ययन किया गया। $N\text{-}NH_4^+$ का जैवशोषण पूर्णतया pH पर आधारित था और प्रारंभिक pH 7 और 3 पर सी. इंडिका (15.21 x मिग्रा/ग्राम) तथा जेट्रोफा तेल–केक (13.59 x मिग्रा/ग्राम) की महत्तम उद्ग्रहण क्षमता पायी गई। सामान्यीकृत रेट मॉडल तथा स्यूडो–सेकण्ड आर्डर के गतिज मॉडल ने, गतिकी जैवशोषण का सही वर्णन किया और यह पाया गया कि इन जैवशोषकों के लिये जैवशोषण प्रक्रिया, छिद्र तथा सतह विसरण द्वारा नियंत्रित हुई थी। चार–चरण बैच जैवशोषक डिजाइन विश्लेषण से पता चला कि 500 ली. जलीय घोल में से 99% क्षमता के साथसी.इंडिका औरजेट्रोफा तेल–केक से 40 मिग्रा/लीटर $N\text{-}NH_4^+$ पृथक होने में क्रमशः 76 तथा 96 मिनट का समय लगा।

लाल शैवाल,कप्पाफायकस अल्वारेजी के जलीय घोल से फॉस्फेट का कुशल निष्कासन

जल से फॉस्फेट दूर करने के लिए समुद्री दीर्घ शैवाल कप्पाफायकस अल्वारेजी के मृत बॉयोमॉस का उपयोग किया गया। विभिन्न मापदण्डों जैसे संपर्क समय, अधिशोषित वाष्प की सांद्रता, जैवशोषक मात्रा तथा तापमान आदि के प्रभावों की जांच की गई। जैवशोषक गतिकी डाटा कोस्यूडो–सेकण्ड आर्डर समीकरण दर द्वारा अच्छी तरह से वर्णित किया गया तथा 80 मिनट पर साम्यावस्था प्राप्त हुई। फॉस्फेट जैवशोषण, फिल्म विसरण प्रक्रिया द्वारा नियंत्रित किया गया। कप्पाफायकस अल्वारेजी पर अधिकतम फॉस्फेट जैवशोषण 25°C पर 59.77 मिग्रा/ग्राम था तथा इसने रेडलिच–पीटरसन मॉडल का अनुसरण किया। तापमान में वृद्धि के साथ कप्पाफायकस अल्वारेजी पर जैवशोषण में भी वृद्धि हुई जो pH 6.0 पर अधिकतम थी।

मन्नार की खाड़ी में कप्पाफायकस अल्वारेजी की उपस्थिति

फरवरी 2013 से अगस्त 2013 के दौरान मन्नार की खाड़ी के सात द्वीप (मन्डपम समूह में छः तथा किलाकराई समूहमें एक); सिंगल द्वीप, क्रुसडाइ द्वीप, पूमरीचंद द्वीप, पुल्लीवासल द्वीप, मनाली द्वीप, हारे द्वीप एवं मुल्ली द्वीप के आसपास सर्वेक्षण किया गया। कप्पाफायकस की स्थापना केवल क्रुसडाइ द्वीप के लिए सीमित पाई गई जबकि टूटे हुये टुकड़े मुल्ली तथा हारे द्वीपों से एकत्रित किये गये। प्रवाहित शैवाल क्रुसडाइ द्वीप के उत्तर–पूर्व की ओर से भी एकत्रित किये गये। इन सभी द्वीपों में पहली बार व्यापक सर्वेक्षण किया गया। मनाली द्वीप के 2.16 वर्ग किमी क्षेत्र का सर्वेक्षण किया गया और दीर्घ शैवाल की जैवविविधता 24 स्थलों पर दर्ज की गई जिसमें टरबेनेरिया डीकुरेन्स, हैलीमेडा ग्रैसीलिस, सरगासम टेनेरीमम तथा समुद्री घास

इनहैलस एकोराइड्स अधिकतम स्थानों को आच्छादित किये हुये थे।

प्रवाहित कप्पाफायकस अंश हारे द्वीप पर भी पाये गये। हारे द्वीप पर लगभग 2.14 वर्ग किमी क्षेत्र का सर्वेक्षण किया गया। 45 स्थलों पर दीर्घ शैवाल की विविधता दर्ज की गई। सरगासम पॉलीसिस्टम, पडीना बोरगेसनी तथा हैलीमेडा ग्रैसीलिस अधिकतम स्थानों को आच्छादित किये हुये थे। मुल्ली द्वीप के लगभग 0.60 वर्ग किमी क्षेत्र का सर्वेक्षण किया गया। 20 स्थलों पर दीर्घ शैवाल जैवविविधता दर्ज की गई। सरगासम पॉलीसिस्टम, कोलरपा रेसीमोसा तथा हैलीमेडा ग्रैसीलिस अधिकतम स्थानों को आच्छादित किये हुये थे।

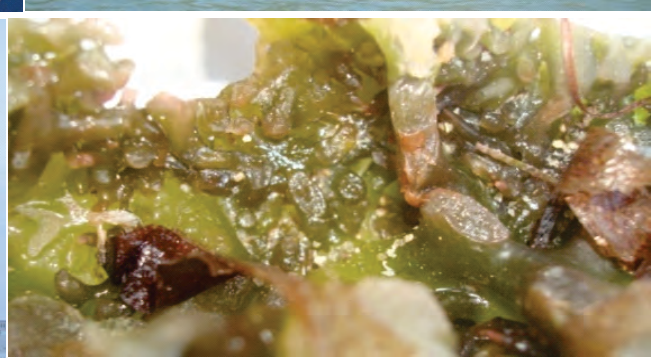
हारे द्वीप के सर्वेक्षण के स्थल



अन्तर्जलीय सर्वेक्षण







प्रवाहित शैवाल के निकट चित्र

पेटरसन तथा भट्ट (2010) ने अपने रिपोर्ट में बताया है कि कप्पाफायकस अल्वारेजी के अंश, दक्षिण पाल्क की खाड़ी के तरफ व्यवसायिक खेती के मैदान से दूर हटकर शीगंल द्वीप को अतिक्रमित कर वहाँ स्थापित हो चुके हैं। उनका अनुमान है कि लगभग 0.20 वर्ग किमी क्षेत्र पर इस शैवाल की उपस्थिति है। इस द्वीप के लगभग 0.60 वर्ग किमी क्षेत्र का सर्वेक्षण किया गया।

प्राकृतिक उत्पाद रसायन

प्राकृतिक बहुलक के मूल्य संवर्धन की दिशा में दीर्घ कालिक दृष्टिकोण

सोडियम आल्जीनेट आधारित कंपानुवर्ती हाइड्रोजेलों की सरंचना–गुणधर्म के संबंध पर अध्ययन

सोडियम आल्जीनेट (Na-Alg) ने 1-नेफ्थीलामाइन के साथ, 1-इथाइल-3-[3-(डाइमिथालेमिनो)-प्रोपाइल]-कार्बोडाइमाइड हाइड्रोक्लोराइड की उपस्थिति में प्रतिक्रिया कर एमाइड व्युत्पन्न किया जो 4%w/v सांद्रता पर नर्म हाइड्रोजेल बनाने में सक्षम था, बाद में यह सहज कंपन से एक चिपचिपे सॉल में परिवर्तित हो गया तथा उत्क्रमणीय प्रक्रिया दर्शाता हुआ कक्ष तापमान पर स्थिर रखने पर अपनी मूल संरचना ग्रहण कर लिया। ऐसे कंपानुवर्ती पदार्थों का जैव चिकित्सा में तथा संवेदकों के रुप में संभावित अनुप्रयोग किया जा सकता है।

अगारोज का कार्यात्मक परिवर्तनः प्रतिदीप्त अगारोज ट्रिप्टोफान आधारित हाइड्रोजेल का सरल संश्लेषण

कार्बोडीमाइड रसायन विद्या का (dicyclohexylcarbodiimide/4-dimethylaminopyridine; DCC/DMAP) उपयोग करके सुक्ष्मतरंगों की सहायता से प्रतिदीप्त अगारोज एल–ट्रिप्टोफान हाइड्रोजेल सामग्री का सरल संश्लेषण किया गया। उत्पाद प्रतिदीप्त हाइड्रोजेल ने 1–1.5% (w/v) पर जल में (λ_{max} 350 nm; 1×10^{-4} M) प्रतिदीप्त उत्सर्जन प्रदर्शित किया जो समान सांद्रता में ट्रिप्टोफान से उल्लेखनीय रुप से (लगभग 65%) ज्यादा था। बाद में नीले हाइड्रोजेल (G-Ag-TrpEst) तैयार करने के लिए अगारोज एस्टर को प्राकृतिक क्रॉस संयोजक जेनीपिन के साथ क्रॉस बंधित किया गया और इस प्रकार अगारोज बैकबोन में ट्रिप्टोफान अर्धांश की प्रविष्टि की पुष्टि की गई। एस्टर तथा क्रॉस बंधित हाइड्रोजेल दोनों ने अगरोज के समान ही जेलिंग क्षमता दर्शायी जो व्यापक परिस्थितियों में माध्यम की विस्तृत pHरेंज (pHs 1.2, 7.0 और 12.5) में स्थिर थे। प्रतिदीप्त हाइड्रोजेलयुक्त ट्रिप्टोफान पदार्थों का जैवचिकित्सा और औषधि उद्योगों में मूलक अपमार्जक तथा संवेदकों के रुप में उपयोग किया जा सकता है।

अगारोज का रुपांतरण प्रतिदीप्त पिरीडीन कार्बोक्सीलिक एसिड एमाइड्स का 6- एमिनोअगारोज के माध्यम से संश्लेषण

कार्बोडीमाइड रसायनविद्या का उपयोग करके निकोटिनिक (AA-NA) तथा पिकोलिनिक (AA-PA) अम्लों के साथ 6-एमिनो अगारोज (AA) के माध्यम से अगारोज के नये प्रतिदीप्त एमाइड्स का सरल संश्लेषण किया गया। डाईआईसो प्रोपाइल एजोडाई–कार्बोक्सीलेट तथा ट्राईफिनाइलफोस्फीन की उपस्थिति में अगारोज की थैलीमाइड के साथ सरल मित्सुनोबु–प्रेरित सूक्ष्मतरंगों के माध्यम से प्रतिक्रिया के पश्चात हाइड्रेजीनोलाइसिस द्वारा 6-एमिनो अगारोज का संश्लेषण किया गया। एमाइड्स के 1×10^{-3} M घोल में उपस्थित NA तथा PA के मोलर तुल्यांक (0.2मिग्रा) की तुलना में जल में AA-NA तथा AA-PA के 1×10^{-3} M विलयनों का प्रतिदीप्त उत्सर्जन (महत्तम 430 तथा 412 nm) उल्लेखनीय रुप से अधिक (लगभग 82% तथा लगभग 90% क्रमशः) था। अगारोज के इन प्रतिदीप्ततायुक्त पिरीडीन कार्बोक्सलिक एसिड का जैवचिकित्सा तथा औषधि उद्योगों में संवेदक के रुप में अनुप्रयोग में लाये जाने की संभावना है।

स्व एवं विलायक अनुक्रियाशील ग्वार गम तथा आयनिक तरल में बहुभित्तीय ग्वार गम कार्बन नैनोट्युब नैनोसंमिश्रित जेल

10% w/v की इष्टतम सांद्रता में आयनिक तरल, 1–ब्युटाइल–3–मिथाइलइमीडाजोलियम क्लोराइड, में ग्वार गम ने नर्म विस्कोइलास्टिक जेल का निर्माण किया। आयनिक तरल में 0.2% w/v की बहुभित्तीय कार्बन नैनोट्युबों के साथ वर्धित सामर्थ्ययुक्त गम की नैनोसंयुगमित जेल तैयार की गयी। संपूर्ण द्विभाजन पर भी जेल ने स्वतः उपचारात्मक की क्षमता दर्शायी। उक्त जेल ने एसीटोन, डाइमिथाइलसल्फॉक्साइड तथा डाइमिथाइल-फोर्मएमाइड नामक तीन ध्रुवीय एप्रोटिक विलायकों की उपस्थिति में भी उपचारात्मक क्षमता दर्शायी।

जैव–आधारित आयनिक तरल तथा प्रगाढ़ गलनक्रांतिक विलायकों में दीर्घविधि सरंचनात्मक और रासायनिक स्थिरता के साथ डीएनए का त्वरित विघटन

सालमन टेस्टिस से प्राप्त डीएनए, दो जैव आधारित आयनिक तरलों में 3.5% w/w तक कक्ष के तापमान पर 6 घण्टे में विलयित हुआ। कोलीन–इन्डोल–3–एसीटेट (chol-IAA) में सेम्पल विलयित करने पर देखा गया कि बहुलक अणु की संरचना में कोई अपक्षय नहीं हुआ, हालांकि अणु में कोलीन–इन्डोल–3ब्युटाइरेट (chol-IBA) में अपक्षय पाया गया। इसके अलावा, कोलीन क्लोराइड तथा इथाइलीन ग्लायकोल मिश्रणयुक्त प्रगाढ़ गलनक्रांतिक विलायकों में डीएनए के विघटन में 5.5% w/w तक वृद्धि हुई। DES में कक्ष के तापमान पर 6 महीने के लिए भंडारण करने पर भी जैव मैक्रोअणु में रासायनिक तथा संरचनात्मक स्थिरता पायी गई।

प्रगाढ़ गलनक्रांतिक जैव विलायक में द्वैत क्रियान्वित डीएनए आधारित पदार्थ तैयार करने का सरल दृष्टिकोण

चुंबकीय तथा प्रति जीवाणु गुणोंयुक्त संकर पदार्थों के बनाने हेतु डीएनए (सालमन टेस्टिस) को Fe_3O_4 नैनोकणों तथा प्रोटॉनिकृत आवरणयुक्त डीटाइटेनेट शीट्स ($H_2.Ti_2O_5.H_2O$) द्वारा कोलीन क्लोराइड तथा इथाइलीन ग्लायकोल के मिश्रण में क्रियान्वित किया गया। Ti शीट्स ने फॉस्फेट समूह के साथ तथा Fe ने संकर पदार्थ में डीएनए के क्षारीय युग्म के साथ परस्पर क्रिया की।

कप्पाफायकस अल्वारेजी समुद्री शैवाल से ईंधन मध्यस्थ कृषि पोषकतत्व तथा शुद्ध जल

सल्फेटीकृत पॉलीसैकराइड समृद्ध, दानेदार बायोमास, -केराजिनन से 5-हाइड्रॉक्सीमिथाइल फरफ्युरल (HMF) तथा पोटैशियम सल्फेट (K_2SO_4) के उत्पादन हेतु एक स्वतः समन्वित प्रणाली विकसित की गई। KCl से समृद्ध रस (0.7 m^3/टन ताजा समुद्री शैवाल) तथा दानेदार बायोमास (0.04 टन शुष्क भार/टन ताजा समुद्री शैवाल) निकालने के लिए ताजे कप्पाफायकस अल्वारेजी शैवाल को पीसा गया।

प्रगाढ़ गलनक्रांतिक विलायक में काइटिन का विघटन तथा काइटिन नैनोफाइबर्स का निर्माण

कोलीन हैलाइड (क्लोराइड/ब्रोमाइड)–यूरिया, कोलीन क्लोराइड–थायोयूरिया, क्लोरोकोलीन, क्लोराइड–यूरिया तथा ग्लायसिन बिटैनिहाइक्लोराइड–यूरिया के मिश्रण के प्रगाढ़ गलनक्रांतिक विलायक (डीइएस), अल्फा–काइटिन के लिए बहुत ही प्रभावी विलायक तंत्र पाये गये। कोलीन क्लोराइड–थायोयूरिया (डीइएस) में जैवबहुलक (9% *w/w*) का विघटन महत्तम पाया गया। कोलीन हैलाइड (क्लोराइड/ब्रोमाइड)–यूरिया तथा कोलीन क्लोराइड–थायोयूरिया मिश्रण (डीइएस) का उपयोग विलायक के रुप में अल्फा-काइटिन नैनोफाइबर्स (CNFs) निर्मित करने के लिए किया गया। कोलीन क्लोराइड तथा थायोयूरिया मिश्रण (डीइएस) के उपयोग द्वारा 20-30 nm व्यास वाले नैनोफाइबर्स बनाये गये। इस तरह बनाये गये नैनोफाइबर्स का उपयोग, कैल्शियम- आल्जीनेट बीड की तुलना में वर्धित लचीलेपनयुक्त कैल्शियम आल्जीनेट जैव नैनोसंमिश्रित जेल बीड्स बनाने में किया गया। इस जैव नैनोसंमिश्रित जेल बीड का उपयोग एक कैंसररोधी औषधि 5-फ्लोरोयुरेसिल के मंद स्राव के अध्ययन के लिए किया गया।

सीएसएमसीआरआई और जमनालाल बजाज उष्णकटिबंधीय रोग अनुसंधान केन्द्र, सेवाग्राम की सहयोगी परियोजना "पौंधों तथा समुद्री शैवाल के अर्कों का क्षयरोधी जैवपरीक्षण" के अंतर्गत किये गये कार्य

सेलीकोर्निया ब्रेचीएटा के क्षयरोधी सक्रिय कच्चे अर्क तैयार करना

अक्टूबर 2012 से दिसम्बर 2013 के दौरान सेलीकोर्निया ब्रेचीएटा के अलग अलग जीवन स्तर के पाँच बार एकत्र किए गए अंशों में से कच्चे जलीय अर्क तथा 1200 MW से उच्चतर तथा 1200 MW से निम्नतर अणुओं वाले जड़ो का जलीय अर्क तैयार किया गया, तथा जेबीटीडीआर केन्द्र में विकसित SEVA TB ELISA द्वारा, माइक्रोबेक्टेरीयम ट्युबरक्युलोसीस के ES-31 प्रतिजन तथा उसके विशिष्ट प्रतिरक्षी का उपयोग करके क्षयरोधी औषधि के रुप में संभावित जांच करने हेतु भेजा गया। आइसोनियाज़िड का एक मानक अवरोधक के रुप में उपयोग किया गया। इसके अलावा नमूनों का INH तथा रिफाम्पिसिन को मानक निरोधात्मक के रुप में उपयोग कर के M.Tb बेसिली H_{37} Ra के साथ परीक्षण किया गया। इसकी आगे % MTT जांच द्वारा पुष्टि भी की गई। ध्रुवीय तथा गैर–ध्रुवीय यौगिकों ने MTT जांच में लगभग 85-95 % निषेध दर्शाया।

आण्विक जीवविज्ञान और जैवप्रौद्योगिकी

एक नितान्त लवणोद्भिद सेलीकोर्निया ब्रेचीएटा से अजैव तनाव अनुक्रियाशील जीन्स की क्लोनिंग, गुण–निर्धारण तथा रुपांतरण

सेलीकोर्निया ब्रेचीएटा सबसे ज्यादा नमक सहिष्णु पौधों में से एक, अपर्णी तथा रसदार एकवर्षी पौधा है जो अत्यंत खारीय परिस्थितियों में लवणीय दलदलों में पनपने में सक्षम है और शुष्क भार के आधार पर लगभग 30-40% सोडियम क्लोराइड जमा कर सकता है। सेलीकोर्निया ब्रेचीएटा तनाव अनुक्रियाशील जीनों के लिए मुख्य जीन संसाधनों में से एक है, जिसे समुद्रीजल कृषि के लिए एक सशक्त वैकल्पिक फसल के रुप में माना जाता है। अनेक जीन्स; *SbMT*-2 (मेटैलोथिओनीन जीन टाइप–2), *SbNHX1* (Na^+/H^+ एन्टीपोर्टर), *SbUSP* (युनिवर्सल स्ट्रेस प्रोटीन जीन), *SbpAPX* (परॉक्सीसोमल एस्कॉर्बेट परॉक्सीडेज) तथा *SbSI*-2 (सॉल्ट–इन्डयुसीबल) के क्लोन बनाये गये, उनका गुण–निर्धारण तथा इन–प्लांटा रुपांतरण किया गया।

ई. कॉलाई में *SbMT-2* तथा उसके हेटरोलॉगस अभिव्यक्ति का प्रतिलिपि विश्लेषण किया गया। *SbMT-2* जीन की अभिव्यक्ति जिंक, कॉपर, सॉल्ट, ताप और शुष्क तनाव के साथ समानान्तर रुप से आरोहित हुई, शीत तनाव से अवरोहित जबकि कैडमियम तनाव के अंतर्गत अप्रभावित रही। *SbMT-2* जीन की हेटरोलॉगस अभिव्यक्ति ने ई.कॉलाई में धातु संचय तथा सहिष्णुता बढ़ाई। *SbMT-2* प्रोटीन के धातु–बंधन गुणधर्म, भारी धातुओं के समस्थापन और/अथवा निर्विषीकरण में अपनी संभावित भूमिका दर्शाते हैं।

ग्लुटाथिओन एस ट्रान्सफेरेज (जीएसटी) को ही व्यक्त करने वाली कोशिकाओं की तुलना में Zn^{++}, Cu^{++} तथा Cd^{++} के लिए पुनः संयोजक *SbMT-2*अभिव्यक्ति करने वाली ई. कॉलाई कोशिकाओं द्वारा उल्लेखनीय सहिष्णुता दर्शायी गयी। कॉपर की तुलना में जिंक की ज़ब्ती 4 गुना अधिक थी और इससे विपरीत, *SbMT-2* ने जीएसटी प्रोटीन की तुलना में 1.23 गुना अधिक कैडमियम के संचय को रोका। संयोजित प्रोटीन *SbMT-2* ने जिंक के साथ अत्यंत आकर्षण (Cu^{++}तथा Cd^{++} से लगभग 2.5 गुना) दर्शाया तत्पश्चात Cu^{++}तथा Cd^{++}आयनों के साथ बराबर आकर्षण दर्शाया।

माइक्रोप्रोजेक्टाइल बमबारी मध्यस्थ रुपांतरण के प्रयोग द्वारा *SbNHX1* जीन के साथ जेट्रोफा कर्कस के ट्रांसजेनिक पौधे विकसित किये गये। ट्रांसजीन का पीसीआर तथा आरटी–पीसीआर द्वारा पुष्टि की गई तथा रियल टाइम qPCR द्वारा कॉपी संख्या निर्धारित की गई। ट्रांसजेनिक लाइनों; JL2, JL8 तथा JL19 की नमक सहिष्णुता की पुष्टि पर्ण वार्धक्य परख, क्लोरोफिल अनुमापन, पौधों की वृद्धि, अंतर्निहित आयन, इलेक्ट्रोलाइट रिसाव तथा मैलोनडायल्डीहाइड (एमडीए) द्वारा की गई। ट्रांसजेनिक लाइनों ने WT की तुलना में 200 mM NaCl तक की बेहतर नमक सहिष्णुता दर्शायी।

पूर्ण लंबाई वाले *SbUSP* जीन में एक प्रोटीन जो यूनिवर्सल स्ट्रेस प्रोटीन (युएसपी) परिवार के अंतर्गत आता है, में 486 बीपी संकेतीकरण का खुला रीडिंग फ्रेम होता है। *SbUSP* ने एडिनोसिन मोनोफोस्फेट के साथ परस्पर क्रिया की तथा फास्फोराइलेशन, ग्लाइकोसाइलेशन तथा एटीपी बांडिग साइट्स जैसे विशेष लक्षण दर्शायें। इन प्लांटा ट्रांसक्रिप्ट प्रोफाइलिंग ने नमक सहिष्णुता के लिये उल्लेखनीय प्रतिक्रिया (7.8-गुना) अभिव्यक्त की साथ ही सूखा, ताप तथा शीत तनाव के दौरान *SbUSP* ट्रांसक्रिप्ट बहुतायत में देखी गईं जो 12 से 24 घण्टे में क्रमशः 3.66, 2.64 तथा 2.14 गुना अधिकतम वृद्धि तक पहुँची। ई. कॉलाई में इस जीन के हेटरोलॉगस अभिव्यक्ति ने तनाव सहिष्णुता में वृद्धि दर्शायी तथा पुनःसंयोजक कोशिकाओं ने अकेले वेक्टर की तुलना में उच्च विकास दर प्रदर्शित किया और स्पॉटपरिक्षण में 10^{-5} तनुता तक वृद्धि दर्शायी।

तनावों के अंतर्गत *SbpAPX* जीन के कार्यात्मक पुष्टिकरण हेतु उसे तम्बाकू में रुपांतरित किया गया। जंगली पौधों की तुलना में *SbpAPX* जीन अति–अभिव्यक्ति ट्रांसजेनिक पौधों ने नमक तथा सूखा तनाव सहिष्णुता में वृद्धि दर्शायी। ट्रांसजेनिक पौधों ने सामान्य तथा तनावपूर्ण, दोनों परिस्थितियों में वनस्पति विकास तथा अंकुरण दरों में वृद्धि दर्शायी।

इसी तरह क्लोन *SbpAPX* जीन का मूंगफली की स्थानीय किस्म में रुपांतरण किया गया और लगभग 40 ट्रांसजेनिक पौधों (T_1) को बेतरतीब रुप से नमक तनाव सहिष्णुता के अध्ययन हेतु चुना गया। नमक तनाव की परिस्थितियों में ट्रांसजेनिक पौधे हरे बने रहे जबकि

अरुपांतरित पौधों के पत्ते सफेद और पीले हो गये। तनाव की परिस्थितियों में ट्रांसजेनिक पौधों ने सामान्य वृद्धि जारी रखी और अपना जीवन चक्र पूर्ण किया। मूंगफली के ट्रांसजेनिक पौधों ने नमक तनाव परिस्थितियों में पर्याप्त सहिष्णुता दर्शायी अतः इसे नमक प्रभावित क्षेत्रों में सतत कृषि हेतु प्रयोग में लाया जा सकता है।

एक नवीन नमक–प्रेरणीय जीन *SbSI-2* को चुनकर उसके कार्यात्मक लक्षणों के निर्धारण हेतु उसे ई. कॉलाई तथा तम्बाकू में रुपांतरित किया गया। *SbSI-2* की अति–अभिव्यक्ति वाले ट्रांसजेनिक तम्बाकू के पौधों ने जंगली पौधों की तुलना में बेहतर वृद्धि मापदण्डों, उच्च सापेक्ष जल मात्रा, अनुकूल ऑस्मोलाइट्स का उन्नत संचय, कम Na^+ तथा प्रतिक्रियाशील ऑक्सीजन प्रजातियों (ROS) का संचय तथा कम इलेक्ट्रोलाइट रिसाव के साथ नमक तथा आसरण सहिष्णुता में सुधार दर्शाया। *SbSI-2* की अति–अभिव्यक्ति ने ROS–बचाव जीन्स के ट्रांसक्रिप्ट स्तर तथा नमक और आसरण तनावों में कुछ तनाव संबंधी ट्रांसक्रिप्शन कारकों को भी बढ़ाया।

परॉक्सीसोमल एस्कॉर्बेट परॉक्सीडेज़ (*pAPX*) जीन की प्रतिलिपि नियंत्रित करने वाली क्रियाविधि

T_1 पौधों में गस (GUS) के मात्रात्मक विश्लेषण से ज्ञात हुआ कि प्रोत्साहक PP5 जीन अभिव्यक्ति के लिए कार्यक्षम है। इन प्लांटा क्षणिक अभिव्यक्ति ने पुनःसूचित किया कि प्रोत्साहक PP5 में तनाव–प्रेरण करने योग्य तत्व शामिल हैं। PP3 में गस की अभिव्यक्ति में अति क्षय और बाद में PP4 तथा PP5 में उन्नत अभिव्यक्ति से अनुमानित होता है कि -696 तथा -433 bp के बीच एक अवरोधक तत्व की उपस्थिति है, जबकि क्रिया बढ़ाने वाले तत्व का अनुमान -838 तथा -697 bp के बीच किया गया। इसके अलावा क्षणिक अभिव्यक्ति विश्लेषण तथा वैद्युतकण संचालन गतिशीलता रुपांतरण परीक्षण से ज्ञात हुआ कि *cis*-कार्यकारी नमूने ATAA और CCTCAA के मूल अनुक्रम, क्रमशः वृद्धिकारक तथा अवरोधक बाध्यकारी साइट के रुप में कार्य करते हैं। अध्ययन के आधार पर *SbpAPX* जीन के *cis*-नियमन के लिए एक मॉडल प्रस्तावित किया गया है।

जीरा (कूमिनम साइमिनम एल.) में एगरोबैक्टेरियम–मध्यस्थी आनुवांशिक रुपांतरण के लिए एक कार्यक्षम पद्धति

जीरा दैनिक जीवन में विभिन्न अनुप्रयोगों वाला औषधीय रुप से महत्वपूर्ण, एक वार्षिक पौधा है। लगभग 1,020 भ्रूण (प्रतिबैच 255 भ्रूणों का औसत) को रुपांतरण परिस्थितियों के इष्टतम के लिए उपयोग किया गया। लगभग 720 भ्रूण (प्रतिबैच 180 भ्रूणों का औसत) के रुपांतरण के लिए उपयोग किया गया और 95 % भ्रूणों ने सह–खेती के बाद अस्थायी ग्लूसरोनाइडेज अभिव्यक्ति दर्शायी। तना प्रसार के लिए कथित ट्रांसजेनिक भ्रूण B5 माध्यम में संवर्धित किये गये और चयन के बाद 21 पुनर्जीवित पौधे प्राप्त किये तथा मूल प्रसार के लिये विनिर्दिष्ट किये गये। T_0 पौधों ने *β*-ग्लूसरोनाइडेज की अभिव्यक्ति दर्शायी और हाइग्रोमाइसीन–फॉस्फोट्रान्सफरेज– *II* तथा *β*- ग्लूसरोनाइडेजजीन्स के क्रमशः 0.96 तथा 1.28 केबी अंश के पीसीआर प्रवर्धन के माध्यम से जीन समाकलन का समर्थन किया गया। 1.5 % रुपांतरण दक्षता की अभिव्यक्ति की गई और कुल 11 ट्रांसजेनिक पौधे दृढ़ीकृत अवस्था पर प्राप्त किये गये तथापि दृढ़ीकरण के दौरान केवल चार पौधों को जलवायु के अनुकूल बनाया गया। दृढ़ीकृत पौधें के जीन की प्रतिलिपि संख्या का सर्दन ब्लाट द्वारा विश्लेषित किया गया और एकल–प्रतिलिपि जीन समाकलन का निरीक्षण किया गया। जीरा के एगरोबैक्टेरियम मध्यस्थी आनुवंशिक रुपांतरण का यह प्रथम सफल प्रयास है।

सेलीकोर्निया ब्रेचीएटा से नमक अनुक्रियाशील नवीन सूक्ष्म **RNAs** की पहचान

सूक्ष्म RNAs (miRNAs) तथा छोटे इंटरफेरिंग RNAs सहित छोटी नॉन–कोडिंग RNA प्रजातियाँ (20–24 न्युक्लियोटाइड), यूकैरियोटिक कोशिकाओं में जीन अभिव्यक्ति के मुख्य नियंत्रक हैं। कुल 159 अनुक्रमों का क्लोन करके विश्लेषण किया गया। 12 अनुमानित miRNAs/पूर्व miRNAs तथा एक छोटे RNA की पहचान की गई और नार्दन ब्लाट द्वारा इसका समर्थन किया गया। अनुमानित miRNAs में से नौ नवीन और तीन संरक्षित miRNA परिवार (MIR169g, MIR1433, MIR138b) के हैं। नार्दन हाइब्रिडाइजेशन तथा रियल टाइम PCR ने दर्शाया कि नौ miRNAs (सात नवीन और दो संरक्षित) तथा एक छोटे RNA ने 2.0 M NaCl पर और दो नवीन miRNAs ने 1.5 M NaCl पर तथा एक संरक्षित miRNA ने 1.0 M NaCl पर अत्यधिक अभिव्यक्ति की। इसके अलावा अलग किये गये miRNA के 67 तथा अनुमानित लक्ष्य जीन

का अनुक्रम समरुपता के आधार पर अनुमान किया गया जिनमें से 50% से अधिक अजैव तनावों के साथ जुड़े रहे हैं। miRNA 169g (Sb-miRNA10) तथा SbmiRNA7 (क्रमशः NF-YA कॉपी का कारक तथा साइटोक्रोम P_{450}-टाटा बॉक्स बाध्यकारी प्रोटीन) के लक्ष्य जीन्सों का रीयल टाइम PCR द्वारा विश्लेषण किया गया।

सेलीकोर्निया ब्रेचीएटा की ऑलिगोसैकराइड मास प्रोफाइलिंग

सेलीकोर्निया के बीज, प्रोटीन से समृद्ध हैं और इसकी कोमल कोपलें हरे सलाद के रुप में खाई जाती हैं। अंकुरण से कुल कोशिकाभित्तीय कार्बोहाइड्रेट को अलग कर β –ग्लूसरोनाइडेजएन्जाइम काकटेल से डाइजस्ट कर के MALDI TOF-TOF मास स्पेक्ट्रोस्कॉपी का उपयोग करके, ओलिगोसैकराइड मास प्रोफाइलिंग (OLIMP) की गयी। सेलीकोर्निया OLIMP लाक्षणिक रुप से मास पीक m/z 477.3297–2094.4363 पर दर्शित होती है। MS स्पेक्ट्रा ने जाइलोग्लूकॉन ओलिगोसैकराइड ब्लाकों के निर्माण को दर्शाया जो XXXG (1084.9927 m/z) से प्रचुरित थे। जाइलोग्लूकॉन ओलिगोमर्स (XXG, XXFG, XLXG तथा XLFG) की लाक्षणिक मास पीक का भी पता लगाया गया, जिसने अति पौष्टिक सोयाबीन पौधे के समान रुपरेखा दर्शायी। वर्तमान अध्ययन आज तक किसी भी खाद्य लवणोद्भिद के लिए OLIMP पर यह प्रथम रिपोर्ट है।

जीवाणु समुदाय संरचना और जन गतिशीलता

हेलोएल्काइन मिट्टी (EC 20 dS/m; pH 9.5) में जीवाणु की जाति संबंधी आनुवंशिक विविधता की तुलना सामान्य मिट्टी (EC 0.93 dS/m; pH 7.2) के साथ की गई। दोनों प्रकार की मिट्टियों में जातीय नकल दर्शाने वाले प्रोटीयोबैक्टेरिया, बैक्टेरवायडेट्स, क्लोरोफ्लेसी, फरमीक्युट्स, एक्टीनोबैक्टेरिया, एसिडोबैक्टेरिया तथा प्लेन्कटोमाइसिटिस पाये गये। सायनोबैक्टेरिया, वेरुकोमीक्रोबिया *OP10* तथा बैक्टेरिया इनसरटी सेडिस सामान्य मिट्टी में पाये गये जबकि नाइट्रोस्पीरा केवल हेलोएल्काइन मिट्टी में पाया गया। हेलोएल्काइन मिट्टी में प्रभावी जाति बैक्टेरवायडेट्स थी उसके बाद प्रोटियोबैक्टेरिया थी जबकि सामान्य मिट्टी में प्रभावी जाति प्रोटियोबैक्टेरिया तथा एक्टीनोबैक्टेरिया थी। हेलोएल्काइन लायब्रेरी में से लगभग 82% परिणाम, पूर्ववर्ती विभिन्न खारे, क्षारीय तथा तेल–प्राकृतिक गैस क्षेत्र की पारिस्थितिकी प्रणालियों से पुनःप्राप्ति से संबंधित थे, जबकि सामान्य मिट्टी से 50% परिणाम कृषि क्षेत्रों, राइजोस्फीयर तथा घास के मैदानों जैसे कृषि से संबंधित स्थानों के प्राप्त जीवाणुओं के सदृश थे। दोनों मिट्टियों के नमूनों के कुल परिणामों में से एक तिहाई नमूनों ने कम ब्लास्ट (<95%) पहचान दर्शायी जिससे संकेत मिला कि ये मिट्टियाँ अद्वितीय, टिकाऊ, नवीन वर्गों को आश्रय देने वाली हो सकती हैं। इसके अलावा सहसंबंध विश्लेषण ने शैनन विविधता सूचकांक के नकारात्मक सहसंबंध तथा प्रजातियों की लवणता (ईसी) तथा पीएच के साथ संतुलितता, लेकिन मिट्टी के नमूनों के कुल कार्बन तथा कुल नाइट्रोजन के साथ सकारात्मक सहसंबंध दर्शाया। हेलोएल्काइन मिट्टी ने कम जीवाणु विविधता दर्शायी तथा सामान्य मिट्टी के समुदायों से उल्लेखनीय रुप से अलग थी। इस अध्ययन में एक अर्द्ध शुष्क क्षेत्र से हेलोएल्काइन मिट्टी ओलीगोट्रोफिक सूक्ष्म जीवों का समर्थन करती है।

अन्य अध्ययन के अंतर्गत खारी मिट्टी के जीवाणु तथा आर्चिया की आबादी सूचकांक पर अन्वेषण किया गया और टारगेटेड मेटाजीनोमिक्स का उपयोग करके एक संभावित सूक्ष्म जीव–पर्यावरण पैटर्न की स्थापना की गई। 16S rRNA तथा कार्यात्मक जीन जो कार्बन स्थिरीकरण (*cbbL*), नाइट्रोजन स्थिरीकरण (*nifH*) अमोनिया ऑक्सीकरण (*amoA*) तथा सल्फर चयापचन (*apsA*) में सम्मिलित थे, का उपयोग करके क्लोन संग्रहालय का बनाया गया। आण्विक जातिवृत्त से हेलोबैक्टेरेसी के आद्य सदस्यों के साथ एक्टीनोबैक्टेरिया, फर्मीक्यूट्स तथा प्रोटियोबैक्टेरिया के प्रभुत्व का पता चला। इस संग्रहालय में नवीन जीवाणु (20%) तथा आद्य वंशो (38%) ने पूर्व प्राप्त अनुक्रमों के साथ ≤95% समानता दर्शायी। जातिवृत्तिक विश्लेषण ने तनाव की स्थिति में निवासी की जीवित रहने की क्षमता का संकेत दिया। 16S rRNA जीन संग्रहालयों में नवीन जीन अनुक्रम शामिल थे जो दूर से संवर्धित जीवाणु के सदृश थे। कार्यात्मक जीन संग्रहालय अद्वितीय था और ज्यादातर क्लोन प्रोटियोबैक्टेरिया से सम्बन्धित पाये गये जबकि *nifH*

जीन संग्रहालय के क्लोनों ने सायनोबैक्टेरिया तथा फर्मीक्यूट्स के साथ अनुरुपता दर्शायी। मात्रात्मक रियल टाइम PCR ने दर्शाया कि बैक्टेरिया की प्रचुरता आर्चियन परिमाण के दो गुना ज्यादा थी। जीन मात्रा निर्धारण ने संबंधित मुख्य जीन्स को आश्रय देने वाले कार्यात्मक मंडली के आकार का संकेत दिया।

अरैकिस हाइपोजिया के राइज़ोस्फीयर से *cbbL* और 16S rRNA जीन टारगेटेड मेटाजीनोमिक्स का उपयोग कर जीवाणु विविधता तथा जनसंख्या गति को भी स्थापित किया गया। राइज़ोफेरिक मिट्टी से कुल 108 *cbbL* क्लोन प्राप्त किये गये जिससे ज्ञात हुआ कि *cbbL* अनुरुप की प्रबलता, राइज़ोबियम, लेग्युमिनोसरम, ब्रेडीराइज़ोबियम जातियाँ, साइनोराइजोबियम मेलिलोटी, आक्रोबैक्ट्रम एन्थ्रोपी तथा एक असंवर्धित *cbbL* आश्रित जीवाणु जाति से सम्बद्ध थी। 16S rRNA जीन क्लोन संग्रहालय ने फर्मीक्यूट्स (34.4%), प्रोटियोबैक्टेरिया (18.3%), एक्टीनोबैक्टेरिया (17.2%) तथा बैक्टेरोइडीट्स (16.1%) का प्रभुत्व दर्शाया। 16S rRNA जीन क्लोन संग्रहालय के लगभग 43% न्यूक्लियोटाइड अनुक्रम नवीन वंशो के थे जिसने प्रकाशित अनुक्रमों के साथ <95% अनुरुपता दर्शायी। *cbbL* तथा 16S rRNA जीन्स की मात्रात्मक रियल टाइम PCR (qRT-PCR) द्वारा निर्धारित प्रतिलिपि संख्या क्रमशः $9.38\pm0.75\times10^{7}$ तथा $5.43\pm0.79\times10^{8}$ (प्रति ग्राम शुष्क मिट्टी) थी।

समुद्री जीवाणु से बाह्य कोशिकीय बहुलकी पदार्थ

अग्रकारी बायोफिल्म स्थापित करने वाले विब्रियो कैम्पवेली तथा विब्रियो फोर्टिस ने प्लान्कटोनिक संवर्धनों में क्रमशः अलग सरंचना युक्त 400 और 134 मिग्रा प्रति ली. बाह्य कोशिकीय बहुभाजीय पदार्थों (इपीएस) का उत्पादन किया। विब्रियो कैम्पवेली के इपीएस में पाँच मोनोसेकेराइड्स–एराबिनोस, गैलेक्टोज, ग्लूकोज, मैनोस और रहेमनोस शामिल थे जबकि विब्रियो फोर्टिस में केवल तीन मोनोसैकेराइड्स–एराबिनोस, गैलेक्टोज और मैनोस हैं। एएफएम के स्थलाकृति विश्लेषण ने इपीएसों की विभिन्न आकारिकी तथा भौतिक गुणधर्मों को दर्शाया। एफटीआईआर और एनएमआर स्पेक्ट्रल विश्लेषण द्वारा पॉलीसैकेराइड्स के कार्यसमूहों के गुणधर्मों का पता चला। इपीएस प्रकृति में अव्यवस्थित थे जिनकी चोटियों में विवर्तन की लाक्षणिकता निहित थी। इपीएस ने उच्च पायसीकारी गतिविधि और स्युडोप्लास्टिक रियोलॉजी दर्शायी।

ओसिनोबैसिलस इहेनिस BK6 ने लगभग 400 मिग्रा प्रति ली. इपीएस का उत्पादन किया। इपीएस के एफटीआइआर विश्लेषण द्वारा उसके विभिन्न कार्यसमूहों (हैलाइड समूह, युरोनिक एसिड तथा सेकेराइड्स) का पता चला। इसके GC-MS विश्लेषण ने दर्शाया कि बाह्यकोशिकीय पॉलीसैकेराइड्स में मैनोस (47.78%), ग्लुकोस (29.71%) तथा एरेबिनोस (22.46%) शामिल हैं। इपीएस का आणुविक द्रव्यमान 2.14×10^{6} डाल्टन था। यह उष्मीय रुप से स्थिर था और इसने स्युडोप्लास्टिक रीहोलॉजी तथा पायसीकारी गतिविधि (66.47%) दर्शायी। इपीएस ने रोग जनक स्टैफाइलोकॉकस आउरियस के प्रति जैवफिल्म प्रतिकारक क्रिया दर्शायी।

लाउरेंसिया पैपिलोसा–लालशैवाल में से मानव रोगजनक जीवाणुओं के विरुद्ध प्रतिजीवाणु गतिविधि वाला 24-शाखीय Δ5 स्टेरॉल

अड़तीस समुद्री शैवालों के मेथेनोल अर्क नमूनों का ग्राम–सकारात्मक (स्टैफाइलोकॉकस आउरियस ATCC 25923 तथा बैसिलस सुबटिलिस ATCC 6051) और ग्राम-नकारात्मक (ई. कॉलाई ATCC 8739 तथा स्यूडोमोनॉस एरुजिनोसा ATCC 9027) जीवाणुओं के लिए स्क्रीनिंग किया गया। लाउरेंसिया पैपिलोसा(सीरामियेल्स, रोडामिलेसी, रोडाफाइटा) ने इन जीवाणुओं के विरुद्ध अधिकतम जीवाणुरोधी क्रिया दर्शायी। चार ग्राम–नकारात्मक वियोजनों (ई. कोलाई, पी. एरुजिनोसा, क्लेबसिएला निमोनिया और शीजेला फ्लैसीनेरी) की रोगविषयक जांच ने जीवाणुरोधी गतिविधि दर्शायी। अर्क को कॉलम क्रोमेटोग्राफी द्वारा प्रभाजित किया गया और सक्रिय अंशों का गैस क्रोमेटोग्राफी मास स्पेक्ट्रोमेट्री (GC–MS) के उपयोग द्वारा एक कोलेस्ट्रॉल व्युत्पन्न 24-propylidene cholest-5-en-3β-ol के रुप में पहचान की गई। इलेक्ट्रोस्प्रे आयनाइजेशन मास स्पेक्ट्रोमेट्री (ESI-MS) तथा एफटी–आईआर स्पेक्ट्रोस्कोपिक विश्लेषण ने भी यौगिक की सरंचना का समर्थन किया। रोग विषयक वियोजन में न्यूनतम निरोधात्मक सांद्रता रेंज 1.2 से 1.7 माइक्रोग्राम प्रति मिली (IC_{50}) थी।

MARINE ENVIRONMENT RESEARCH

Assessment of ambient environmental quality for Dholera Special Investment Region

The baseline environmental quality was studied in the project area three times in a year, from April 2011 to March 2012 covering three seasons (Premonsoon from April 2011 to June 2011; post monsoon from September 2011 to December 2011 and winter season from December 2011 to March 2012). The summary of the results are as under



The map showing stations within the Dholera SIR region (●), peripheral of Dholera SIR (●) and coastal sampling stations (●)

The ambient air quality data indicated that particulate matter (Size less than 10 µm, PM_{10} andSize less than 2.5 µm, $PM_{2.5}$) was relatively high at Dholera throughout the year and this might be due to higher vehicular traffic. The parameters like NO_2, SO_2, CO, ozone and ammonia were well below the permissible limits while both benzene and benzo(a) pyrene were below the detection limit. Particulate metals like Ni and Pb were below the permissible limits, however, As was detected at few sampling stations. The air quality index (AQI) values of all the seasons showed that no site of the study region had severe air pollution in any season. During construction phase of special investment region (SIR), suspended solids should be controlled by sprinkling of water and by employing enclosures to construction area to allow the particles to settle

down. Approach road to the construction site should be black topped to prevent fugitive dust generation.

Noise levels at most of the stations, except few, were higher than the Central Pollution Control Board (CPCB) residential area day time noise standard. However, the significance of the anticipated noise impact is low in the study areas. To minimize the noise impact on nearby communities during construction phase, the schedules should be optimized to daytime working and the night activities should be scaled down. High noise generating equipment should not be operated simultaneously and the operation of such equipment/activities shall be avoided during night time.

Many of the ground water resources of Dholera SIR are not suitable for any domestic applications including drinking purpose. Total suspended solids (TSS) in ground water at all the sampling stations were more than the permissible limit (USEPA: 0-5 mg/L and WHO: 5 mg/L). Almost all the water samples showed high level of TDS. At most of the stations, BOD and DO values were higher and lower, respectively, than the recommended values. Potability of water with respect to microbiological analysis revealed that most of the water samples had most probable number (MPN) 1600 or >1600 number of *E.coli* /100ml, which indicate that these waters are microbiologically not suitable not only for drinking purpose but also for domestic applications. Thus, the ground water quality in the study area is very poor due to faecal contamination, high salinity and high organic load. Use of such water resources for drinking purpose will cause health hazards. Wastewater generated during construction phase from sprinkling or washing activities would contain excessive amounts of cement and other contaminants. This water shall be settled and neutralized before proper discharge. Proper sanitation facilities should be provided to the laborers during the construction phase and the sewage shall be treated through septic tank followed by soak pit system. So the overall impact on ground water environment during construction phase due to the proposed SIR will be of short term duration and insignificant.

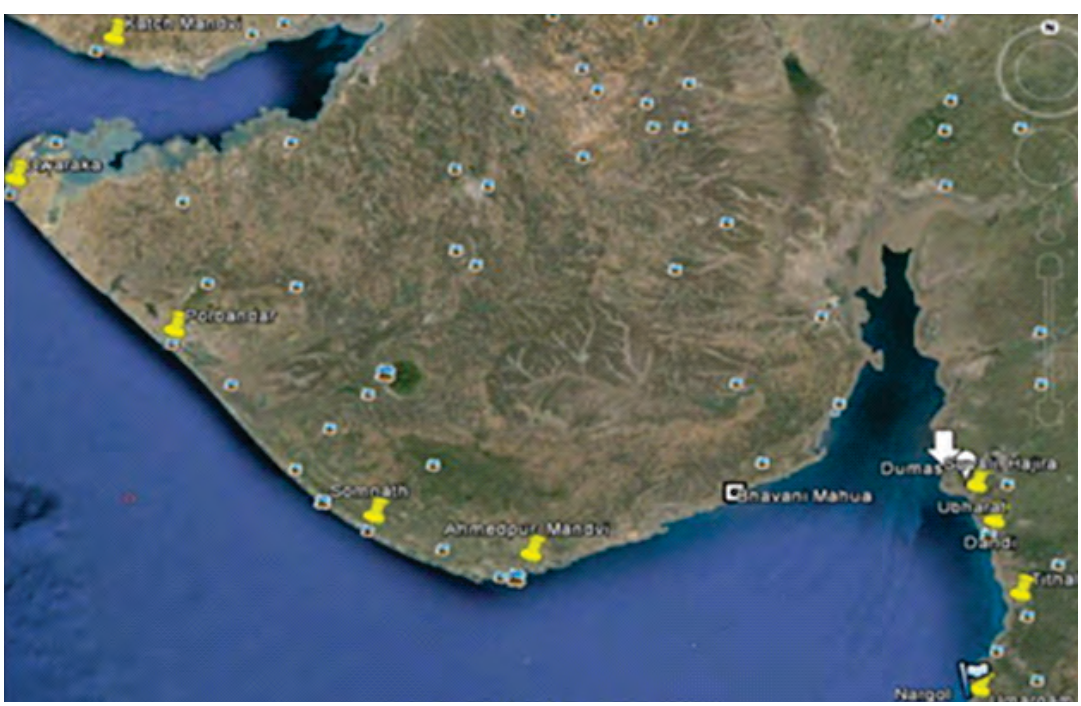
The cation exchange capacity (CEC) of soils in the study area was higher than the prescribed range. Also, sodium absorption ratio (SAR) values in all the three seasons widely varied among the sampling stations. High SAR is obviously due to salinity ingress in the region. Moreover, the conductivity values were also higher than the recommended value indicating salt affected soil. All the soil analyzed showed medium rating with respect to available nitrogen and poor rating with respect to available phosphorous. Thus, the quality of soil in the study area, especially near coastal region, is affected by salt as well as deficient in nutrients and hence not suitable in the present form for agricultural purpose. Since, the proposed SIR is on a non-agricultural land, it is not likely to alter the crop production, if any, in the study area, during the construction phase.

The physicochemical analysis of coastal water and sediment showed that most of the parameters were normal for that of the coast. In general, concentration of heavy metals in seawater were well within the permissible limit of CPCB norms for primary water quality criteria for class SW I waters. Total twenty five and fifteen different genera of phytoplankton and zooplankton, respectively, were observed in the study region. *Surirella, Coscinodiscus* sp. and *Nitzschia* sp. were abundantly present among the phytoplankton while foraminifera as the dominating group in zooplankton. Diversity index (SWDI) values for phyto-, and zooplankton indicated that the seawater quality of this region is varied between good to very good, which represent non polluted seawater. However, bacteriological analysis of seawater indicates that Dholera and Rahtalav coastal areas are relatively influenced by sewage contamination. All the wastewater including sewage during both construction and operational phase of Dholera SIR should be provided adequate treatment for meeting the prescribed norms of Gujarat Pollution Control Board (GPCB) for disposal, if any.

Study on pollution levels at various beaches of Gujarat (A consultancy project funded by GPCB, Gandhinagar

Under this project, health of total 13 beaches is to be studied for one season, with respect to tourism development. The beaches are

1	Ahmedpur-Mandvi, Dist. Junagadh	8	Tithal, Dist. Valsad
2	Somnath, Dist. Junagadh	9	Umargaon, Dist. Valsad
3	Bhavani Beach-Mahuva, Dist. Bhavnagar	10	Sultanabad-Dumas, Dist. Surat
4	Dwaraka, Dist. Jamnagar	11	Suvali-Hazira, Dist. Surat
5	Mandvi, Dist.Kutchch	12	Dandi, Dist. Navsari
6	Porbander	13	Ubhrat, Dist. Navsari
7	Nargol, Dist. Valsad		



At each beach, number of stations are fixed based on the length of the beach and also keeping in mind polluted and unpolluted areas of the beach. Seawater and sediments samples collected from each station will be analyzed for their physicochemical parameters including pesticides and biological parameters including phytoplanktons, zooplanktons, protozoa and various types of pathogenic and nonpathogenic bacteria. Beach Environmental Health Assessment (BEHA) and Beach Litter Measurement (BLM) for each beach will also be done. Beach debris is an obvious sign of the impact of human activities on the coastal environment. It is recognized as a significant pollution issue that has an array of environmental consequences. Biologically, beach debris may maim and kill wildlife and degrades habitats. The economic impacts are wide ranging with negative impacts upon both the fishing industry and recreational fishers. The loss of aesthetic values and the potential impact on human health is also of concern.

The seawater samples will be analyzed for pH, temperature, turbidity, salinity, dissolved oxygen, BOD, oil & grease, total organic carbon (TOC), NO_2-N, NO_3-N, PO_4-P and trace metals (Zn, Pb, Cd, Co, Cr, Cu, Ni, As, Mn) and pesticides/insecticides along with biological parameters where as sediment samples will be analyzed for texture, Total Organic Carbon and heavy metals (Al, As, Cr, Mn, Fe, Co, Cd, Pb, Ni, Cu, Zn) and benthic fauna. The sampling as well as analysis is under progress.

Occurrence and distribution of selected heavy metals and boron in ground water of Gulf of Khambhat region, Gujarat, India

The concentration of selected heavy metals, like As, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn as well as B, was measured by Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) in groundwater samples from various locations in Gulf of Khambhat (GoK), an inlet of the Arabian Sea in the state of Gujarat, India, during post-monsoon, winter and pre-monsoon seasons in a year. Most of the heavy elements are characterised by low mobility under slightly alkaline and reducing conditions; concentrations in confined aquifers are within the Maximum Permissible values for drinking water. The temporal changes indicate that a majority of metals is entering the aquifer during monsoon. Principle component analysis of the heavy metal data suggest that Co, Cu, Cd and Zn are interrelated with each other and derived significantly from anthropogenic route, while input of Pb and Cr may be due to atmospheric deposition in the study area. Both weathering of rocks and anthropogenic input were found to be the main sources of elements in the ground water. The heavy metal levels in ground waters of GoK region in comparison with some of European and Asian sites were higher; however, these metal levels were found to be comparable with few urban sites in the world.

Biosorption of ammoniacal nitrogen from aqueous solutions with low cost biomaterials: Kinetics and optimization of contact time

The biosorption of ammoniacal nitrogen ($N\text{-}NH_4^+$) from aqueous solutions by dead biomass of brown seaweed *Cystoseira indica* and *Jatropha* oil cake (JOC), which is generated in the process of biodiesel recovery from its seeds, was studied. The $N\text{-}NH_4^+$ biosorption was strictly pH dependent, and maximum uptake capacity of *C.indica* (15.21 mg/g) and JOC (13.59 mg/g) was observed at initial pH 7 and 3, respectively. The generalised rate model and pseudo-second-order kinetic models described the biosorption kinetics accurately and the sorption process was found to be controlled by pore and surface diffusion for these biosorbents. Results of four-stage batch biosorber design analysis revealed that the required time for the removal of 40 mg/L $N\text{-}NH_4^+$ from 500 L of aqueous solution with 99% efficiencies were 76 and 96 min for *C.indica* and JOC, respectively.

Efficient removal of phosphate from aqueous solutions by red seaweed, *Kappaphycus alverezii*

Dead biomass of marine macro algae, *Kappaphycus alverezii* (*K. alverezii)* was used for the removal of phosphate from water. The effect of different parameters such as contact time, adsorbate concentration, biosorbent dose and temperature was investigated. The biosorption kinetics data were best described by the pseudo-second order rate equation, and equilibrium was achieved after 80 min. The phosphate biosorption was governed by film diffusion process. The maximum phosphate biosorption on *K.alverezii* was 59.77 mg/g at 25 °C and it followed the Redlich-Peterson model. The biosorption on *K.alverezii* increased with increasing temperature and was the highest at pH 6.0.

Occurrence of *K. alvarezii* in Gulf of Mannar

The survey was conducted in and around seven islands of Gulf of Mannar (six in Mandapam group and one in Kilakarai group), namely; Single island, Krusadai island, Poomarichand island, Pullivasal island, Manali island, Hare island and Mulli island during February to August, 2013. The establishment of *Kappaphycus* has been restricted only to Krusadai island, while the drifted fragments were colelcted from Mulli island and Hare island. The drifted alga was also collected from north-east side of Krusadai island. The extensive survey was conducted in all these islands for the first time.

About 2.16 sq km area was surveyed in Manali

island, the macro-algal diversity was recorded at 24 locations where *Turbinaria decurrens, Halimeda gracilis, Sargassum tenerrimum*and seagrass*Enhallus acoroides*constituted maximum canopy cover. The drifted *Kappaphycu* fragmts was also recored from Hare island. About 2.14 sq km area was surveyed in Hare island. The macro-algal diversity was recorded at 45 locations.*Sargassum polycystum, Padina boergessnii*and*Halimeda gracilis*constituted maximum canopy cover.

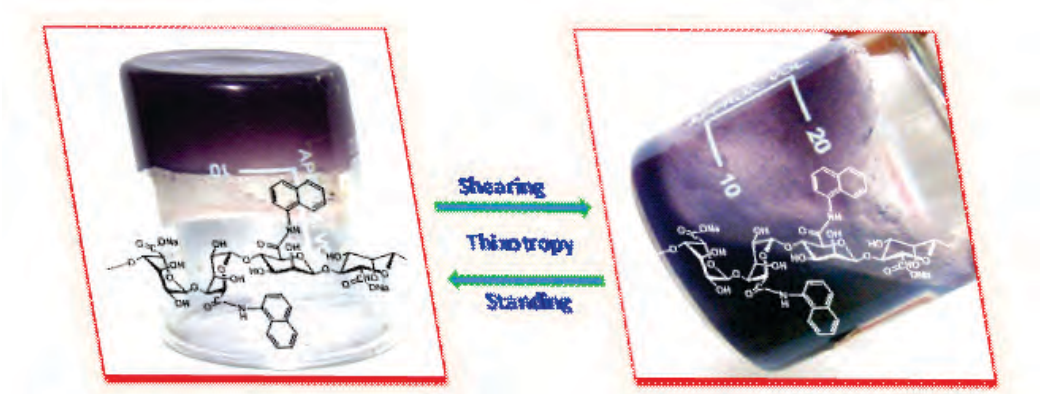
About 0.60 sq km area was surveyed in Mulli island. The macro-algal diversity was recorded at 20 locations *Sargassum polycystum, Caulerpa racemosa* and *Halimeda gracilis*constituted maximum canopy cover. Patterson and Bhatt (2010) in their report stated that fragments of *K. alvarezii* drifted away from commercial cultivation grounds along the South Palk bay have invaded and established at Shingle Island. They have estimated that about 0.20 sq km area was occupied by this alga. About 0.60 sq km area was surveyed in this island.

NATURAL PRODUCTS CHEMISTRY

Sustainable approaches towards value addition to natural polymers

Studies on the structure-property relationship of sodium alginate based thixotropic hydrogels

Sodium alginate (Na-Alg) was reacted with 1-naphthylamine in the presence of 1-ethyl-3-[3-(dimethylamino)-propyl]-carbodiimide hydrochloride (EDC/HCl) affording an amide derivative capable of forming soft hydrogel at a concentration of 4% w/v. The latter upon gentle stirring turned into a viscous sol, which assumed the original gel structure upon standing at room temperature in a reversible process. Such thixotropic materials have the potential to be used in biomedical applications and as sensors (*RSC-Advances. (2013), 3, 15744-15751*).

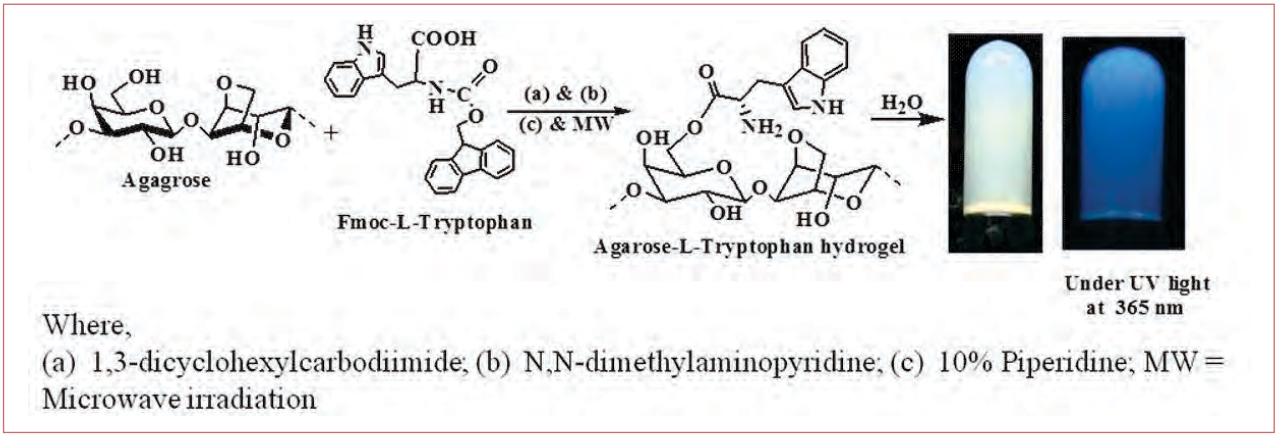


1-Naphthylamine functionalized sodium alginate hydrogel exhibiting thixotropic property

Functional modification of agarose: A facile synthesis of a fluorescent agarose-tryptophan based hydrogel

Microwave assisted facile synthesis of a fluorescent agarose-L-tryptophan hydrogel material employing carbodiimide chemistry (dicyclohexylcarbodiimide/4-dimethylaminopyridine; DCC/DMAP) was prepared. The product formed fluorescent hydrogel at 1–1.5% (w/v), exhibiting fluorescence emission in water ($_{max}$ 350 nm; 1 × 10^{-4} M), which was significantly higher (ca. 65%) than that of tryptophan at the same concentration. Subsequently, the agarose ester was cross linked with the natural cross linker genipin to yield a blue hydrogel (G-Ag-TrpEst), confirming thereby the insertion of tryptophan moiety on to

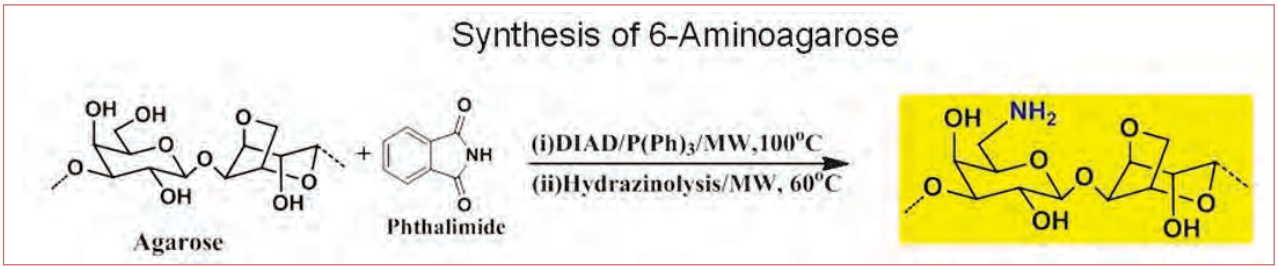
agarose backbone. Both the ester and cross linked hydrogels demonstrated gelling characteristics similar to agarose and were stable across a wide range of pH media (pHs 1.2, 7.0 and 12.5) under ambient conditions. These tryptophan containing fluorescent hydrogel materials may find applications in biomedical and pharmaceutical industries as potential radical scavengers and sensors(*Carbohydr Polym. (2013), 97,165-171*).



L-Tryptophan functionalized agarose hydrogel exhibiting fluorogenic property

Modification of agarose: 6-Aminoagarose mediated syntheses of fluorogenic pyridine carboxylic acid amides

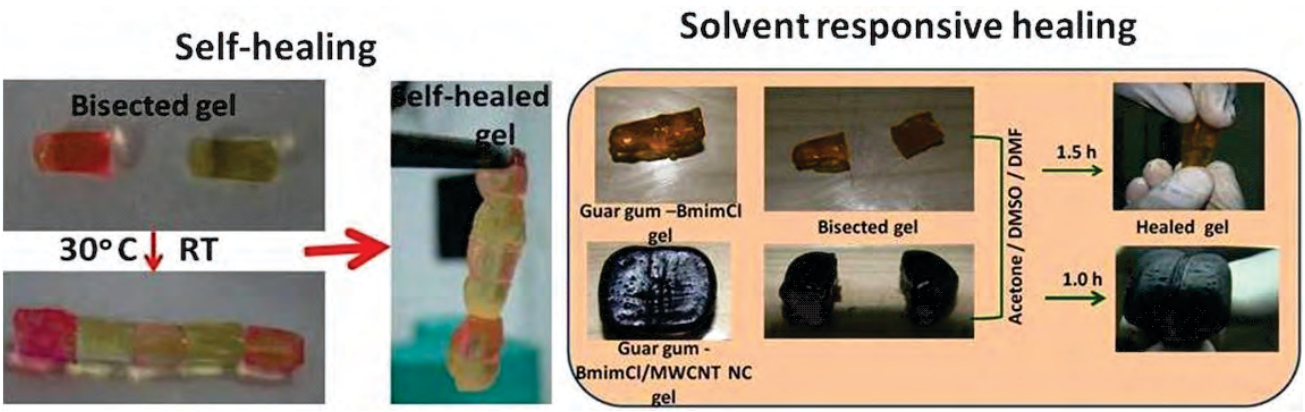
A facile 6-aminoagarose (AA) mediated synthesis of new fluorogenic amides of agarose with nicotinic (AA-NA) and picolinic acids (AA-PA) employing carbodiimide chemistry was developed. 6-Amino agarose (AA) was synthesized in a facile Mitsunobu-inspired microwave mediated method involving the reaction of agarose with phthalimide in presence of diisopropyl azodicarboxylate and triphenylphosphene (DIAD/TPP) followed by hydrazinolysis. The fluorescence emissions (max 430 and 412 nm) of 1×10^{-3} M solutions of AA-NA and AA-PA in water were significantly higher (ca. 82% and ca. 90%) than those of the molar equivalents (0.2 mg) of NA and PA present in the 1×10^{-3}M solutions of the amides, respectively. These fluorogenic pyridine carboxylic acid amides of agarose may find applications as sensors in biomedical and pharmaceutical industries (*Carbohydr Polym.(2014), 106, 365–373*).



Synthesis of 6-aminoagarose

Self and solvent responsive guar gum and guar gum-multiwalled carbon nanotubes nanocomposite gels prepared in an ionic liquid

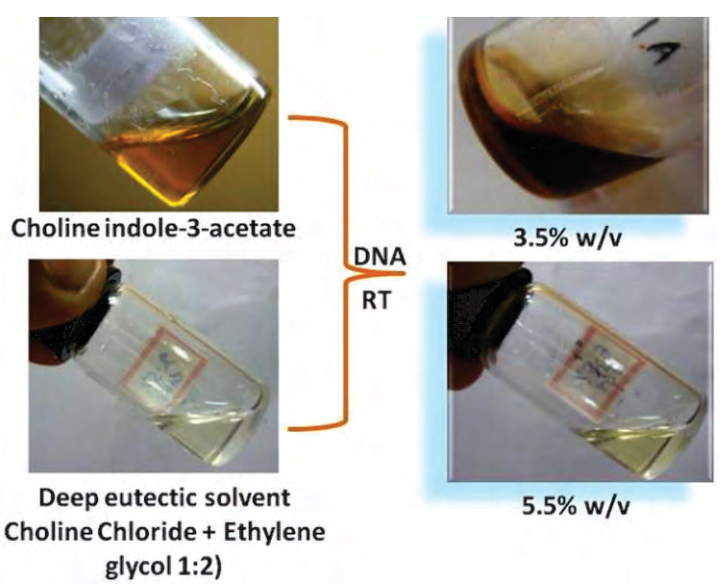
Guar gum formed a soft viscoelastic gel in 1-butyl-3-methylimidazolium chloride, an ionic liquid at an optimized concentration of 10% *w/v*. A nanocomposite gel of the gum with enhanced strength could be prepared with 0.2% *w/v* of multiwalled carbon nanotubes (MWCNT) in the ionic liquid. The gel showed self-healing ability upon complete bisection. The above gel also showed healing ability in presence of three polar aprotic solvents namely acetone, dimethylsulphoxide and dimethylformamide (*Carbohydr Polym. (2013), 98, 1025-1030 ; RSC Adv. (2013), 3, 16509 – 16515*).



Self and solvent responsive healing of guar gum ion gel prepared in 1-methyl-3-butylimidazolium chloride.

Rapid dissolution of DNA in bio-based ionic liquid and deep eutectic solvents with long-term structural and chemical stability

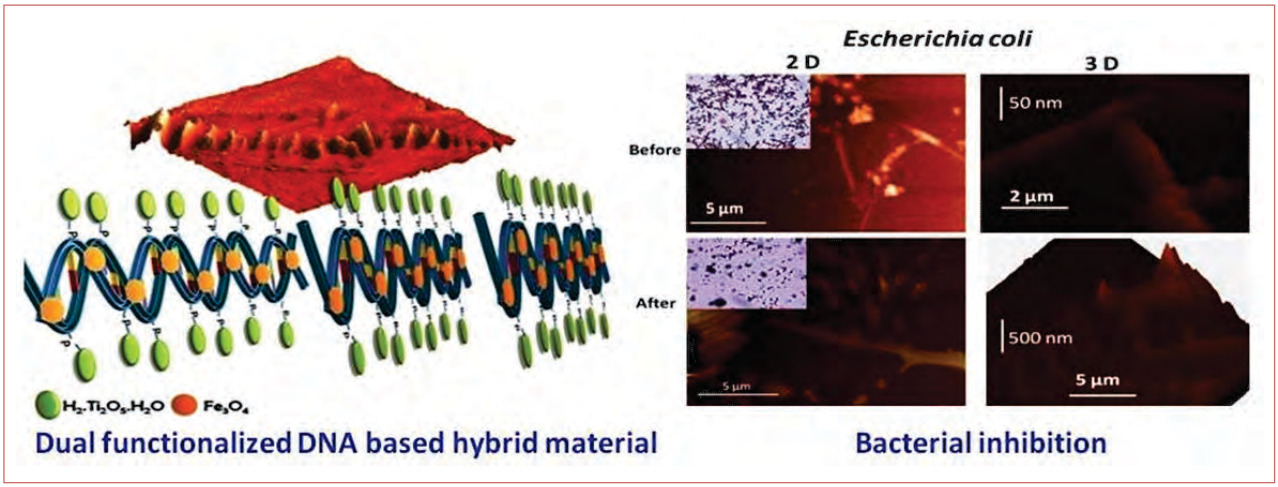
DNA from salmon testes was solubilised in two bio-based ionic liquids up to 3.5% *w/w* in 6 h at room temperature. No structural degradation of the polymer molecule was observed for the sample solubilised in choline-indole-3-acetate (chol-IAA) However, the molecule was found to be degraded in choline-indole-3-butyrate (chol-IBA). Further, the dissolution of the same DNA was increased upto 5.5% w/w in a deep eutectic solvent consisting of the mixture of choline chloride and ethylene glycol. The long-term chemical and structural stability of the bio-macromolecule was observed up to six months of storage at roomtemperature in the DES as well *(Chem Commun. (2013), 49, 6849 – 6851; Chem Commun.(2013), 49, 9606-9608).*



Dissolution of DNA in bio-ionic liquid and deep eutectic solvent.

A facile approach to prepare dual functionalized DNA based material in a bio- deep eutectic solvent

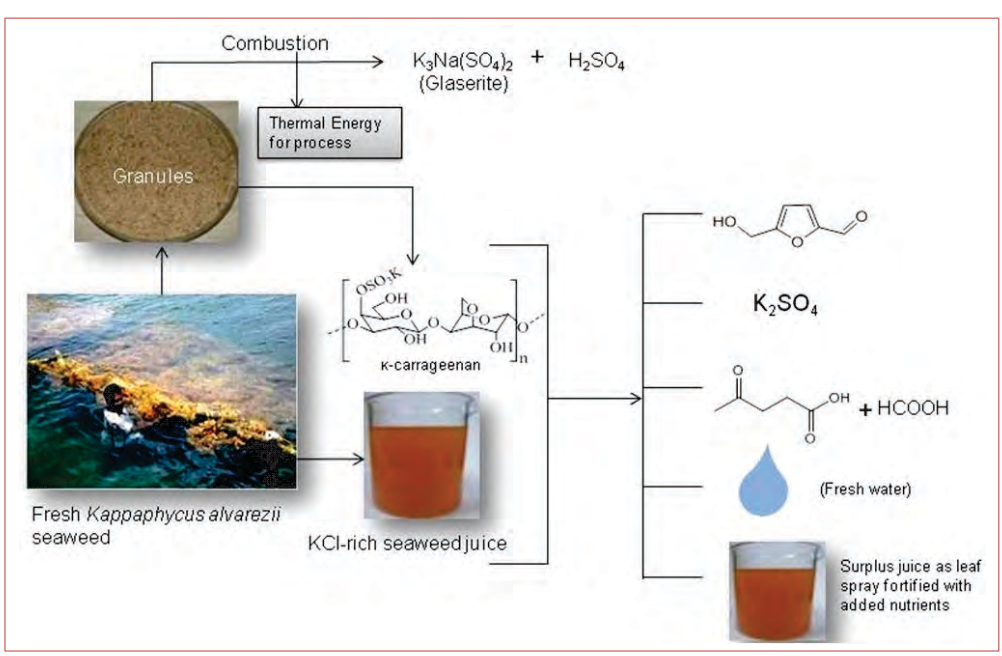
DNA (Salmon testes) was functionalized by Fe_3O_4 nanoparticles and protonated layered dititanate sheets ($H_2.Ti_2O_5.H_2O$) in the mixture of choline chloride and ethylene glycol to yield a hybrid material having magnetic and anti-bacterial properties. Ti sheets were found to interact with the phosphate moieties, while Fe interacted with the base pair of DNA in the hybrid material(*Chem Commun.(2014), 50, 3989-3992*).



Functionalized DNA based material having magnetic and anti-microbial properties.

Fuelintermediates, agricultural nutrients and pure water from *Kappaphycus alvarezii*seaweed

A standalone integrated scheme for the production of 5-hydroxymethyl furfural (HMF) and potassium sulphate (K_2SO_4) from granular biomass rich in the sulphated polysaccharide, -carrageenan was developed. Fresh *Kappaphycus alvarezii* seaweed was crushed to expel the juice rich in KCl (0.7 m^3/ton of fresh seaweed) and granular biomass (0.04 t dry weight/ton of fresh seaweed)(*RSC Adv. (2013), 3, 17989-17997*).

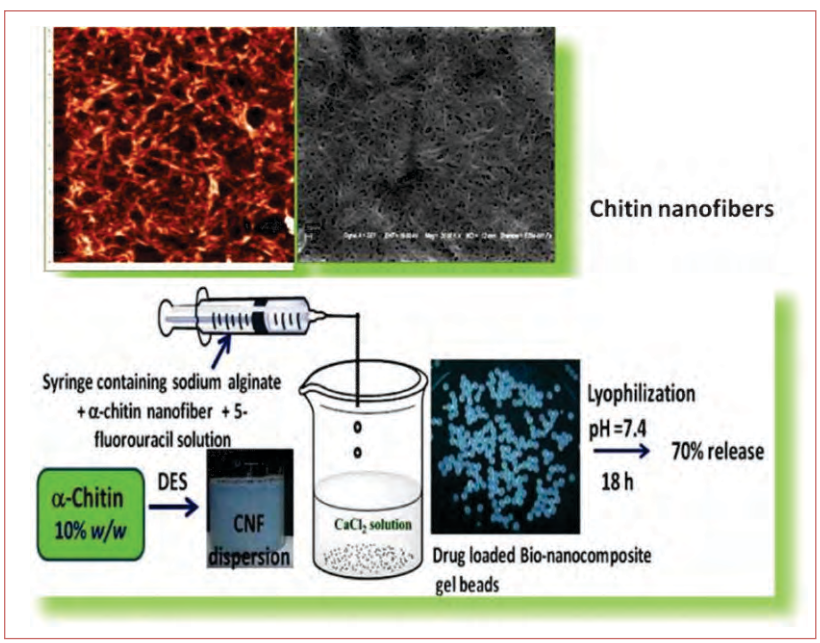


Multiple products from *Kappaphycusalvarezii*

Dissolution of chitin in deep eutectic solvents and preparation of chitin nanofibers

Deep eutectic solvents (DESs) consisting of the mixtures of choline halide (chloride/bromide)-urea, choline chloride-thiourea, chlorocholine chloride-urea and glycine betainehydrochloride-urea were found to be effective solvent systems for -chitin. Maximum dissolution of the biopolymer (9% *w/w*) was observed in the DES consisting of choline chloride-thiourea. DESs consisting of the mixtures of choline halide (chloride/bromide)-urea and choline chloride-thiourea were used as solvents to prepare α-chitin nanofibers (CNFs). CNFs of diameter 20-30 nm could be obtained using the DESs comprising of the mixture of choline chloride and thiourea. The CNFs obtained using the DES as a solvent were used to prepare calcium alginate bio-

nanocomposite gel beads having enhanced elasticity in comparison to Ca-alginate beads. The bio-nanocomposite gel beads thus obtained were used to study slow release of 5-fluorouracil, an anticancer drug (*RSCAdv.(2013), 3, 18149 – 18155; Carbohydr Polym. (2014), 103, 466-471*).



Chitin nano fibers and its application

Work done in the collaborative project between CSMCRI and Jamnalal Bajaj Tropical Disease Research Centre, Sevagram entitled "Antitubercular bioassays of plant and marine algal extracts"

Preparation of anti-TB active crude extracts of *Salicornia Brachiata*

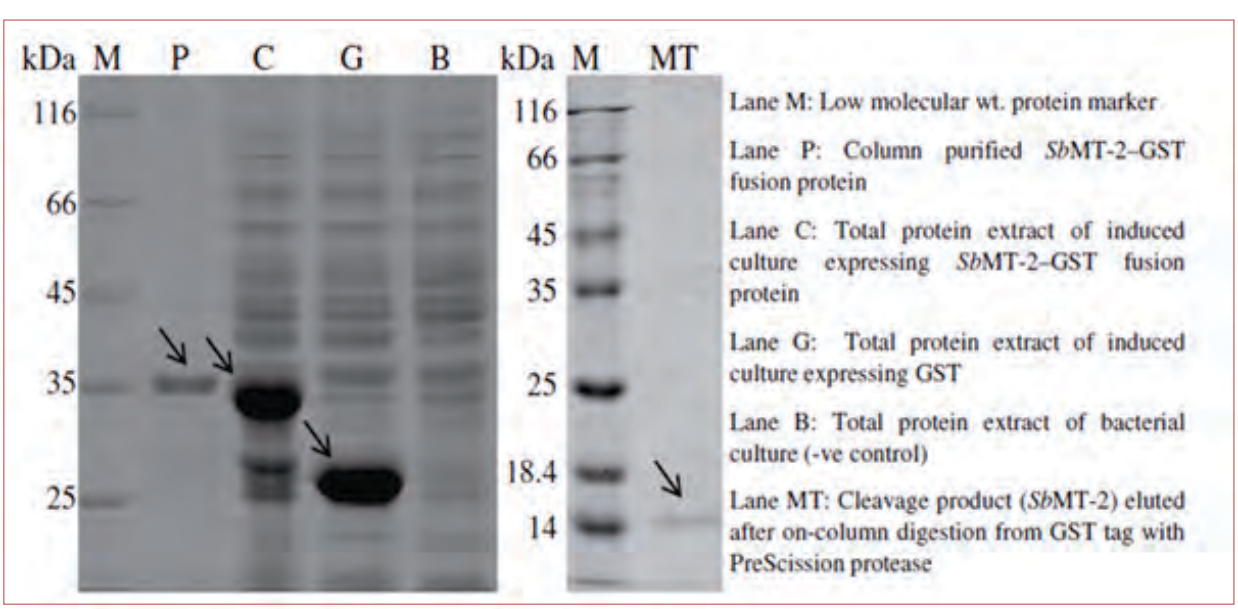
Crude aqueous extracts and water extracts of the root containing molecules of MW higher than 1200 and lower than 1200 were prepared of *Salicorniabrachiata* collected five times of its different life stage during October 2012 to December 2013 and were sent to JBTDR for activity by in-house developed SEVA TB ELISA for detecting anti TB drug potential using ES-31 antigen of *Mycobacterium tuberculosis* and its specific antibody. Isoniazid was used as a standard inhibitor. Further the samples were tested with axenic culture of avirulent M.Tb bacilli H_{37} Ra using INH and rifampicin as standard inhibitory drugs. Further confirmation was also done by % MTT assay. The samples containing polar and non-polar compounds showed about 85-95 % inhibition in MTT assay.

MOLECULAR BIOLOGY AND BIOTECHNOLOGY

Cloning, characterization and transformation of abiotic stress responsive genes from *Salicornia brachiata*: an extreme halophyte

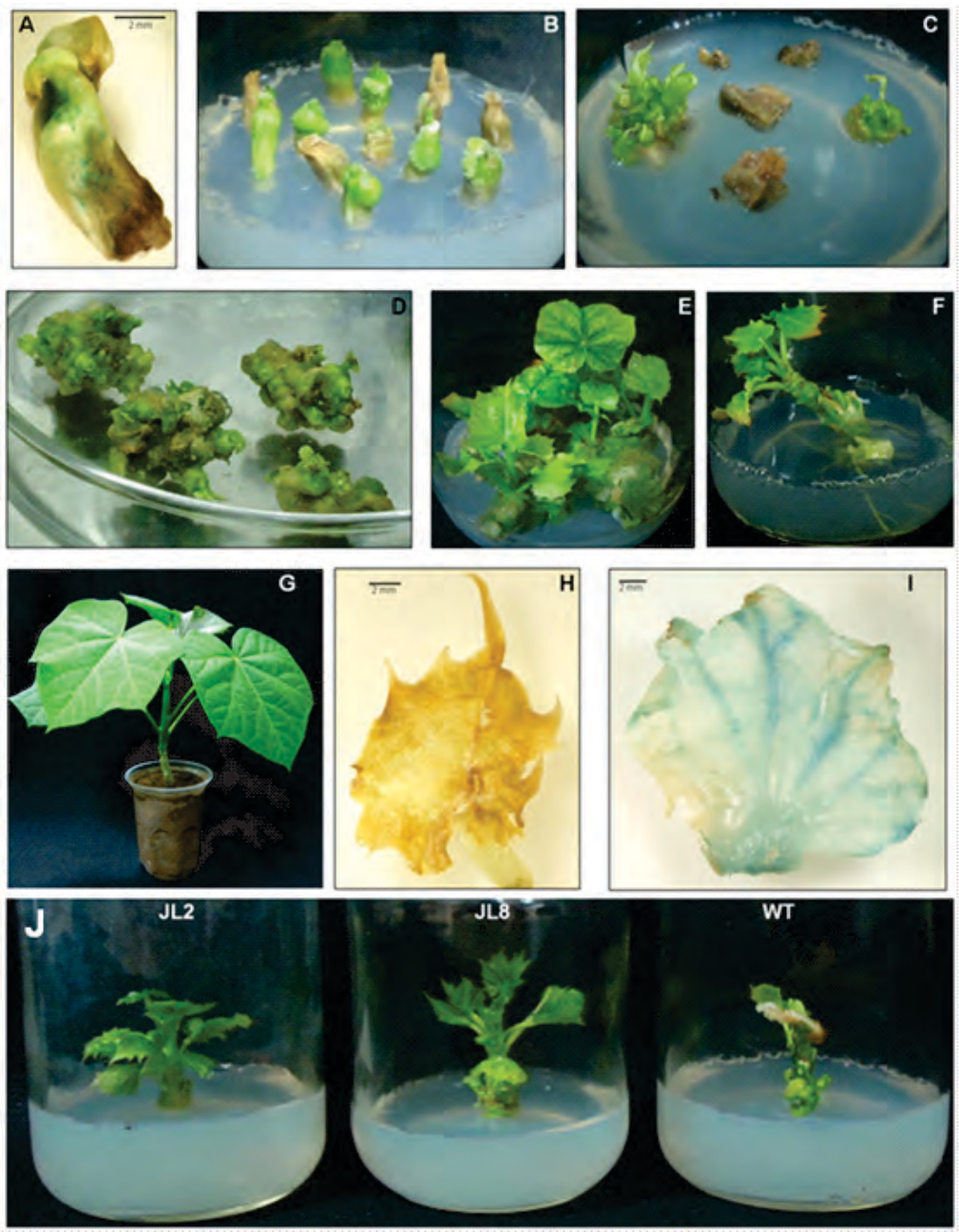
Salicornia brachiata is a leaf-less annual succulent, one of the most salt tolerant plant, capable of growing under highly saline conditions on salt marshes and can accumulate NaCl as much as 30-40% on dry weight basis. *S. brachiata* is one of the major gene resources for stress responsive genes and considered as a potential alternative crop for seawater agriculture. Several genes, *SbMT-2* (metallothionein gene type 2), *SbNHX1* (Na^+/H^+ antiporter), *SbUSP* (universal stress protein gene), *SbpAPX*) (peroxisomal ascorbate peroxidase) and *SbSI*-2 (salt-inducible) were cloned, characterized and *in-planta* transformed.

Transcript analysis of *SbMT-2* and its heterologous expression in *E. coli* was carried out. Expression of *SbMT-2* gene was up-regulated concurrently with zinc, copper, salt, heat and drought stress, down regulated by cold stress while unaffected under cadmium stress. Heterologous expression of *SbMT-2* gene enhanced metal accumulation and tolerance in *E. coli*. Metal-binding characteristics of *SbMT-2* protein show its possible role in homeostasis and/or detoxification of heavy metals. Significant tolerance was observed by *E. coli* cells expressing recombinant *SbMT-2* for Zn^{++}, Cu^{++} and Cd^{++} compared to cells expressing glutathione S-transferase (GST) only. Sequestration of zinc was 4-fold higher compared to copper and in contrast *SbMT-2* inhibits the relative accumulation of cadmium by 1.23-fold compared to GST protein. Fusion protein *SbMT-2* showed utmost affinity to zinc (approx. 2.5 fold to Cu^{++} and Cd^{++}) followed by Cu and Cd ions with same affinity *(Gene (2012,)499, 280–287*).



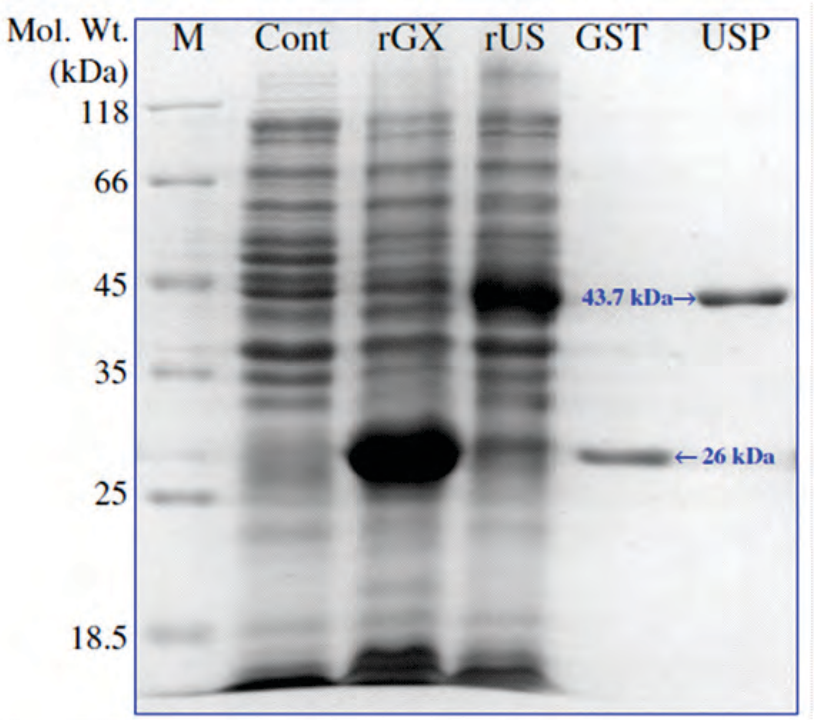
Over-expression of *SbMT-2*–GST fusion protein in *E. coli*. SDS-PAGE of *SbMT-2*–GST fusion protein and GST protein induced by IPTG (1 mM) and isolated at 6 h of the induction from *E. coli* cells.

Transgenic plants of *Jatropha curcas* with the *SbNHX1* gene were developed using microprojectile bombardment mediated transformation. Integration of the transgene was confirmed by PCR and Rt-PCR and the copy number was determined by real time qPCR. Salt tolerance of the transgenic lines JL2, JL8 and JL19 were confirmed by leaf senescence assay, chlorophyll estimation, plant growth, ion content, electrolyte leakage and malondialdehyde (MDA) content analysis. Transgenic lines showed better salt tolerance than WT up to 200 mM NaCl (*PLOS ONE (2013,) 8, e71136*).



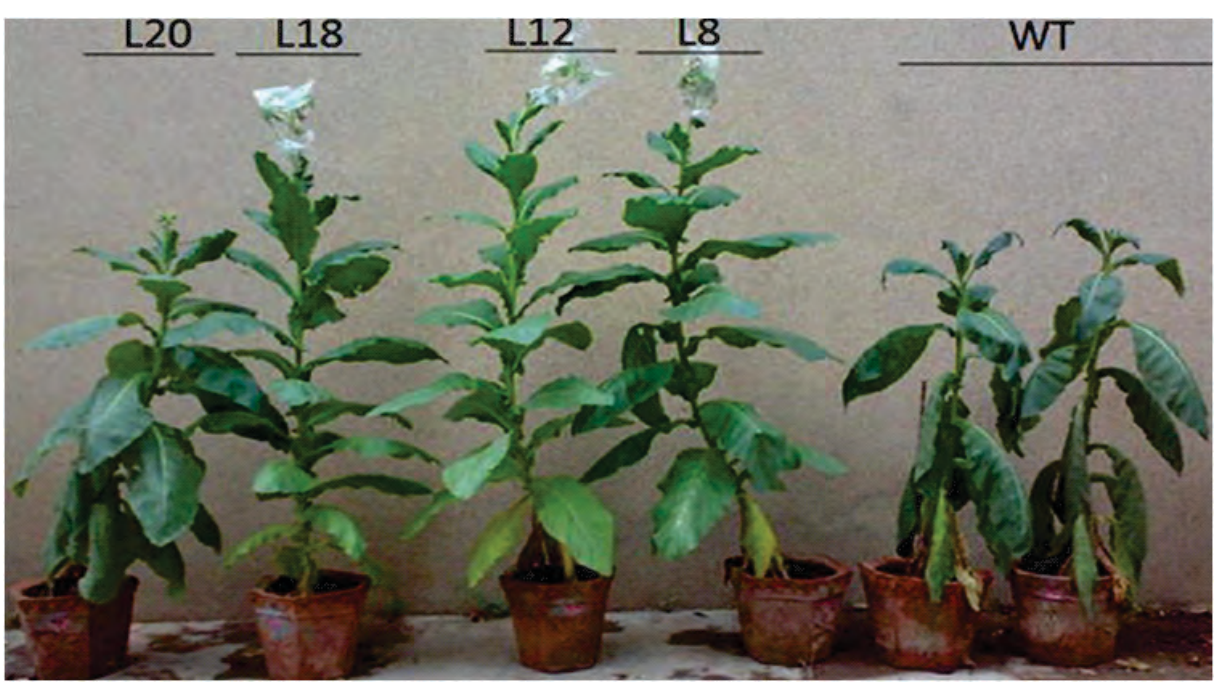
Genetic transformation of *J. curcas* via microprojectile bombardment. (A) Transient gus expression on embryo axis after 24 h of bombardment. Selection of transformants (B) during 1st round (8 days old), (C) during 3rd round (60 days old) on hygromycin. Generation of transformants; (D) multiple shoot induction, (E) multiple shoot regeneration (120 days old), (F) rooting (200 days old), (G) hardening of transgenic plant in plastic jar (250 days old). GUS assay of (H) non transformed leaf, (I) leaf of transgenic plant and (J) effect of 200 mM NaCl on *in vitro* growing transgenic lines JL2 and JL8, and WT after 21 days.

The full length *SbUSP* gene contained an open reading frame (ORF) of 486 bp encoding for a protein that belongs to the universal stress protein (USP) family. The *SbUSP* interacted with adenosine monophosphate and exhibited characteristic motifs, phosphorylation, glycosylation and ATP binding sites. *In planta* transcript profiling exhibited a significant expression response (7.8-fold) to salt stress, additionally abundant of *SbUSP* transcripts were observed during drought, heat and cold stress, reaching a maximum increase of 3.66-, 2.64- and 2.14-fold, respectively, at 12 or 24 h. The heterologous expression of this gene in *Escherichia coli* provided enhanced stress tolerance and recombinant cells have higher growth rate compared to vector alone and showed growth at up to a 10^{-5} dilution in the spot assay (*Gene (2014), 536, 163–170*).



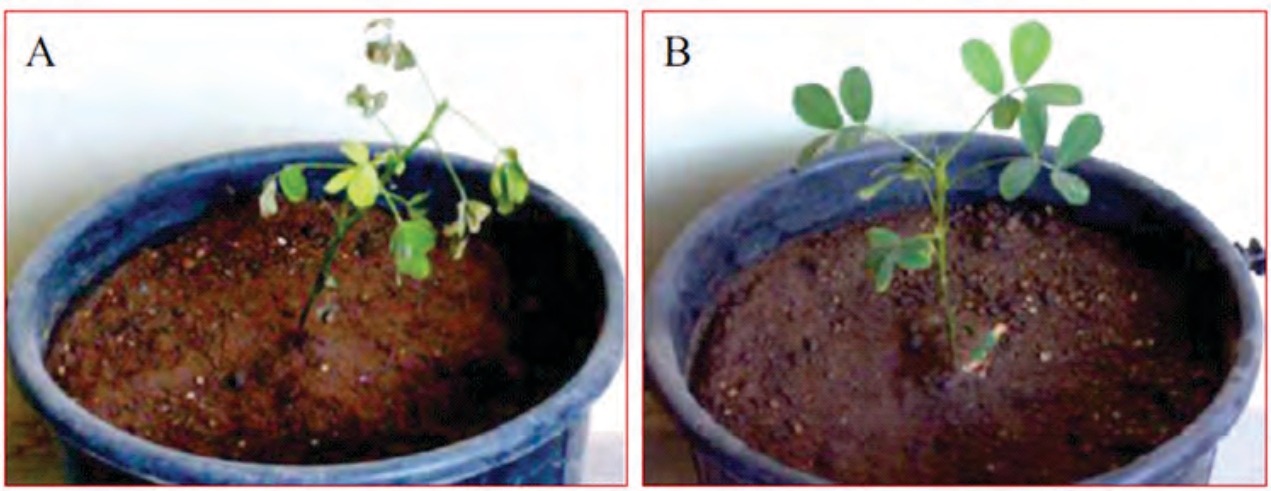
Over-expression of SbUSP–GST fusion protein in E. coli. (a) SDS-PAGE of SbUSP–GST fusion protein andGST protein induced by IPTG (1 mM) and isolated at 6 h of the induction from E. coli cells. Protein extracted from bacterial cells alone (cont; bacterial cell control), harboring pGEX vector (rGX; vector control) or fused vector (rUS). M: molecular weight protein marker, GST: purified GST protein (26 kDa) and USP: purified SbUSP–GST fusion protein (43.7 kDa).

The *SbpAPX* gene was transformed to tobacco for their functional validation under stresses. Transgenic plants over-expressing *SbpAPX* gene showed enhanced salt and drought stress tolerance compared to wild-type plants. Transgenic plants showed enhanced vegetative growth and germination rate both under normal and stressed conditions (*Mar. Biotechnol. (2014), 16,321–332*).



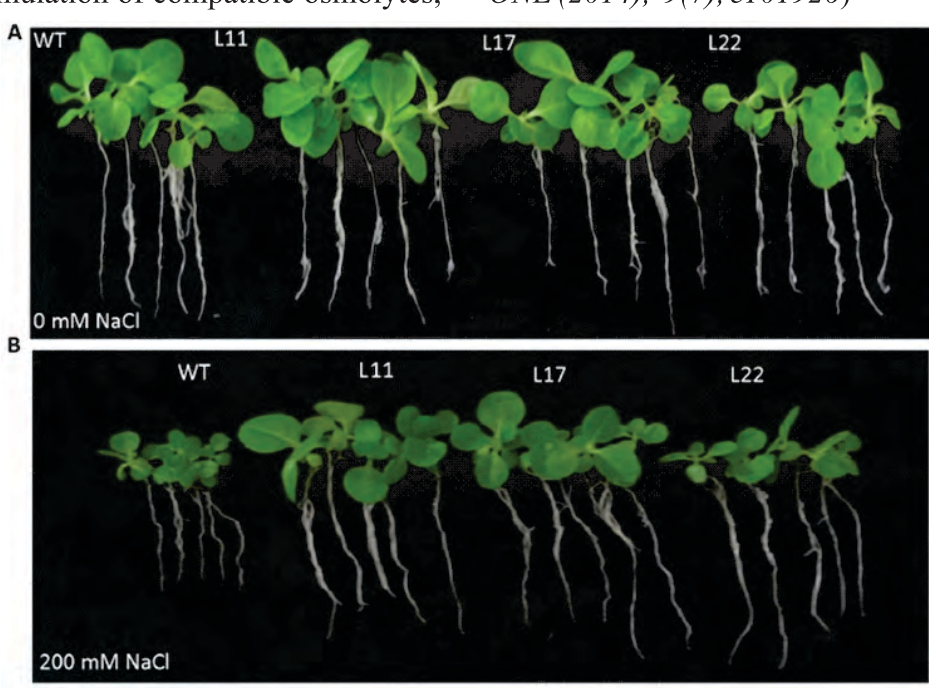
Phenotypes of *SbpAPX* T_1 transgenic lines and WT tobacco plant under prolonged NaCl stress. WT and four independent T_1 transgenic tobacco plants (L8, L12, L18 and L20) grown for 6 weeks and then subjected to 200 mM NaCl stress treatment for 28 days

Similarly, cloned *SbpAPX* gene was also transformed to local variety of peanut and about 40 transgenic plants (T_1) were selected randomly and subjected for salt stress tolerance study. Transgenic plants remained green however non-transgenic plants showed bleaching and yellowish leaves under salt stress conditions. Under stress condition, transgenic plants continued normal growth and completed their life cycle. Transgenic peanut plants exhibited adequate tolerance under salt stress condition and thus could be explored for the cultivation in salt affected areas for the sustainable agriculture (*Gene (2014,) 547, 119–125*)



Effect of salt stress on peanut transgenic line (T_1) and control plant. Phenotype of the wild type (WT) plant (A) and transgenic plant (B) after 14 days of 150 mM NaCl treatment.

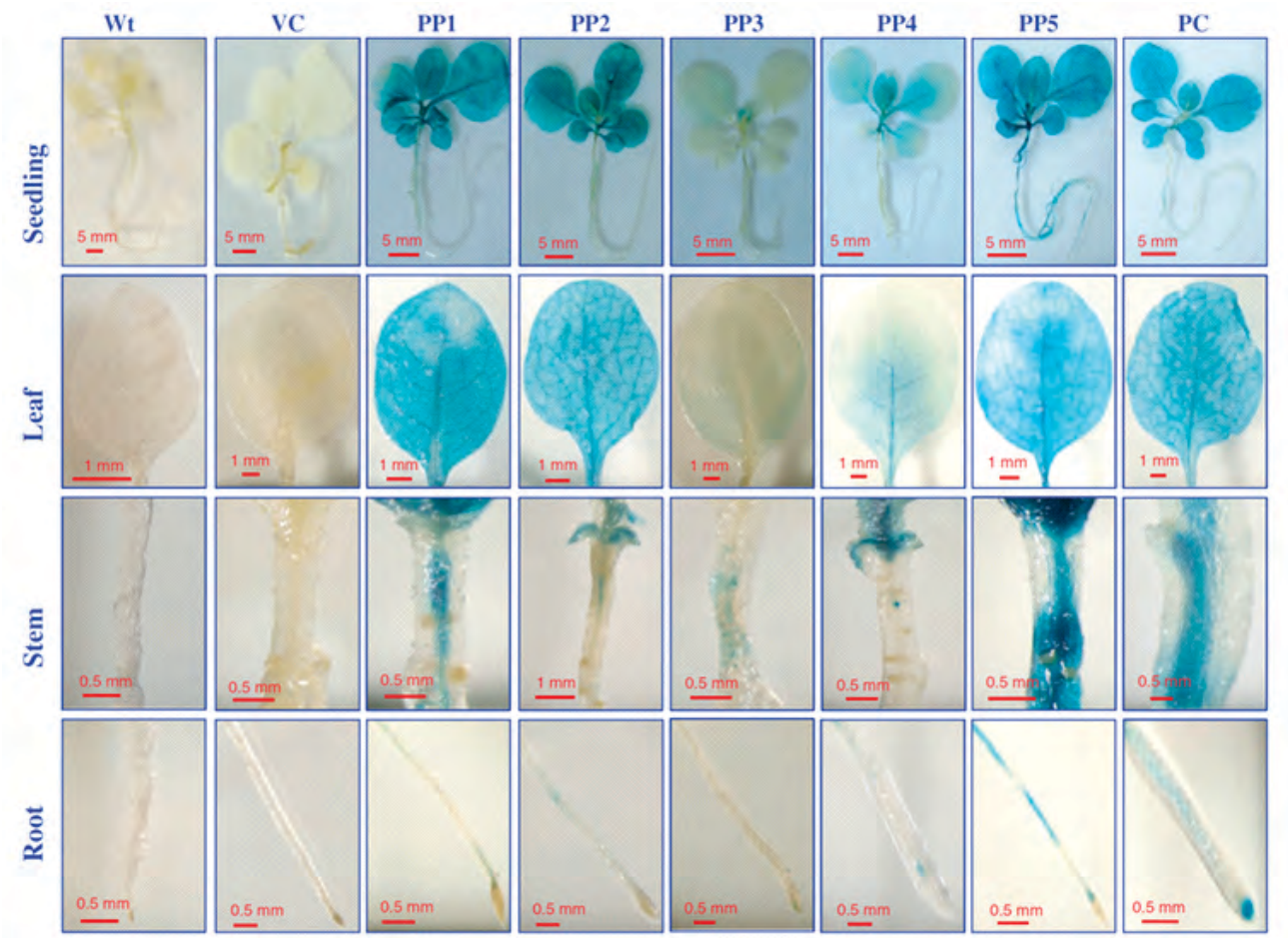
A novel salt-inducible gene *SbSI-2* was selected and transformed in *E. coli* and tobacco for functional characterization. Transgenic tobacco plants overexpressing *SbSI-2* have improved salt- and osmotic tolerance, accompanied by better growth parameters, higher relative water content, elevated accumulation of compatible osmolytes, lower Na^+ and reactive oxygen species (ROS) accumulation and lesser electrolyte leakage than the wild-type. Overexpression of the *SbSI-2* also enhanced transcript levels of ROS-scavenging genes and some stress-related transcription factors under salt and osmotic stresses. (*PLOS ONE (2014), 9(7), e101926*)



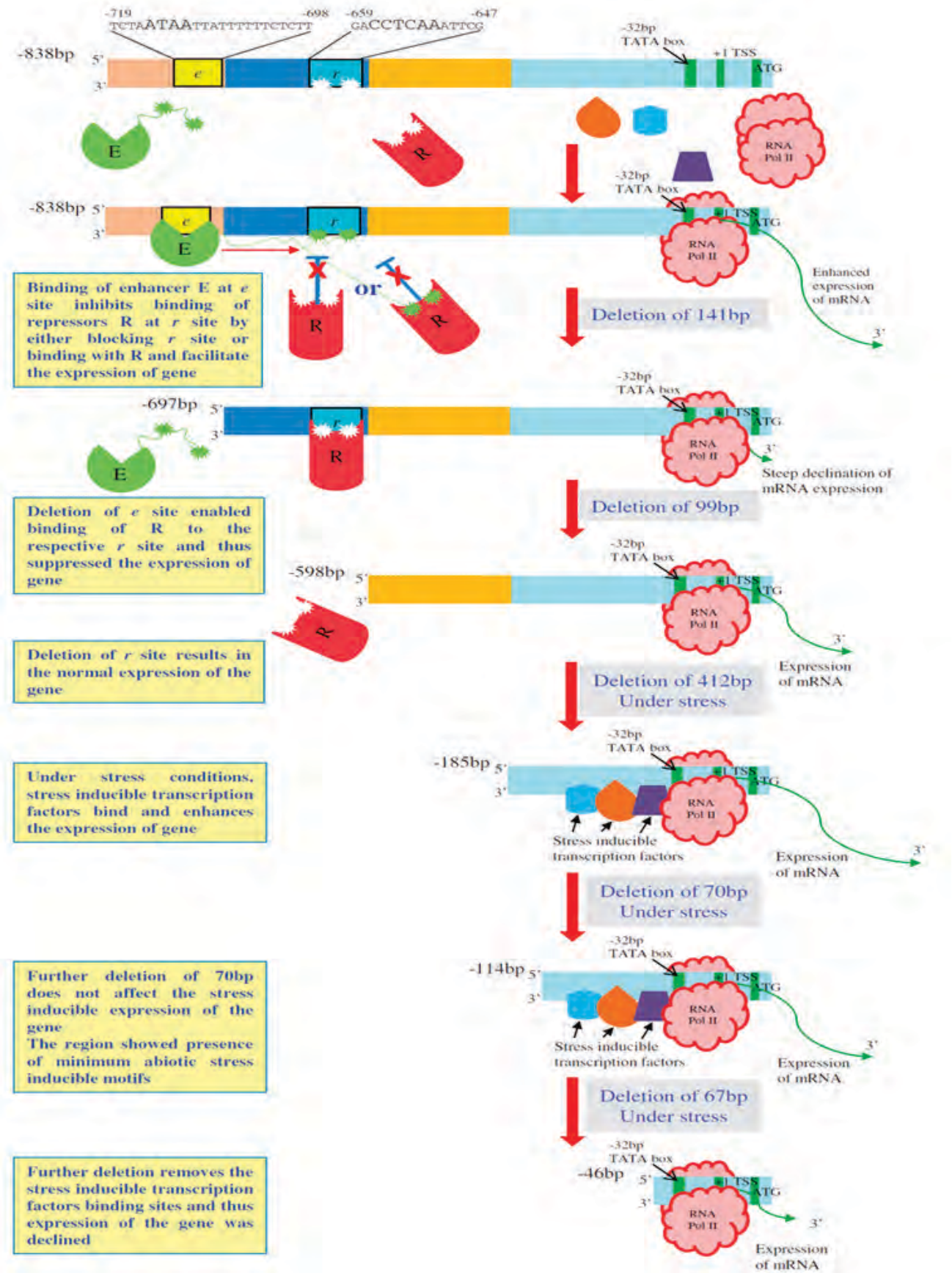
Phenotypic comparison of the growth of WT and transgenic lines overexpressing the SbSI-2 gene under salt stress. Growth comparison of transgenic lines (L11, L17 and L22) and WT seedlings after 30 days in (A) 0 mM, and (B) 200 mM NaCl

The transcriptional regulatory mechanism of the peroxisomal ascorbate peroxidase (*pAPX*) gene

Quantitative expression analysis of GUS in T_1 plants revealed that promoter PP5 is efficient for gene expression. *In planta* transient expression further suggested that the promoter PP5 contains efficient stress-inducible elements. A steep decline in GUS expression in PP3, and thereafter an elevated expression in PP4 and PP5, suggested the presence of a repressor element between -696 and -433 bp, while an enhancer element was predicted between -838 and -697 bp. Further, transient expression analyses and electrophoretic mobility shift assay revealed that the core sequence of *cis*-acting motifs ATAA and CCTCAA function as enhancer and repressor binding sites, respectively. Based on the study, a model is proposed for the *cis*-regulation of the *SbpAPX* gene (*Plant Cell Physiol. (2014).55: 201–217*)



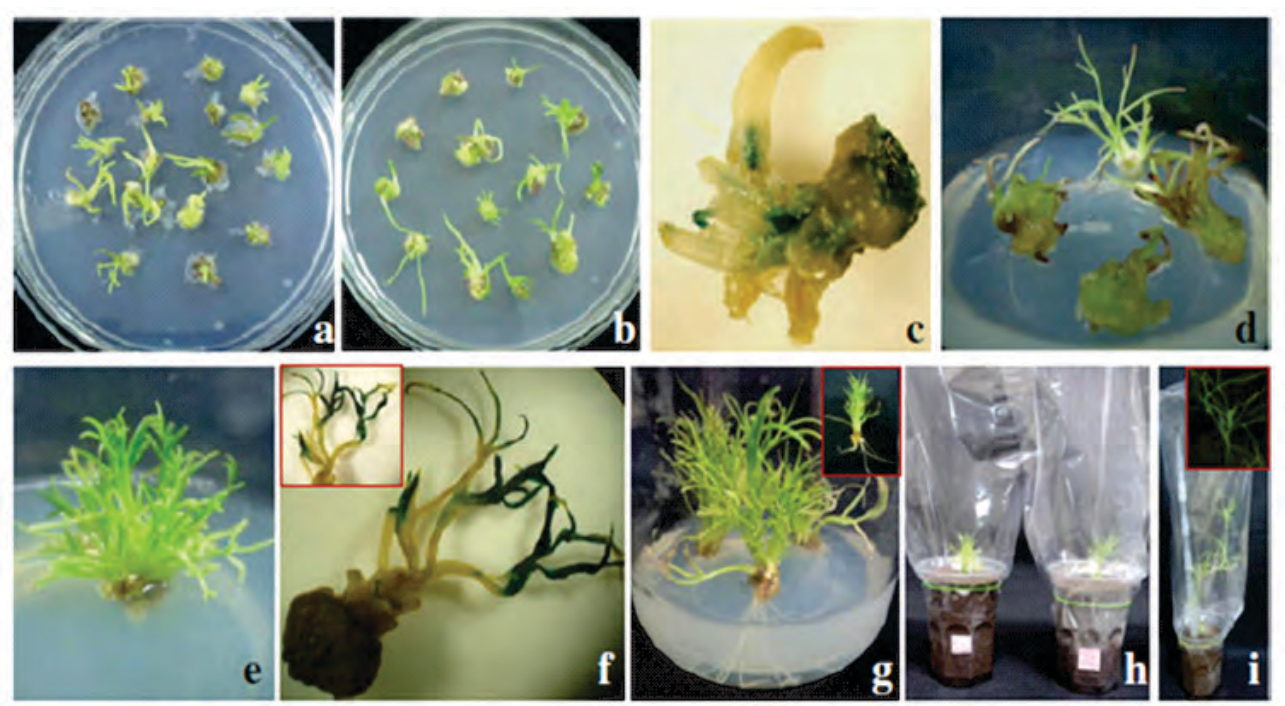
Histochemical GUS assay of seedlings, leaves, stems and roots of T1 transgenic tobacco plants developed by transforming the promoter constructs (PP1–PP5), pCAMBIA1301 (PC), vector control (VC) and wild-type plant (Wt).



Proposed model for transcriptional expression regulation of the *SbpAPX* gene. Binding of enhancer (E) at the enhancer sites (e) masked the binding of repressor R to the respective repressor site (r), which leads to high expression of the gene (GUS). Deletion of the e site leads to a reduction of gene (GUS) expression because of binding of repressor (R) to the respective site (r). Deletion of the r site resulted in the expression of the gene (GUS).

An efficient method for agrobacterium-mediated genetic transformation in cumin (*Cuminum cyminum L.*)

Cumin is an annual herbaceous medicinally important plant having diverse applications in daily life. About 1,020 embryos (a mean of 255 embryos per batch) were used for the optimisation of transformation conditions. About 720 embryos (a mean of 180 embryos per batch) were used for transformation and 95 % embryos showed transient *β-glucuronidase* expression after co-cultivation. Putative transformed embryos were cultured on B5 medium for shoot proliferation and 21 regenerated plants were obtained after selection and allowed to root. T_0 plantlets showed *β-glucuronidase* expression and gene integration was confirmed via PCR amplification of 0.96 and 1.28 kb fragments of the *hygromycin-phosphotransferase II* and *β-glucuronidase* genes, respectively. A transformation efficiency of 1.5 % was demonstrated and a total of 11 transgenic plants were obtained at the hardening stage, however, only four plants acclimatised during hardening. Gene copy number was analysed by Southern blot analysis of hardened plants and single-copy gene integration was observed. This is the first successful attempt of *Agrobacterium*-mediated genetic transformation of cumin (*Appl Biochem Biotechnol. (2013), 171,1–9*).



Agrobacterium-mediated genetic transformation, selection, regeneration and GUS expression of cumin. (**a**) co-cultivation of cumin embryos (pre-cultured) with *Agrobacterium tumefaciens* strain EHA105, (**b**) transformed explants after washing with cefotaxime, (**c**) transient GUS expression just after co-cultivation, (**d**) selection of transformants on hygromycin; **e** multiple shoot regeneration, (**f**) T_0 proliferated shoots showing GUS expression, (**g**) rooting, (**h**) hardening of transgenic lines and (**i**) acclimatised transgenic plant (T_0) showing flowering

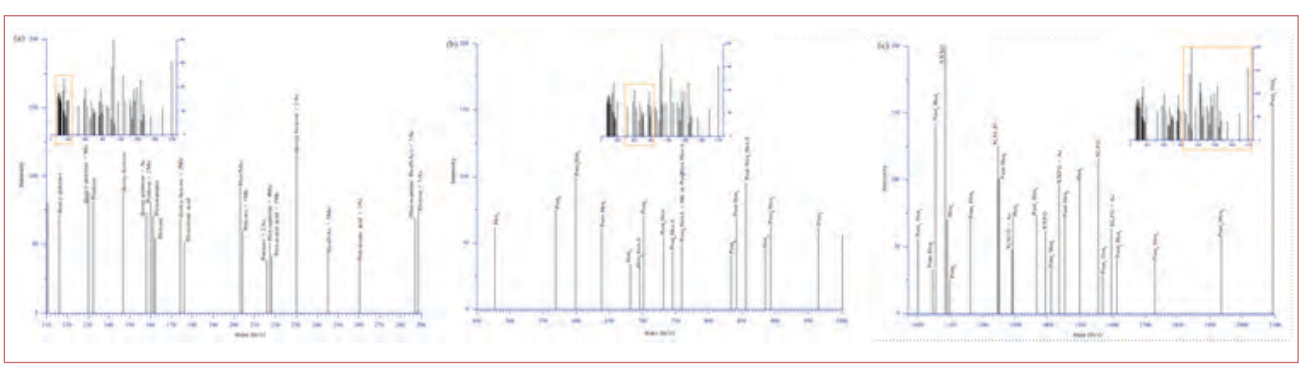
Identification of salt-responsive novel microRNAs from *Salicornia brachiata*

The small, non-coding RNA species (20–24 nucleotides), including microRNAs (miRNAs) and small interfering RNAs, are key regulators of gene expression in eukaryotic cells. A total of 159 sequences were cloned and analysed. Twelve putative miRNAs/pre-miRNAs and a small RNA were identified and confirmed by northern blot. Among the putative miRNAs, nine are novel and three belong to the conserved miRNA families (MIR169g, MIR1433, MIR138b). Northern hybridisation and real-time PCR showed that nine miRNAs (seven novel and two conserved) and one small RNA were highly expressed at 2.0 M NaCl, two novel miRNAs at 1.5 M NaCl, and

one conserved miRNA at 1.0 M NaCl. Furthermore, 67 putative target genes of the isolated miRNA were predicted on the basis of sequence homology, of which more than 50 % are associated with abiotic stresses. The target genes of miRNA 169g (Sb-miRNA10), and SbmiRNA7 (NF-YA transcription factor and cytochrome P_{450}-like TATA box binding protein respectively) were analysed by real-time PCR. (*Plant Biotechnol Rep. (2014) DOI 10.1007/s11816-014-0324-5*).

Oligosaccharide mass profiling of *Salicornia brachiata*

Salicornia seeds are rich in protein and tender shoots are eaten as salad greens. Total cell wall carbohydrate was isolated from seedlings, digested with β -glucanase enzyme cocktail and oligosaccharide mass profiling (OLIMP) was performed by using MALDI TOF-TOF mass spectroscopy. Salicornia OLIMP is represented by characteristic mass peaks m/z 477.3297–2094.4363. MS spectra exhibit xyloglucan oligosaccharide building blocks, dominated by XXXG (1084.9927 m/z). Characteristic mass peaks (m/z) of xyloglucan oligomers (XXG, XXFG, XLXG and XLFG) were also detected, which showed resemblance to the mass profile of highly nutritious plant soybean. The present study is the first report on OLIMP for any edible halophyte, so far (*Carbohydrate Poly. (2013), 92: 1942– 1945*).



MALDI-TOF-TOF mass spectra of *Salicornia brachiata* after digestion with the β -glucanase enzyme cocktail; (a) zoom of m/z 110–300, (b) zoom of m/z 450-1000 and (c) zoom of m/z 1000–2100. Peaks were marked with corresponding mono- and oligo-saccharides.

Bacterial community structure and population dynamics

The phylogenetic diversity of bacteria in a haloalkaline soil (EC 20 dS/m; pH 9.5) was compared with a normal soil (EC 0.93 dS/m; pH 7.2). Clones representing phyla *Proteobacteria*, *Bacteroidetes*, *Chloroflexi*, *Firmicutes*, *Actinobacteria*, *Acidobacteria* and *Planctomycetes* were found in both soils. *Cyanobacteria*, *Verrucomicrobia*, *OP10* and *Bacteria incertae sedis* were detected in normal soil whereas *Nitrospira* was found only in haloalkaline soil. The dominant phylum in the haloalkaline soil was *Bacteroidetes* followed by *Proteobacteria* whereas normal soil was dominated by *Proteobacteria* and *Actinobacteria*. About 82% of the sequences from the haloalkaline library were related to those previously retrieved from various saline, alkaline and oil-natural gas field ecosystems whereas 50% of the sequences from normal soil resembled sequences of bacteria retrieved from agriculture-related habitats viz. agriculture fields, rhizosphere and grasslands. One third of the total sequences from both soil samples showed low BLAST identities (<95%) suggesting that these soils may harbor unique, novel taxa. Further, the correlation analysis revealed negative correlations of Shannon diversity indices and species evenness with salinity (EC) and pH but positive correlations with total carbon and total nitrogen contents of the soil samples. The haloalkaline soil exhibited less bacterial diversity and communities were significantly different from those of normal soil. In this study, the haloalkaline soil from a semi-arid region supports oligotrophic microbes (*Geomicrobiol J. (2013), 30, 517–529*)

Sample	No. of Clones Sequenced	No. of phylotypes[a] or OTUs (S)	Shannon Diversity index (H)	Evenness[b] (E)	Simpson Index	No. of singletons	Coverage[c] (%)
HAHS	166	82	3.79	0.86	0.076	62	62.6
NLS	147	77	4.07	0.94	0.018	43	70.7

[a] Phylotypes were defined as clone sequences with <97% 16S rRNA gene sequence similarity to other clones.
[b] Evenness E = H/Hmax where Hmax = ln S and S = No. of OTUs.
[c] Coverage% = (1-No. of singletons/ No. of clones sequenced) × 100.

Summary of diversity and predicted richness of clone libraries of HAHS and NLS soil sample computed using MOTHUR

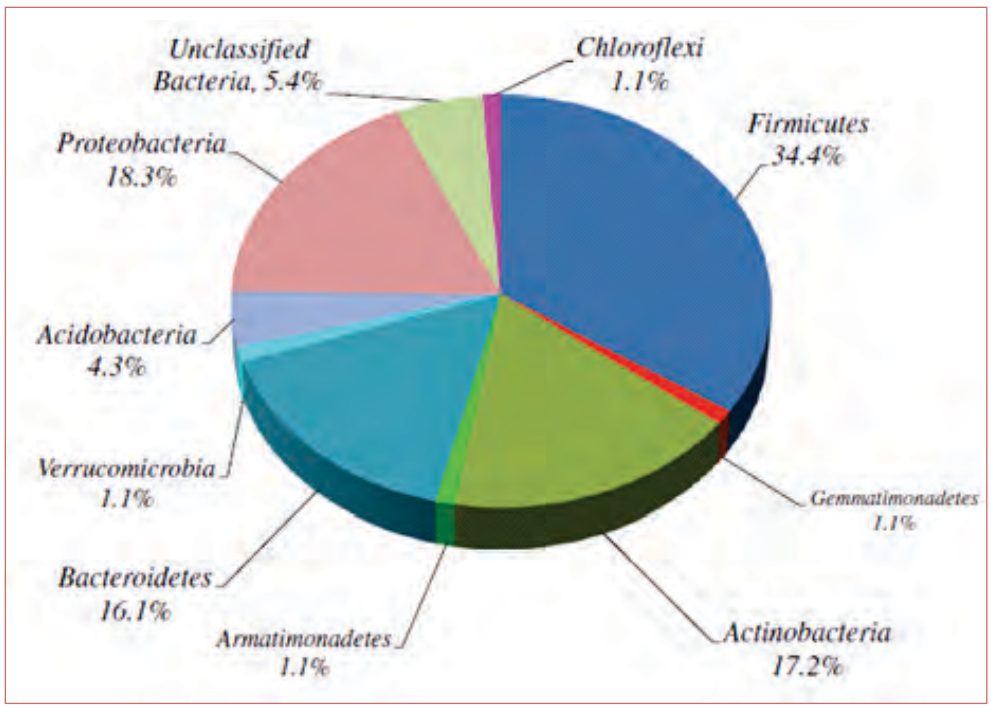
Another study on population indices of bacteria and archaea were investigated from saline–alkaline soil and a possible microbe–environment pattern was established using gene targeted metagenomics. Clone libraries were constructed using 16S rRNA and functional gene(s) involved in carbon fixation (*cbbL*), nitrogen fixation (*nifH*), ammonia oxidation (*amoA*) and sulfur metabolism (*apsA*). Molecular phylogeny revealed the dominance of *Actinobacteria*, *Firmicutes* and *Proteobacteria* along with archaeal members of *Halobacteraceae*. The library consisted of novel bacterial (20%) and archaeal (38%) genera showing ≤95% similarity to previously retrieved sequences. Phylogenetic analysis indicated ability of inhabitant to survive in stress condition. The 16S rRNA gene libraries contained novel gene sequences and were distantly homologous with cultured bacteria. Functional gene libraries were found unique and most of the clones were distantly related to *Proteobacteria*, while clones of *nifH* gene library also showed homology with *Cyanobacteria* and *Firmicutes*. Quantitative realtime PCR exhibited that bacterial abundance was two orders of magnitude higher than archaeal. The gene(s) quantification indicated the size of the functional guilds harboring relevant key genes. (*Microbiol Res. (2013), 168, 165–173*).

Analysis of 16S rRNA and functional gene(s) indices of clone libraries constructed using gene targeted metagenomics.

Clone Library	No. of Clones Sequenced	No. of phylotypes[a] or OTUs (S)	Shannon Diversity index (H)	Evenness[b] (E)	Simpson Index (D)	No. of singletons	Coverage[c] (%)
Archaeal 16S rRNA	49	29	3.15	0.93	0.034	19	61.3
Bacterial 16S rRNA	145	99	4.33	0.94	0.013	79	45.0
cbbL	54	27	3.04	0.92	0.461	14	74.0
nifH	51	20	2.45	0.80	0.11	13	74.5
amoA	55	4	0.52	0.37	0.738	2	96.3
apsA	63	10	1.62	0.70	0.30	2	96.8

[a] Phylotypes were defined as clone sequences containing clones showing <97% for 16S rRNA and <90% for functional genes *cbbL*, *nifH*, *amoA* and *apsA* sequence similarity to their respective clones.
[b] Evenness $E = H/H_{max}$, where $H_{max} = \ln S$ and S = no. of OTUs.
[c] Coverage % = [(1 – no. of singletons)/no. of clones sequenced] × 100.

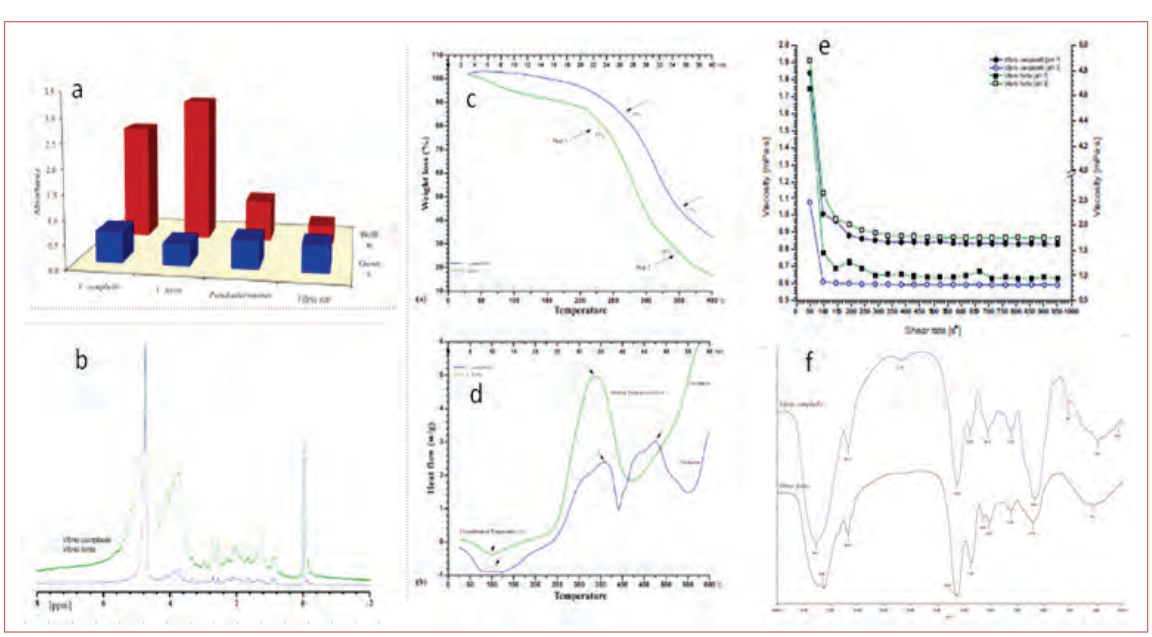
The bacterial diversity and population dynamics were also established using *cbbL* and 16S rRNA gene targeted metagenomics approach from the rhizosphere of *Arachis hypogaea*. A total of 108 *cbbL* clones were obtained from the rhizospheric soil which revealed predominance of *cbbL* sequences affiliated to *Rhizobium leguminosarum*, *Bradyrhizobium sp.*, *Sinorhizobium meliloti*, *Ochrobactrum anthropi* and a variety of uncultured *cbbL* harbouring bacteria. The 16S rRNA gene clone library exhibited the dominance of *Firmicutes* (34.4%), *Proteobacteria* (18.3%), *Actinobacteria* (17.2%) and *Bacteroidetes* (16.1%). About 43% nucleotide sequences of 16S rRNA gene clone library were novel genera which showed <95% homology with published sequences. Gene copy number of *cbbL* and 16S rRNA genes, determined by quantitative real-time quaPCR (qRT-PCR), was $9.38\pm0.75\times10^{7}$ and $5.43\pm0.79\times10^{8}$ (per g dry soil), respectively (*Gene (2012,) 506, 18–24*).



Relative contributions of different phylogenetic groups to the 16S rRNA clone library on the basis of OTU data.

Extracellular polymeric substances from marine bacteria

The early biofilm colonizing *Vibrio campbellii* and *Vibrio fortis* produced 400 and 134 mg L−1 extracellular polymeric substances (EPS), respectively of distinct composition in planktonic cultures. The EPS of *V. campbellii* consisted of five monosaccharides: arabinose, galactose, glucose, mannose and rhamnose, however that of *V. fortis* has only three monosaccharides: arabinose, galactose and mannose. The AFM topography analysis showed different morphology and physical characteristics of EPSs. FTIR and NMR spectral analyses revealed characteristic functional groups of the polysaccharides. EPSs were amorphous in nature and contained characteristic diffraction peaks. EPSs showed high emulsifying activity and pseudoplastic rheology. (*Carbohydr Polym. (2013) 94: 882–888*).

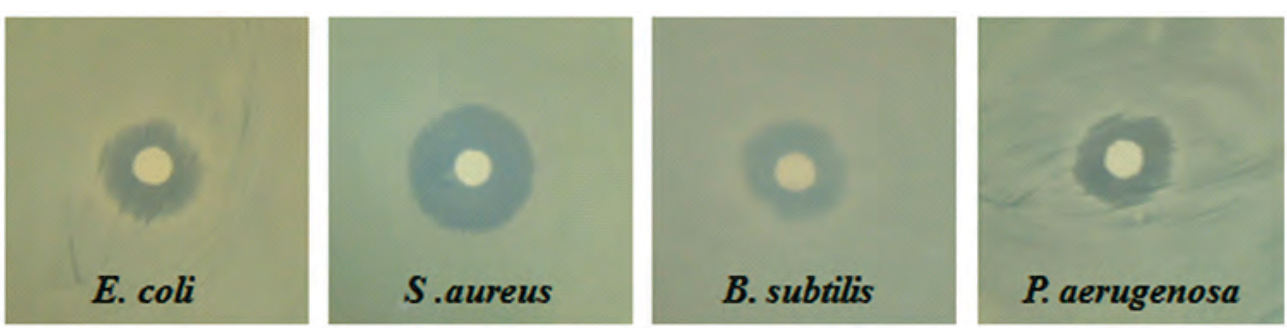


a) Growth rate and biofilm formation of selected bacterial isolates, b) Proton nuclear magnetic resonance (^{1}H NMR) spectra, c) Thermogravimetric, (d) DSC thermogram, e) Rheology and f) FT-IR spectra of EPSs extracted from *Vibrio spp*.

Oceanobacillus iheyensis BK6 produced approximately 400 mg L^{-1} extracellular polymeric substances (EPS). FTIR analysis of the EPS revealed different functional groups (halide groups, uronic acid and saccharides). The GC-MS showed that the extracellular polysaccharides comprised of mannose (47.78%), glucose (29.71%) and arabinose (22.46%). The molecular mass of the EPS was about 2.14×10^6 Da. It was thermally stable and showed pseudoplastic rheology and emulsifying activity (66.47%). The EPS exhibited antibiofilm activity against a pathogenic strain of *Staphylococcus aureus* (*Carbohydr Polym.(2014), 101, 29–35*).

24-Branched Δ5 sterols from *Laurencia papillosa* red seaweed with antibacterial activity against human pathogenic bacteria

Methanol extract of thirty-eight seaweeds samples were first screened against Gram-positive (*Staphylococcus aureus* ATCC 25923 and *Bacillus subtilis* ATCC 6051) and -negative (*Escherichia coli* ATCC 8739 and *Pseudomonas aerugenosa* ATCC 9027) bacteria. *Laurencia papillosa* (Ceramiales, Rhodomelaceae, Rhodophyta) gave maximum antimicrobial activity against these bacteria. It was finally tested against four clinical Gram-negative isolates (*E. coli*, *P. aerugenosa*, *Klebsiella pneumoniae* and *Shigella flexineri*) and exhibited antibacterial activity. The extract was fractionated by column chromatography and the active fraction was identified as a cholesterol derivative, 24-propylidene cholest-5-en-3β-ol using gas chromatography mass spectrometry (GC–MS). The electrospray ionization mass spectrometry (ESI-MS) and FT-IR spectroscopic analysis also supported the structure of the compound. The minimum inhibitory concentration ranged from 1.2 to 1.7 µg/mL (IC_{50}) against clinical isolates (*Microbiol Res. (2014) 169: 301–306*).



Growth inhibition by *L. papillosa* extract (halos, mm) against different bacteria.

प्रकरण 4
CHAPTER



प्रक्रिया डिज़ाइन एंव इंजीनियरिंग
Process Design and Engineering

प्रक्रिया डिज़ाइन एंव इंजीनियरिंग

प्रक्रिया डिज़ाइन और इंजीनियरिंग विभाग विशिष्ट अनुसंधान कार्यों एवं तकनीकी विकास पर कार्य करता है। समुद्री बिटर्न तथा अन्य पोटाश युक्त आपूर्ति स्टॉक से सीधे पोटाश की प्राप्ति हेतु प्रक्रिया विकसित की गई है। इस प्रक्रिया में पोटैशियम को चयनित रुप से अवक्षेपित किया गया तत्पश्चात उसे उपयुक्त अम्ल का उपयोग कर इच्छित पोटैशियम नमक (जैसे पोटैशियम नाइट्रेट, पोटैशियम सल्फेट आदि) में परिवर्तित किया गया। पेटेन्ट कराने के लिए PCT पेटेन्ट आवेदन (WO2013/150363 A1) प्राप्त कर लिया गया है और राष्ट्रीय स्तर पर फाइल करने का कार्य प्रगति पर है। हाल ही में हमने अग्नि कार्यों के उपयोग के लिए पोटैशियम नाइट्रेट के उत्पादन हेतु तकनीकी जानकारी का लाइसेंस प्राप्त कर इसका सफलतापूर्वक प्रदर्शन किया है। यह प्रक्रिया, बायोमास राख/चार से पोटाश की प्राप्ति के साथ–साथ पोटैशियम क्लोराइड (MOP) का बहुपोषक पोटाश उर्वरकों में परिवर्तन के लिए भी कुशलतापूर्वक कार्य करती है।

गुजरात वन विभाग के सहयोग से सासण–गिर में सभी वातानुकूलित पर्यटक वाहनों को जेट्रोफा बायोडीजल से चलाने की पहल विभाग ने की है। हाल ही में हमने केवल जल को माध्यम के रुप में लेकर (बिना किसी धातु उत्प्रेरक) के मिथाइल इमिडेजो [1,2-a] पिरिडीन्स के संश्लेषण के लिए एक नवीन पद्धति विकसित की है। ये औषधीय रुप से महत्वपूर्ण मध्यवर्ती हैं जो विषाणुरोधी, जीवाणुरोधी, कवकनाशी तथा प्रदाहरोधी गुणों से युक्त होते हैं। इन मध्यवर्तिओं द्वारा व्यवसायिक रुप से उपलब्ध अल्पिडेम, ऑलप्रीनोन मिनोड्रोनिक अम्ल(हृदय संबंधी बीमारियों तथा ऑस्टियोपोरेसिस के उपचार हेतु) नीकोपिडेम, सारीपिडेम (अवसादनाशक) तथा प्रकाश सक्रिय GSK812397 (एचआईवी संक्रमण के उपचार हेतु) बनाया जाता है। हमने इमिडेजो [1,2-a] पिरिडीन-3-कार्बोल्डिहाइड्स के अच्छे उत्पादन के लिए सिल्वर उत्प्रेरित अंतराण्विक एमिनोऑक्सीजनेशन प्रक्रिया विकसित की है। इमिडेजो [1,2-a] पिरिडीन्स तथा इमिडेजो [1,2-a] पिरिडीन-3-कार्बोल्डिहाइड्स, दोनों औषधि उद्योगों में अत्यधिक उपयोगी मध्यवर्ती हैं।

विभिन्न हेटरोऐरोमैटिक प्राथमिक एमिन्स की NaOH-उत्प्रेरित चयनित N-अल्काइलेशन तथा 4-फिनाइल-2-एमिनोथियाजोलों की NaOH-मध्यस्थ N1, C5-डिअल्काइलेशनका अध्ययन किया गया। मंद परिस्थिति के अंतर्गत NaOH उत्प्रेरक की उपस्थिति में अल्काइलेशन एजन्टों के रुप में बेन्जायलिक अल्कोहल के साथ हेटरो एमिन्स के N-अल्काइलेशनके लिए यह संक्रमण धातु मुक्त नवीन पद्धति है।

हमने पहलीबार सामान्य विलायक मुक्त, एल–प्रोलीन उत्प्रेरित, एमिन्स के साथ कार्बोक्जामाइड्स के ट्रान्सएमिडेशन के लिए पर्यावरण अनुकूल हरित तथा सतत प्रक्रिया विकसित की है। पहले से ज्ञात ट्रान्सएमिडेशन उत्प्रेरकों की तुलना में एल–प्रोलीन, किफायती, आसानी से उपलब्ध और एक विस्तृत रेंज में अनुरुप ट्रान्सएमिडेशन उत्पादों के अच्छे एवं उत्कृष्ट उत्पादन के लिए उपयुक्त है।

हमने एकमात्र ऑक्सीकारक के रुप में आण्विक ऑक्सीजन का उपयोग करके, मंद परिस्थितियों के अंतर्गत दो C – N बंध के ऑक्सीकृत लिंकेज के साथ कार्बन (sp3)– H सक्रियण द्वारा इमिडेजो [1,2-a] पिरिडीन्स की सरल, सक्रिय कॉपर उत्प्रेरित संश्लेषण प्रक्रिया विकसित की है। यह, ज़ोलीमिडीन का एक ही चरण में संश्लेषण की पहली रिपोर्ट है। दो सक्षम Cu(I)-उत्प्रेरित डोमिनो संश्लेषण i) आसानी से उपलब्ध तथा किफायती पिरिडीन्स तथा मिथाइल कीटोन्स की प्रतिक्रिया ii) एमिनो पिरिडीन्स, मिथाइल कीटोन्स तथा डाइसल्फाइड के तीन घटक युग्मन की एक ही पात्र में प्रतिक्रिया, विकसित की गयी। हमने कक्ष तापमान पर, संक्रमण धातु उत्प्रेरक के बिना इमिडेजो[1,2-a] पिरिडीन व्युत्पन्नों के रेगोसेलेक्टिव सल्फाइनेशन के लिए सक्षम कार्यनीति विकसित की है।

जलहीन परिस्थिति में $KHSO_4$ उत्प्रेरित ब्रोमो–इथर के संश्लेषण की हरित उत्प्रेरक पद्धति वर्णित की गयी। वर्तमान प्रोटोकॉल सरल तथा संक्रमण धातु उत्प्रेरक/विलायक मुक्त कीमो चयनात्मक है और इसमे $KHSO_4$ उत्प्रेरक फिर से उपयोग करने योग्य है। हमने H-β जियोलाइट को विषमजातीय तथा पुनःचक्रीय उत्प्रेरक के रुप में उपयोग कर के ब्रोमोहाइड्रीन्स के आंतराण्विक निर्जलीकरण द्वारा β-ब्रोमोस्टाइरीन के संश्लेषण के लिए एक पर्यावरण अनुकूल हरित उत्प्रेरक पद्धति विकसित की है। विनाइल ब्रोमाइड्स की α-ब्रोमोकीटोन्स में ऑक्सीकृत पुनर्व्यवस्था तथा HBr/H_2O_2 प्रणाली के उपयोग द्वारा ऑल्कीन से α, α -डाइब्रोमोकीटोन्स का प्रत्यक्ष संश्लेषण वर्णित किया गया। कक्ष तापमान पर, H_2O_2 को अनुकूल

ऑक्सीकारक के रुप में उपयोग करके HBr- उत्प्रेरित ऑक्सीकृत पुनर्व्यवस्था द्वारा विनाइल ब्रोमाइड्स सेब्रोमोकीटोन्स में रुपांतरण के लिए यह एक नवीन अभिगम है।

इस विभाग द्वारा प्राकृतिक बहुलकों द्वारा कार्यात्मक पदार्थों का संश्लेषण और मरुस्थलीय पौधों तथा समुद्री शैवाल के अर्क की स्क्रीनिंग की गई। अगारोज/जाइलेन से बेहतर जेल क्षमतावाला संयुक्त हाइड्रोजेल तैयार किया गया। पैरासिटामोल, इंडोमेथासिन जैसी सरंचनात्मक रुप से भिन्न औषधियों का उपयोग करके, चिटोसन–पॉलीमैनुरोनिक तथा चिटोसन–पॉलीग्लुरोनिक एसिड योगोत्पाद के नियंत्रित अवमुक्तन का मूल्यांकन किया गया। माइक्रोवेब इरैडियेशन के अंतर्गतपोटैशियम परसल्फेट का मंदक के रुप में उपयोग कर जल आधारित तेज पद्धति का प्रयोग कर अगरोज एवं κ-केरागीनान के पृष्ठ पर न्युक्लियोबेस साइटोसिन ड्राफ्ट कर नवीन प्रतिदीप्त बहुलकीय पदार्थ बनाये गये। अगरोज–साइटोसिन व्युत्पन्न की इस उल्लेखनीय प्रतिदीप्त क्रिया क्षमता का संवेदक के रुप में विभिन्न अनुप्रयोगों में उपयोग होने की संभावना है।

kC/Xylan/PVP-आधारित हाइड्रोजेल पदार्थ माइक्रोवेब की सहायता से संश्लेषित किये गये और उनकी भौतिक, रासायनिक तथा द्रव प्रवाहिकी संबंधी गुणों का अध्ययन किया गया। कप्पाफायकस अल्वारेजी समुद्री शैवाल से इंधन मध्यवर्ती, कृषि पोषक तत्वों तथा शुद्ध जल के उत्पादन हेतु एक स्वयंसिद्ध समेकित प्रणाली विकसित की गयी है। ग्रेसीलेरिया ड्यूरा अगारोज से सोडियम कार्बोक्सीमिथाइल अगारोज तथा कैल्शियम कार्बोक्सीमिथाइल अगारोज के एक ही पात्र में माइक्रोवेब सहायक, सरल संश्लेषण का वर्णन किया गया है। यह प्रक्रिया उपयोगकर्ता के अनुकूल है तथा प्रतिस्थापन की परंपरागत पद्धति जिसमें 3 घण्टे से ज्यादा समय लगता था, की तुलना में सर्वोच्च प्रतिस्थापन 15 मिनट में प्राप्त किया गया। इन हाइड्रोजेल का विद्युत रासायनिक उपकरणों, सूक्ष्म जीवविज्ञान, जैव चिकित्सा तथा औषधियों के क्षेत्रों में अनुप्रयोगों की संभावना है। सीएसआईआर नेटवर्क परियोजना–"वहनयोग्य स्वास्थ्य सुरक्षा हेतु मरुस्थलीय तथा समुद्रीशैवालों के अर्कों की स्क्रीनिंग" अंतर्गत जैवसक्रिय अर्क और जैवसक्रिय बहुलक पदार्थ बनाये गये।

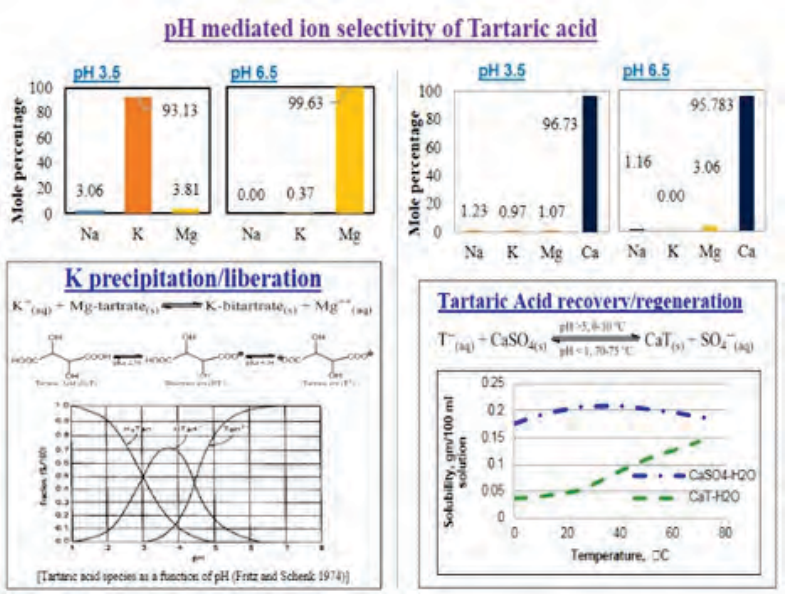
इस विभाग ने सौर ऊर्जा प्रणाली के क्षेत्र में उल्लेखनीय कार्य किया है। कम कार्बन पदचिह्नों के साथ शुद्ध पी-नाइट्रोबेन्जाइल ब्रोमाइडबनाने की पूरी तरह से पर्यावरण अनुकूल हरित प्रक्रिया के लिए सौर प्रकाश–उष्मा रासायनिक प्रतिक्रिया तथा उच्च क्रांतिक CO_2कार्यों का विभाग द्वारा वर्णन किया गया है। अंतर बहुलक फिल्म से सौर चालित ऋणायन विनिमय पर आधारित मेम्ब्रेन बनाने तथा उसका विद्युत अपोहन में उपयोग के बारे में एक वर्धित प्रक्रिया विकसित की गयी है। डाइसाइक्लोपेन्टाडीन का साइक्लोपेन्टाडीन में सौर चालित पुनःसाध्य परिवर्तन का प्रदर्शन किया गया जो ऊर्जा प्रणालियों तथा शुद्ध रसायनों के लिए महत्वपूर्ण अभिकारक हो सकते हैं।

एक नवीन, अप्रत्यक्ष प्रकार के सौर ड्रायर की डिजाइन तैयार की गयी और खाद्य उत्पादों को सुखाने के लिए इसका परीक्षण किया गया। ऐसे ड्रायर पश्चिम बंगाल के सुंदरवन के सागर द्वीपों में स्थापित किये गये जो अत्यधिक सफल रहे और इन्होनें इस क्षेत्र के लोगों की अच्छी स्वीकृति प्राप्त की है। सामुदायिक स्तर पर अधिक उत्पादन देने वाली, ऊर्जा–कुशल फोटोवोल्टिक पी.वी–आर.ओ. रिवर्स ऑस्मोसिस यूनिट विकसित की गयी। ऊटी मेंनिलगिरी के आवश्यक तेल MSME क्लस्टर को उन्नत किया गया जिसने 52% तक ऊर्जा की बचत की। सामाजिक कार्यों की भागीदारी में भी विभाग ने व्यापक कार्य किया है जिसका वर्णन प्रकरण–7 में किया गया है।

Process Design and Engineering

Process know-how for production of potassic chemicals and fertilisers through selective K-precipitation using tartaric acid

A process has been developed for recovery of potash directly from sea bittern and other K-bearing feed stocks. In this process, potassium is selectively precipitated and subsequently converted to desired potassium salts (viz., potassium nitrate, potassium sulphate, mono potassium phosphate, potassium ammonium sulphate, potassium ammonium phosphate etc.) using suitable acid. The process pivots around two equilibrium processes, one involving the *potassium bitartrate–magnesium tartrate* pair and the other involving the *calcium tartrate–tartaric acid* pair. These were conveniently manipulated by changing pH and temperature. PCT patent application (WO2013/150363 A1) has been cleared for patentability and national phase filing is in progress. CSIR-CSMCRI has recently licensed the process know-how for production of potassium nitrate for fire-works application & completed successful demonstration. This process also works efficiently for recovery of potash from biomass ash/char as well as for conversion of potassium chloride (MOP) in to multi-nutrient K-fertilisers.





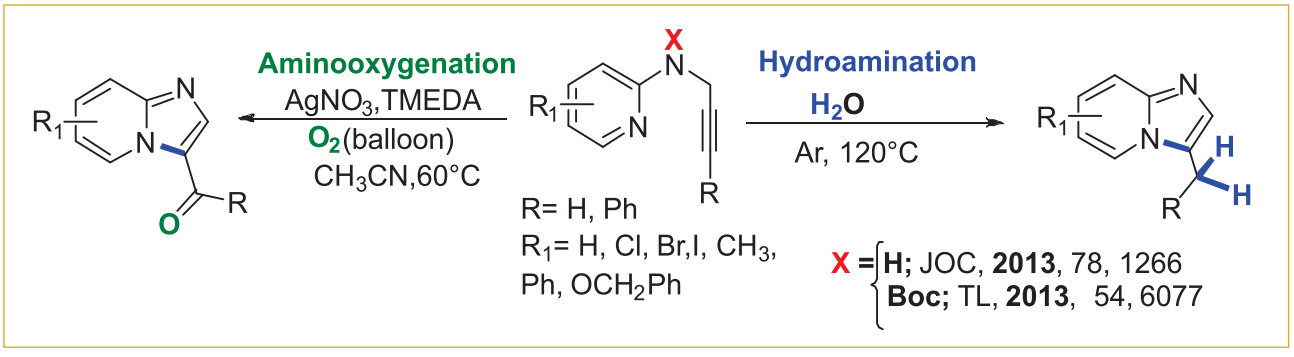
Jatropha biodiesel

Significant work in production of standard grade Jatropha biodiesel has been done by the division during this period which has contributed in the service of society. Details are provided in chapter-7 of this report.

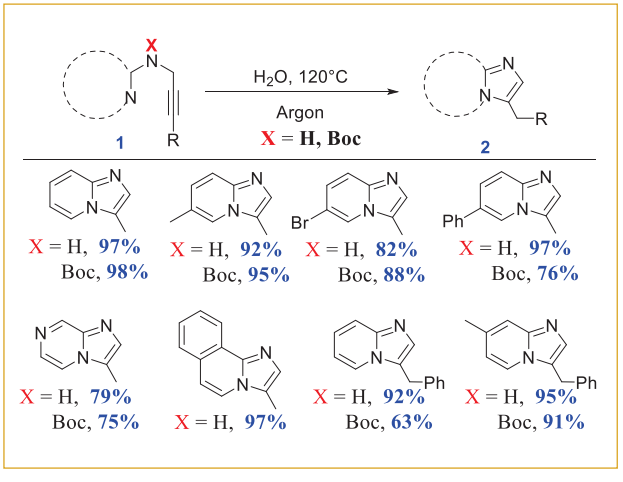
Synthesis of N-Heterocyclic Compounds

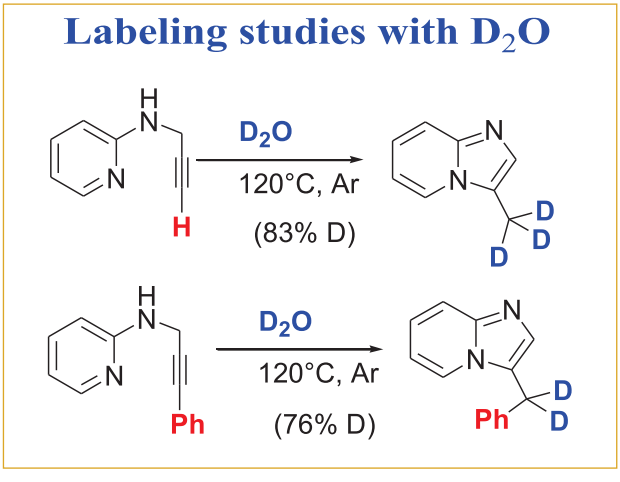
Synthesis of imidazo(1,2-a)pyridines: "Water Mediated" hydroamination and silver-catalyzed aminooxygenation

Recently we have developed a novel method for the synthesis of methyl imidazo[1,2-a]pyridines with only water as a medium without any metal catalyst. These are pharmacologically important intermediates which exhibit antiviral, antibacterial, fungicidal, and anti-inflammatory properties. Many commercially available drugs including alpidem, olprinone,minodronic acid (to treat anxiety, heart failure and osteoporosis), necopidem, saripidem (sedative and anxiolytic) and optically active GSK812397 candidate(HIV infection) were synthesized through these intermediates.



We have also developed silver-catalyzed intramolecular aminooxygenation method to synthesize imidazo[1,2-a]pyridine-3-carbaldehydes in moderate to good yields. Both imidazo[1,2-a]pyridines and imidazo[1,2-a]pyridine-3-carbaldehydes are highly useful intermediates in pharmacological industries. Due to the high significance of these methods the work has been published in *J Org Chem. (2013), 78, 1266-1272; Tetrahedron Lett. (2013), 54, 6077.*

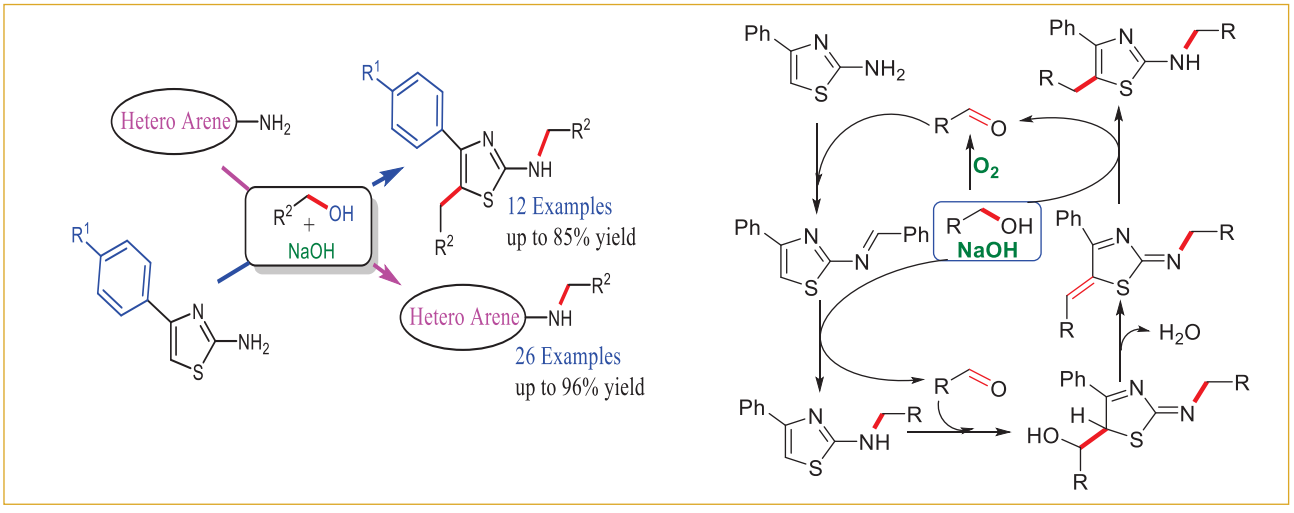




Sodium hydroxide catalysed N–alkylation of (hetero)aromatic primary amines and N1, C5-dialkylation of 4-phenyl -2- aminothiazoles with benzyl alcohols

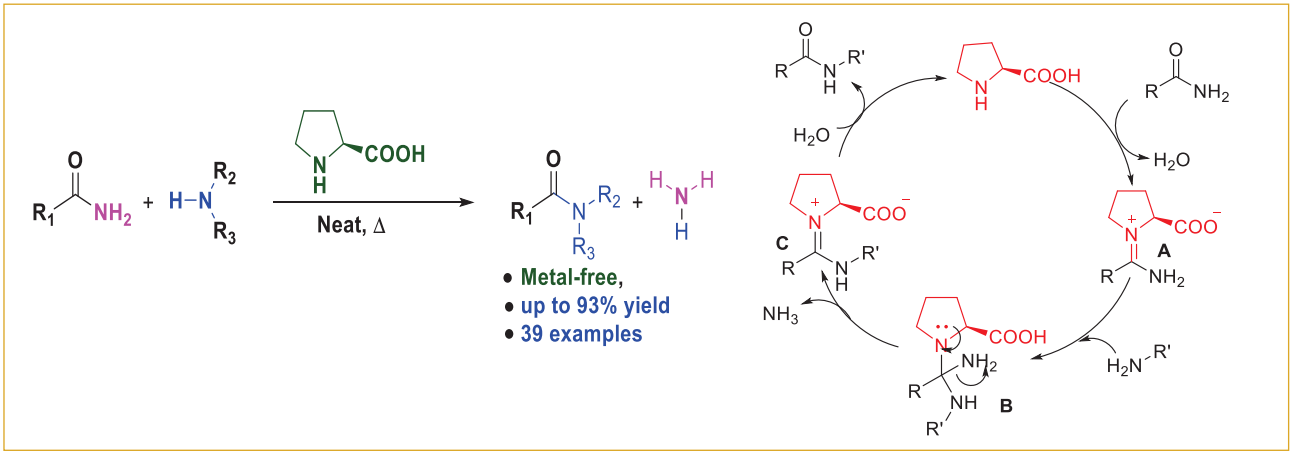
NaOH-catalyzed selective N-alkylation of various heteroaromatic primary amines and NaOH-mediated N1, C5-dialkylation of 4-phenyl-2-aminothiazoles has been investigated. Reaction of *in-situ* generated aldehyde with amine yields the N-alkylated and N1, C5-dialkylated products through hydride ion transformation from alcohol. This is a transition metal-free novel method for *N*-alkylation of hetero amines with benzylic alcohols as alkylating agents in presence of catalytic NaOH under mild conditions. Reaction of 4-phenylthiazol-2-amines with benzyl alcohols gave N1, C5-dibenzyl-4-phenylthiazol-2-amines

in good yields with one equivalent of NaOH. Compared to previously known transition metal catalysts, NaOH is inexpensive, readily available, convenient to use. The method is applicable for a wide range of benzylic alcohols as alkylating agents *(J Org Chem. (2013), 78, 6775-6781)*.



L-proline: catalyzed transamidation of carboxamides with amines

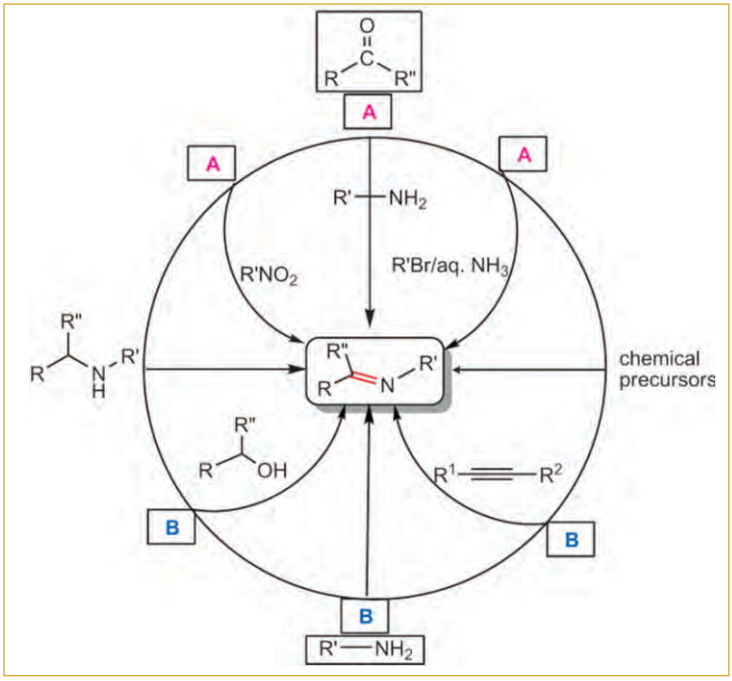
The amide bond is one of the most important linkages in nature due to its presence in peptides and protein structures and has been well recognized in chemistry and biology. In addition, amides serve as versatile intermediates for the preparation of pharmaceuticals, agrochemicals, polymers, and materials. Traditionally amides are prepared by the reaction of amines with carboxylic acid derivatives (alcohols, or aldehydes, hydroamination of alkynes and hydration of nitriles).Transamidation is a distinct biochemical activity associated with several neurodegenerative disorders such as Alzheimer's and Hungtinton's disease.



Transamidation is an attractive tool and represents one of the most convenient and straightforward methods, that would exchange the constituents of two different amide groups. Despite the advances achieved with many transition metal catalyzed transamidation, the separation of the metal catalyst from products is a central issue to consider. This separation is of particular importance for the synthesis of pharmaceutical fine chemicals, because of metal residual toxicity in the target compounds. In view of the above perceptions, we developed green and sustainable methods and a general solvent-free L-proline catalyzed transamidation of carboxamides with amines for first time. Compared to previously known transamidation catalysts, L-proline is inexpensive, is readily available, and can be used conveniently and applicable for wide range to produce corresponding transamidation products in good to excellent yields (*Org Lett. (2013), 15,1496*).

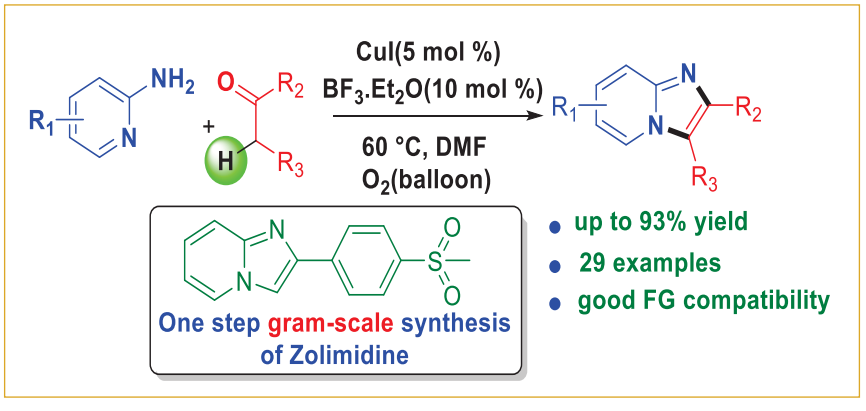
Catalytic methods for imine syntheses

A focused review article on catalytic methods for imine syntheses has been compiled. In the review we have described different methods reported for imines syntheses. The review has been organized according to the methods employed for imine synthesis from stoichiometric to catalytic amounts of metals including Ru, Au, V, Cu, Mn, Co and Pd. Emphasis was also given for other various methodologies such as photocatalysis, electrocatalysis, organocatalysis and miscellaneous methods. Ample of information on condensation of carbonyl/alcoholic compounds with amines and direct oxidation of amines to imines has been described. Further among various metal catalyzed reactions, specific attention has been made on copper catalyzed imine synthesis as copper is less toxic and comparatively inexpensive and easily accessible metal catalyst. The review was published in *Asian J Org Chem. (2013), 2, 726-744.*



Copper (I) iodide – catalysed aerobic oxidative synthesis of imidazo[1,2-a]pyridines from 2-aminopyridines and methyl ketones

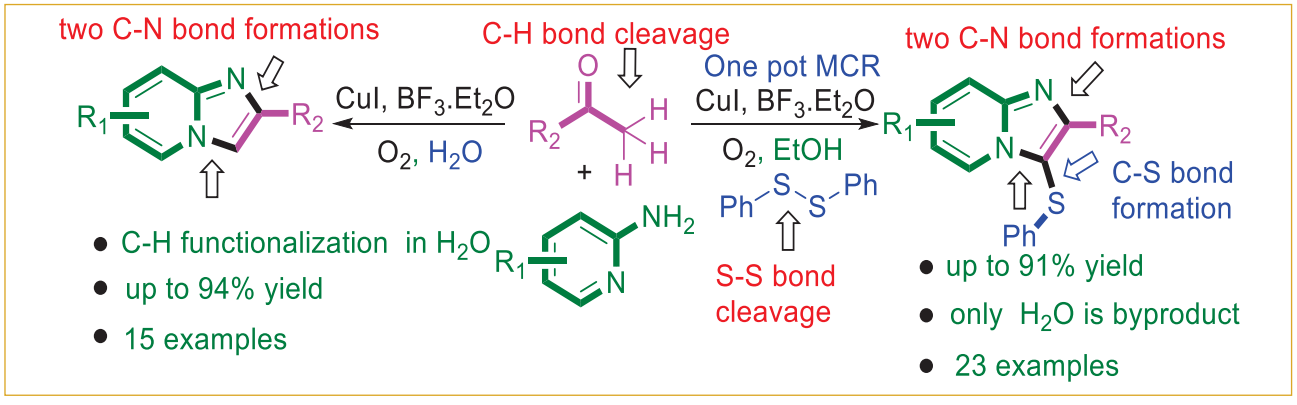
We have developed an operationally simple, copper-catalyzed synthesis of imidazo[1,2-a]pyridines via C(sp3)– H activation with oxidative linkage of two C – N bonds under very mild conditions using molecular oxygen as a sole oxidant. The process allows quick and atom-economical assembly of imidazo[1,2-a]pyridines including Zolimidine from inexpensive and readily available 2-aminopyridines and methyl ketones with broad range of functional group tolerance. The method is applicable to perform on a gram scale synthesis as tested for Zolimidine. This is the first report for a single step synthesis of Zolimidine. The mechanistic studies indicated the essential role of CuI and O_2 for the present investigation (*Adv Synth Cat. (2013), 355, 2217*).



Copper (I) iodide-catalyzed aerobic oxidative C-N and C-S bond formations through C-H activation: Synthesis of functionalized imidazo[1,2-a]pyridines

Developed two efficient Cu(I)-catalyzed domino synthesis; i) reaction of readily available and inexpensive amino pyridines and methyl ketones ii) one pot three component coupling reaction (TCRs) of amino pyridines, methyl ketones and disulfide. The former reaction is efficient in aqueous conditions and latter is in ethanol medium. Both reactions the are through C-H

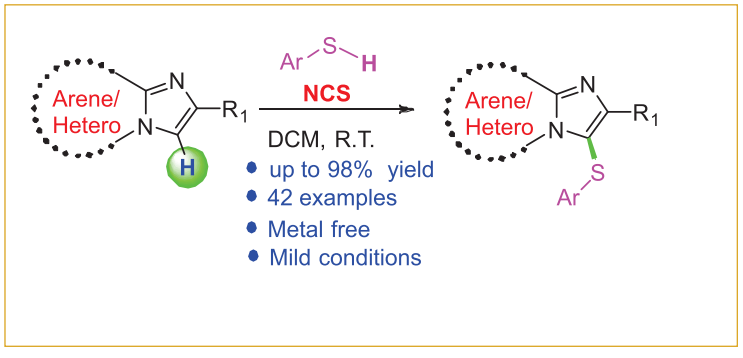
activation under aerobic conditions with tandem two C-N bonds and C-S bond formations for the synthesis of IP derivatives and sulfenylimidazo [1,2-a] pyridines respectively. Also developed the (TCRs) of various methyl ketones with 2-aminopyridines in the presence of CuI/BF_3.E_2O is an efficient method for the oxidative synthesis of sulfenylimidazo[1,2-a]pyridines in moderate to excellent yields. Based on the works the

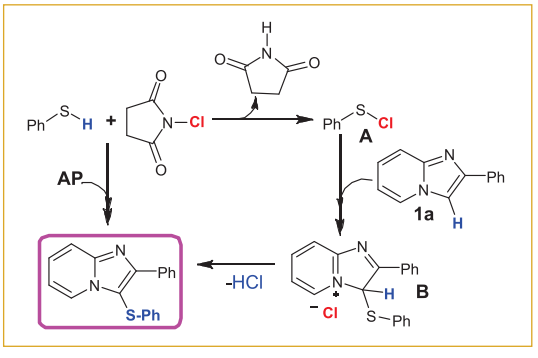


manuscript has been published in *Asian J Org Chem. (2014), 3, 609-613*. This communication has been highlighted under HOT TOPICS on C—H Activation from Wiley publication. http://www.wiley-vch.de/util/hottopics/c-h-activation/

Regioselective sulfenylation of imidazoheterocycles

Biological profile is mainly reliant on the nature of the substituents and introduction of sulfenyl groups on the azaheterocyclic rings that could impart marked biological properties. As a result; the synthesis of sulfenated imidazoheterocyclic molecules have gained much attention. However, few reports available for the synthesis of these molecules employing preparative sulphonating agents in presence of transition metal catalysts and others. We have developed an efficient strategy for the regioselective sulfenylation of imidazo[1,2-a]pyridine derivatives without transition metal catalysts at room temperature. Also the scope of the methodology has been extended to other imidazo[2,1-b]thiazoles and 2-phenylbenzo[d]imidazo[2,1-b]thiazole derivatives. We report herein an efficient *N*-chlorosuccinimide (NCS) promoted synthesis of sulfenated azaheterocycles at room temperature under transition metal-free conditions. Sulfenylation is promoted by NCS under metal-free conditions with broad range of substrate scope *(Org Lett. (2014), 16, 2978−2981)*.

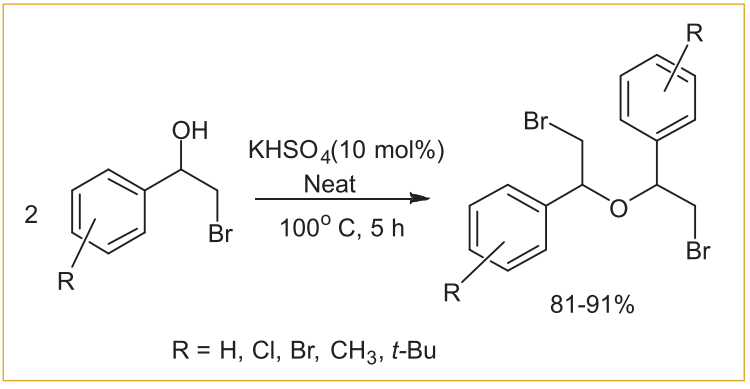




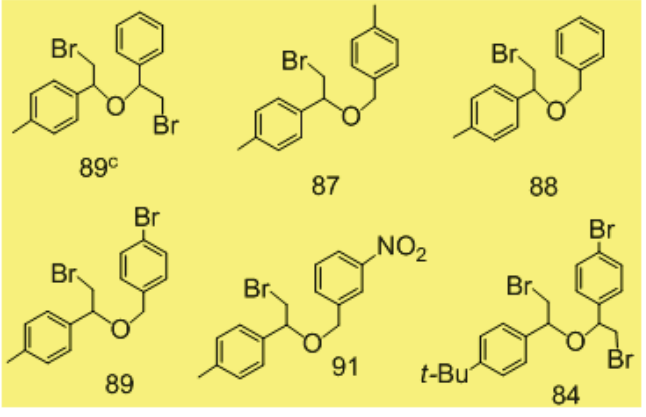
Organo-bromocompounds

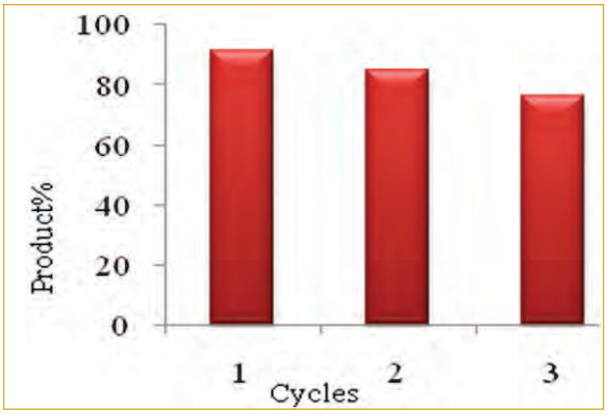
Green catalytic method for the synthesis of bromo-ethers

An economical and green conversion of 2-bromo-1-phenylethanols and benzylic alcohols into 1,1'-oxybis(2-bromoethane-1,1-diyl)dibenzenes and 1-(1- (benyloxy)-2-



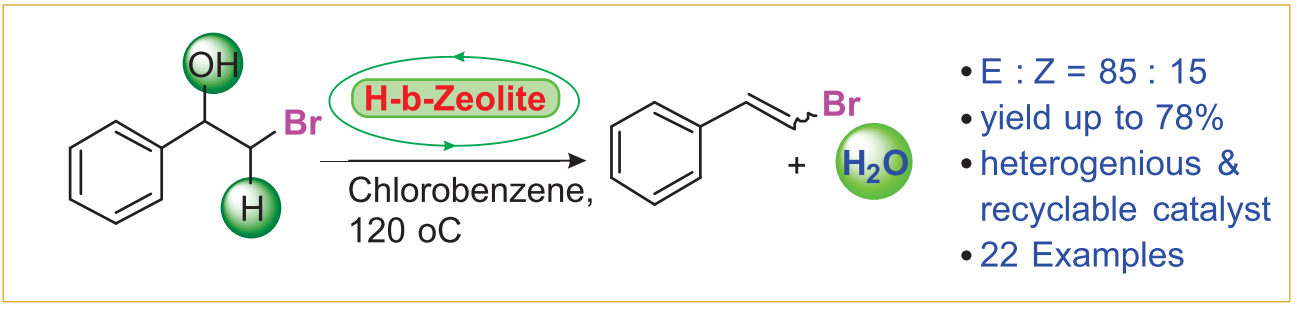
bromomethy)benzenes catalyzed by $KHSO_4$ under neat condition is described. The present protocol is facile and chemo-selective without transition metal catalyst/solvent and the $KHSO_4$ catalyst is recyclable. This is novel and green method for the synthesis of bromoethers catalysed by

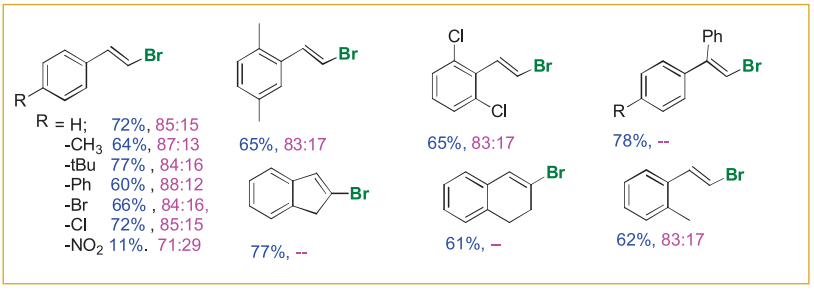


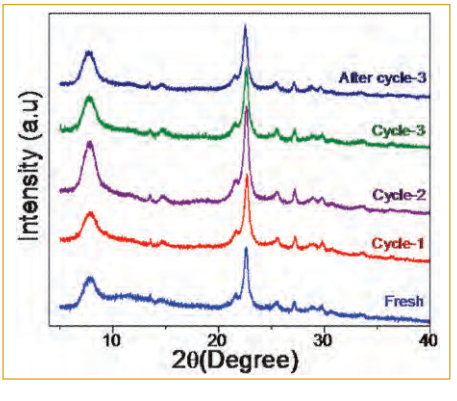


$KHSO_4$ under neat conditions. The major advantages of the method are; cheap catalyst, neat condition provides the desired products in high yields. Furthermore, water is the only by-product in this reaction, which makes the present process environmentally benign. To assess the reusability of $KHSO_4$, after completion of the reaction the catalyst was retrieved from the reaction mixture by simple filtration, dried, and recycled under the same experimental conditions up to three consecutive cycles without significant loss of catalytic activity. (*Synthetic Commun. (2013), 43, 587-599*).

Catalytic method for the synthesis of β-bromostyrenes



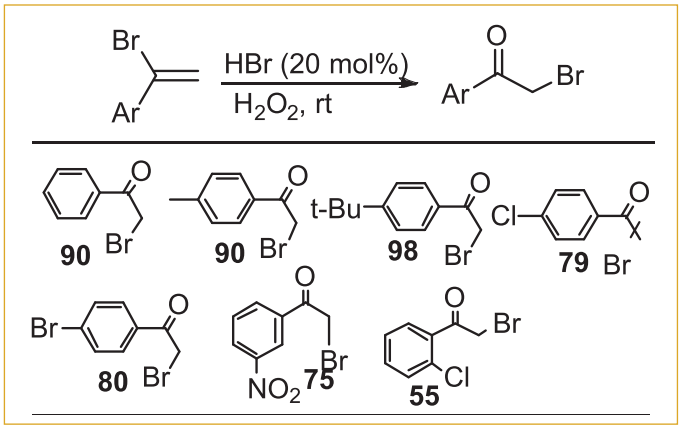


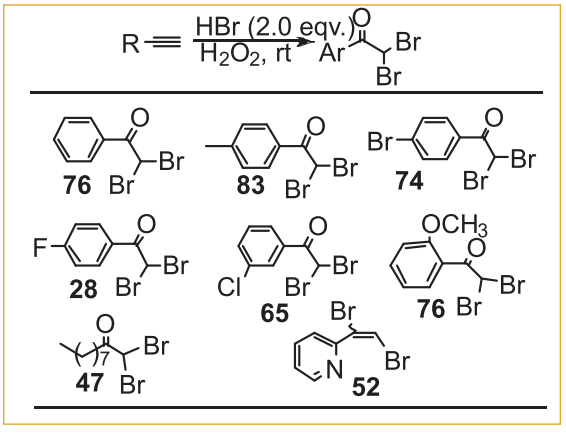


We have developed a green catalytic method for synthesis of β-bromostyrenes through intramolecular dehydration of bromohydrins using H-β zeolite as heterogeneous and recyclable catalyst. The present method is applicable to variety of substituted styrene derivatives under moderate conditions. The present approach highlights a useful alternative to the traditional Hunsdiecker reaction involving the halo decarboxylation of cinnamic acid derivatives. Notably, water is the only by-product generated, making this transformation more atom-economical and greener than the traditional methods. The present catalytic system have the following significant advantages over previously reported procedures for the synthesis of β-bromostyrenes: i) atom efficiency and no by-product formation [only water is eliminated in the process], ii) applicable for variety of substituted styrenes (including alpha substituted derivatives), iii) H-β-zeolite catalyst is inexpensive and commercially available, and iv) easy separation of the catalyst and it can be reused up to three consecutive cycles without appreciable loss of catalytic activity. The representative products are provided *(Tetrahedron Lett. (2014), 55, 1793-1795).*

Oxidative rearrangement of vinyl bromides to α-bromoketones and direct synthesis of α, α -dibromoketones from alkynes using HBr/H_2O_2 system

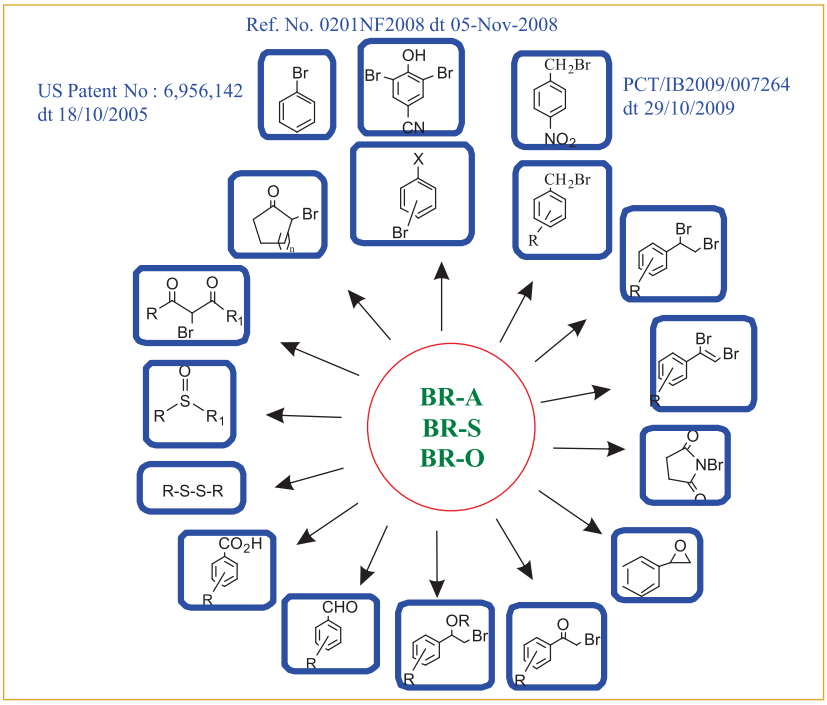
The synthesis of -bromoketones through oxidative rearrangement of vinyl bromides is described. This oxidative rearrangement has been initiated with catalytic BrOH generated in-situ using 20 mol% HBr and H_2O_2 as oxidizing agent. The BrOH reacts with π electrons of vinyl bromides to provide intermediate 1,2-dibromophenyl ethanols. Elimination of HBr from this intermediate yields stable -bromoketones. In this fashion HBr acts as a good catalyst for facilitating the rearrangement of vinyl bromides to - bromoketones. Using HBr-H_2O_2 system, good yields of α, α-dibromoketones was obtained directly from alkynes. This is a novel approach for the conversion of vinyl bromides to -bromoketones through HBr-catalyzed oxidative rearrangement utilizing H_2O_2 as a benign oxidant at room temperature. Good yields of dibromoketones were synthesized directly from alkynes using HBr- H_2O_2 system. The mild reaction conditions, which are compatible with many functional groups, should make this underutilized reaction more attractive to synthetic chemists (*J Ener Chem Eng. (2013), 1, 27).*





Bromide-bromate couple of varying ratios for bromination, vicinal functionalisation and oxidation in clean manner

The review highlights applications of bromide-bromate couple in organic synthesis. The couple having 5:1 mole ratio of bromide to bromate is useful for preparation of dibromo derivatives from alkenes/alkynes. The 2:1 couple effects substitution with high bromine atom efficiency. Vicinal functionalization of olefins has also been studied. The 1:8 bromide-bromate couple has

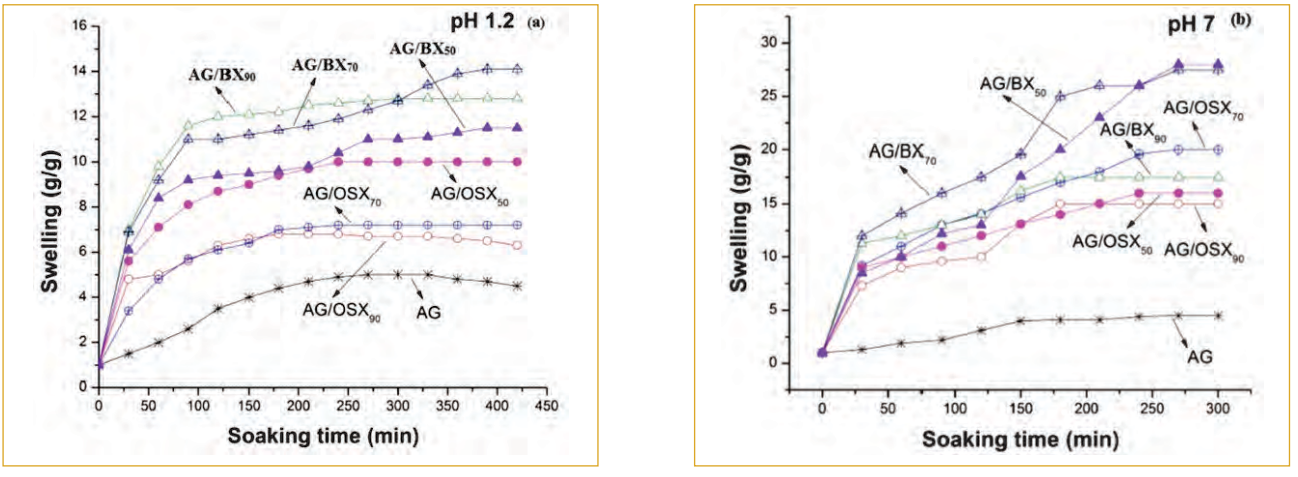


proved promising in several oxidation reactions, the performance exceeding that of bromate alone. This reagent was also the most effective for deiodination of styrene-based iodohydrins with concomitant rearrangement by a novel pathway. In all the cases, the reagents were activated through in situ acidification. The 5:1 reagent is obtained as intermediate during liquid bromine manufacture and the other reagents were prepared from it using ClO^-. Liquid bromine could be avoided in the product life cycle (*Curr Org Synth. (2013), 10, 864-884*).

Synthesis of functional materials using natural polymers & screening of terrestrial plants and marine algal extracts

Physicochemical and rheological properties of agarose/xylans composite hydrogel materials

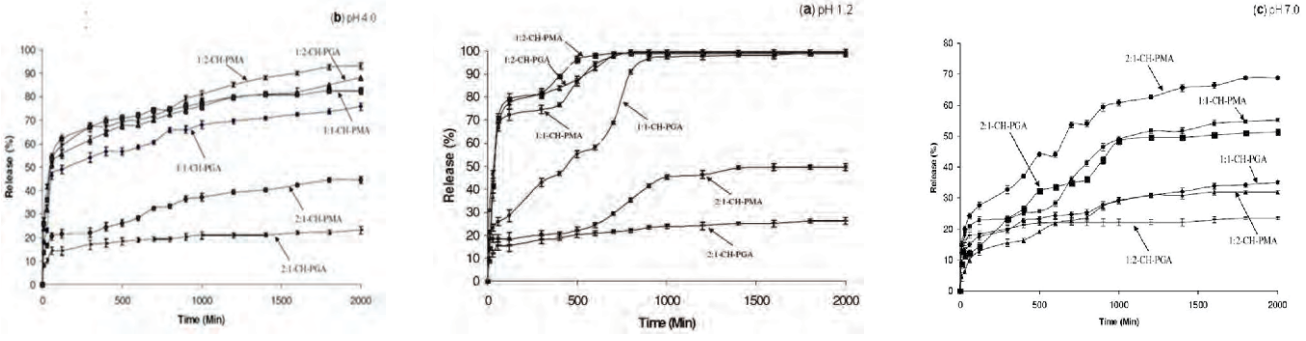
Agarose (AG)/Xylans [beech (BX) and oat spelt (OSX)] composite hydrogels were prepared by effortless mixing method, using water as solvent. The gelling behavior of the composite hydrogels was investigated by a rheometer fitted with a temperature control facility. Improved gelling properties were observed as a result of incorporation of BX and OSX into the appropriate native aqueous agarose solution. A significant increase in the viscosity and elastic modulus of the parent AG was found with incorporation of xylans. The gelling and melting points of the mixtures resembled that of pure agarose gel, except for 90% xylan concentration. A significant increase in swelling ability of the parent AG was found with incorporation of xylans, while syneresis was reduced on addition of xylans. The physicochemical and rheological properties of seaweed polysaccharide agarose were modified significantly after blending with xylans, allowing their use in new applications (*Polym Compos. (2013), 34, 978–988*).



Swelling of AG, AG/OSX_{50-90}, and AG/BX_{50-90} hydrogels (a) in pH 1.2 and (b) in pH 7.

Controlled-release performance of chitosan-polyuronic acid adducts

Controlled release performance of chitosan-polymannuronic (CH-PMA) and chitosan-polyguluronic (CH-PGA) acid adducts, has been evaluated using five structurally different drugs, i.e., paracetamol (PCT), indomethacine (IND), isoniazid (INH), atenolol (ATN) and pravastatin (PST). The release rates of PCT, INH and ATN, all containing -NH-CO-moieties, show an inverse correlation with the change in pH, i.e., highest at pH 1.2 and lowest at pH 7.4. A reversed trend is noted with IND and PST, having no -NH-CO-moieties; the release rates are highest at pH 7.4 and lowest at pH 1.2. This appears to have a correlation with the structural features of the adducts and the drugs alike, containing -NH-CO-groups, manifesting pH-dependent preferential interactions of -NH-CO-groups through intermolecular hydrogen bonding facilitated at higher pH. This study presents an array of biopolymer-based materials, which can be harnessed for delivering specific dosage schedules and would be of potential utility in pharmaceutical formulations (*Indian J Chem-A. (2013), 52A, 1269-1274*).



Controlled release of paracetamol in (a) acidic pH (1.2), (b) in pH 4.0, and (c) in pH (7.0) from chitosan adducts with PGA (CH-PGA) and PMA (CH-PMA).

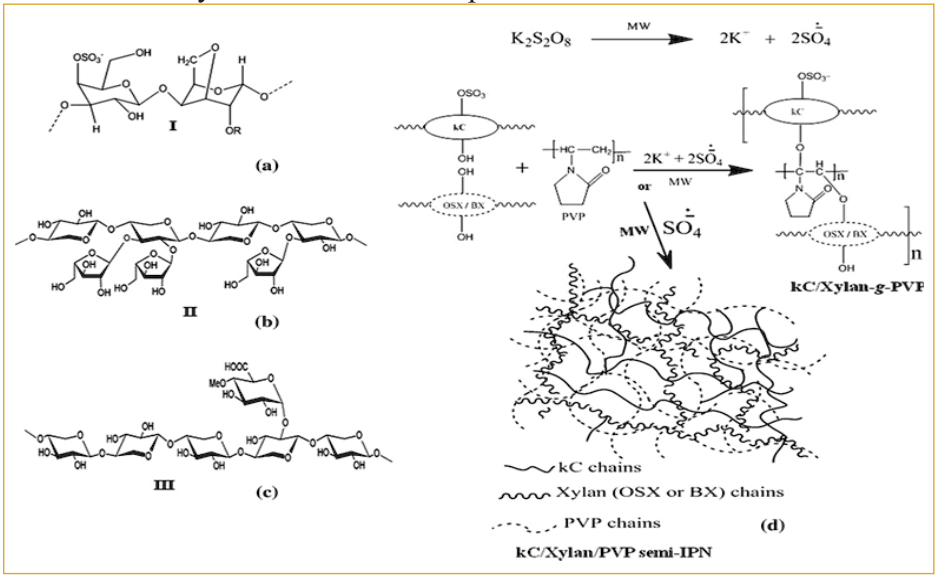
Facile synthesis of fluorescent polysaccharides: Cytosine grafted agarose and κ-carrageenan

New fluorescent polymeric materials were synthesized by grafting the nucleobase cytosine on to the backbone of agarose and κ-carrageenan, employing a rapid water based method under microwave irradiation using potassium persulphate (KPS) as an initiator. The emission spectrum of the modified agarose and κ-carrageenan recorded in aqueous solution (5×10^{-5} M) exhibited emission maxima ($\lambda_{em,max}$) at 348 nm by excitation at 266 nm. The emission intensity was enhanced by ca. 104% and 60% compared to that of pure cytosine solution of the same concentration. When the concentration of pure cytosine solution was made equivalent to concentration of the cytosine molar component (3.09×10^{-5}) and (3.5×10^{-5}) present in 5×10^{-5} M solution of modified agarose and κ-carrageenan, respectively, then ca. 143% and 81% enhancement in emission intensity was observed. The remarkable fluorescent activity of the agarose–cytosine derivative may have potential uses as sensor in various applications (*Carbohydr Polym. (2012), 87, 1971–1979*).

Microwave-assisted synthesis of kC/xylan/PVP-based blend hydrogel materials: physicochemical and rheological studies

Hydrogel systems composed of kC/Xylan (kC/OSX or kC/BX) blends and linear polyvinylpyrrolidone (PVP) were prepared in presence of water soluble initiator, potassium persulphate (KPS) with microwave irradiation. The hydrogel materials were investigated by measuring their syneresis, swelling, gel fraction, and rheological properties. Physicochemical and rheological properties of the natural polysaccharide (kC/Xylans) blends were modified significantly after blending with PVP. The introduction of PVP and the formation of semi-interpenetrating polymer network (semi-IPN) structure improved the gelling properties of the resulting hydrogels. It has been proven that a high incorporation of PVP could only be obtained

if the hydrogels were prepared using KPS initiator and microwave irradiation in combination. FTIR, CP-MAS 13C NMR, and elemental analysis confirmed the presence of PVP in the blends but no direct evidence for covalent bonds could be obtained (*Cellulose. (2014), 21, 553-568*).



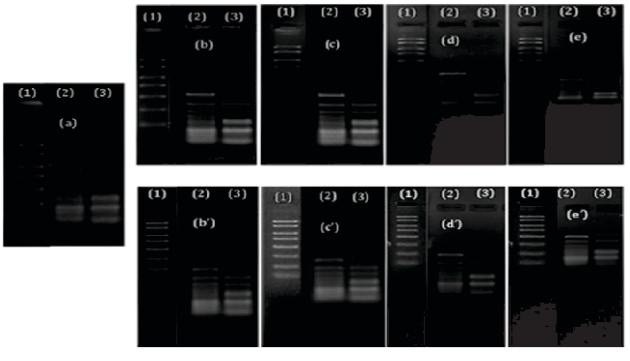
Repeating sugar units of (a) kappa-carrageenan, (b) oat spelt xylan, (c) beech xylan, and (d) a probable routes for the formation of kC/Xylans/PVP-based blend hydrogels.

Fuel intermediates, agricultural nutrients and pure water from *Kappaphycus alvarezii* seaweed

A standalone integrated scheme for the production of 5-hydroxymethyl furfural (HMF) and potassium sulphate (K_2SO_4) from granular biomass rich in the sulphated polysaccharide, -carrageenan was developed. Fresh *Kappaphycus alvarezii* seaweed was crushed to expel the juice rich in KCl (0.7 m^3/ton of fresh seaweed) and granular biomass (0.04 t dry weight/ton of fresh seaweed) (*RSCAdv. (2013), 3, 17989-17997).*

Preparation and functional evaluation of agarose derivatives

A facile microwave-assisted one-pot synthesis of sodium carboxymethylagarose and calcium carboxymethylagarose from *Gracilaria dura* agarose (Ag) has been described. The process is user friendly, and the highest degree of substitution was obtained within 15 min compared with the conventional method, which requires more than 3 h. Solubility and gelling behaviour of the modified Ag products were found to be dependent on degree of substitution of the products. The characterizations were done by using Fourier transform infrared spectroscopy, 1H- and 13C-nuclear magnetic resonance spectroscopy, thermogravimetric analysis, scanning electron microscopy, Inductively coupled plasma spectrophotometry (ICP), rheology, conductometer analysis, and DNA gel electrophoresis. These agarose derivatives were easily soluble in water and exhibited low thermal hysteresis, improved conductivity, and improved the DNA resolution ability of the parent G. dura Ag hydrogels. These hydrogels may have potential applications in the areas including electrochemical devices, microbiology, biomedical, and pharmaceuticals fields (*J Appl Polym Sci. (2014), 131, 40630*).



Gel electrophoresis images of (a) 1.2 % (w/v) parent agarose gel (Ag); (b) Ag gel with 0.2% (*w/v*) Na-$CMA_{DS0.27}$; (b') Ag gel with 0.2% (*w/v*) Ca-$CMA_{DS0.27}$; (c) Ag gel with 0.2% (*w/v*) Na-$CMA_{DS0.46}$; (c') Ag gel with 0.2% (*w/v*) Ca-$CMA_{DS0.46}$; (d) Ag gel with 0.2% (w/v) Na-$CMA_{DS0.69}$; (d') Ag gel with 0.2% Ca-$CMA_{DS0.69}$; (e) Ag gel with 0.2% (*w/v*) Na-$CMA_{DS1.11}$; (e') Ag gel with 0.2% (*w/v*) Ca-$CMA_{DS1.11}$. Lane 1: 1.2 kb DNA ladder; Lanes 2 and 3: samples after AFLP analysis with two different primers.

Work done under CSIR-Network Project "Affordable healthcare- screening of terrestrial plant and marine algal extracts"

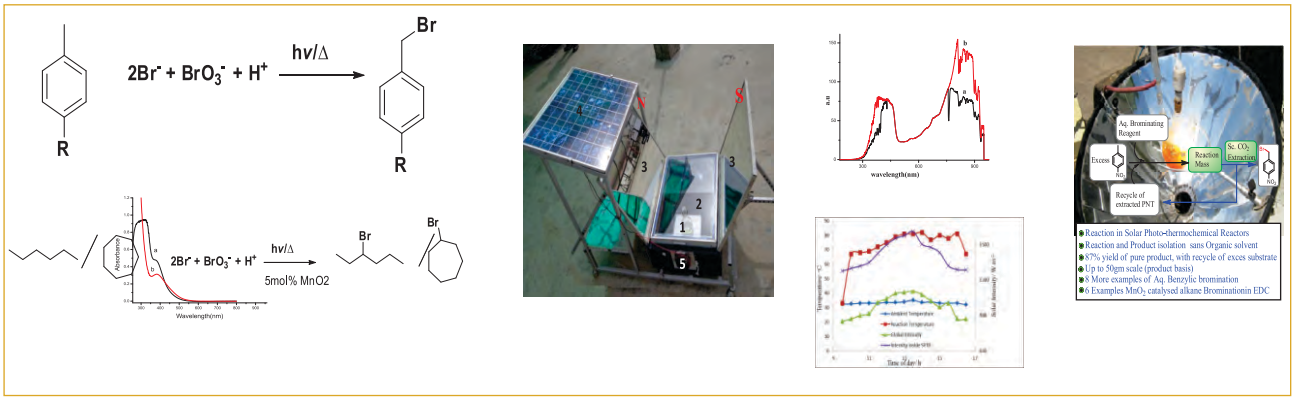
Preparation of bioactive extracts and synthesis of bioactive polymeric materials

Aqueous extracts were prepared from *Salicornia brachiata*, collected five times of its different life stage during October 2012 to December 2013 and were sent to JBTDR for activity by in-house developed SEVA TB ELISA for detecting anti TB drug potential using ES-31 antigen of *Mycobacterium tuberculosis* and its specific antibody. Isoniazid was used as a standard inhibitor. Further, the samples were tested with axenic culture of avirulent M.Tb bacilli H_{37} Ra using INH and rifampicin as standard inhibitory drugs. Further confirmation was also done by % MTT assay. The samples containing polar and non-polar compounds showed about 85-95 % inhibition in MTT assay. Four plant extracts were prepared and sent to CSIR-IHBT for anti-inflammatory activity. Results are promising and needs further confirmation under different parameters. Synthesized five agarose derivatives and sent for anti-cancer activity to CSIR-IICT. Further work is going on.

Solar energy driven chemical reactions

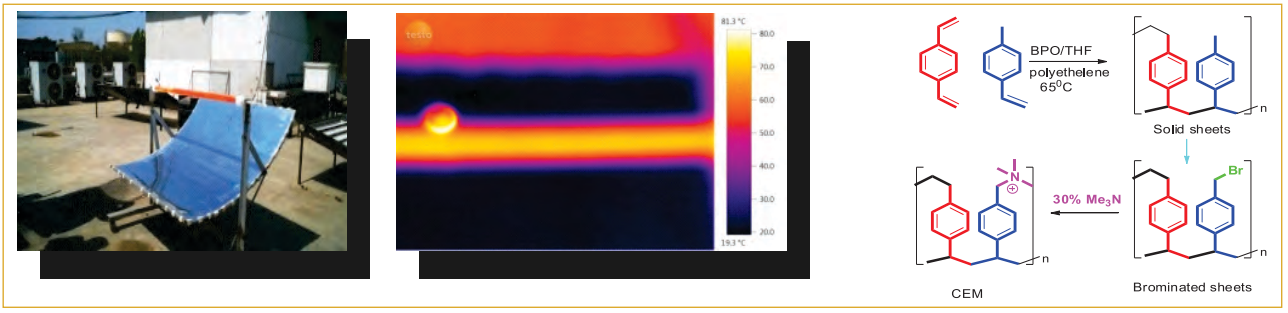
Solar photo-thermochemical reaction and supercritical CO_2 work up for a fully green process of preparation of pure p-nitrobenzyl bromide (PNBBr)

The work was attempted to advance the synthesis of this commercially important molecule employed in protection–deprotection strategies. Its successful synthesis employing neat substrate and solar radiation as the sole energy source to drive this photo-thermochemical reaction was reported. Further, 100% pure PNBBr could be isolated from the solid reaction mass in 87% yield by leaching out the excess substrate through supercritical CO_2 (Sc-CO_2) extraction. The reaction was therefore accomplished cleanly in all respects and with low carbon footprint.



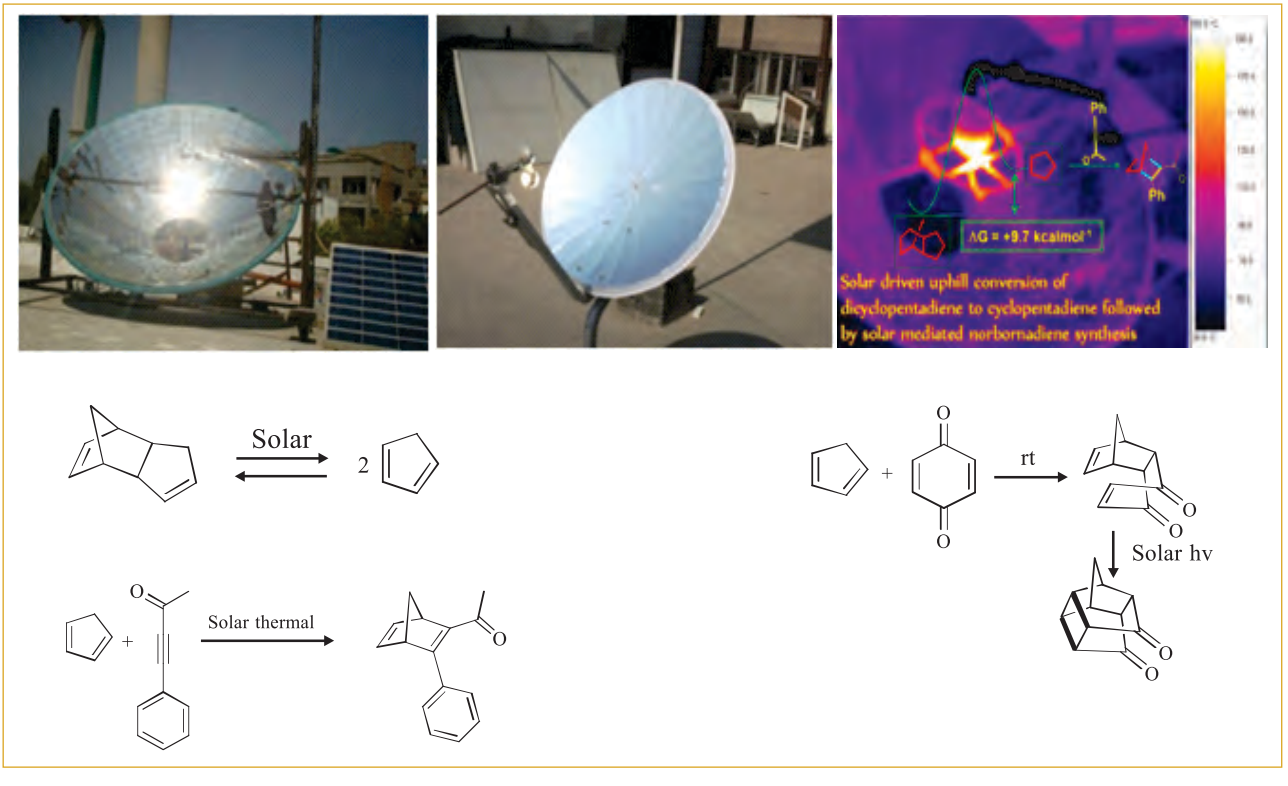
Solar driven anion exchange membrane preparation from inter-polymer film and its application in electro dialysis

An improved protocol was reported wherein the photothermochemical bromination of *p*MSty-co-DVB/PE film was carried out successfully using concentrated solar radiation from an 8x square parabolic trough concentrator. The membrane (120 cm x 12 cm; 32% w/w *p*MS) was rolled in the form of a hollow cylinder and inserted in the tube containing 4 molar equivalent of NBS in dichloroethane. The tube was rotated manually so as to provide uniform exposure to radiation. The maximum degree of benzylic bromination achieved on a typical sunny day in April-May was 87% with a 0.089 mm film. The corresponding AEM obtained upon treatment with trimethyl amine exhibited ion exchange capacity of 1.6 meq g^{-1}, ionic resistance of 4 ohm cm^{-1} and transport numbers of 0.983 and 0.941 in NaCl and HCl, respectively.



Solar driven uphill conversion of dicyclopentadiene to cyclopentadiene: an important synthon for energy systems and fine chemicals

Solar driven uphill retro Diels Alder conversion of dicyclopentadiene to cyclopentadiene (ΔH = +23.4 kcal mol^{-1}; ΔG = +9.7 kcal mol^{-1}) was demonstrated in this work. Solar energy was further utilized for conversion of the resultant cyclopentadiene into a norboradiene derivative through Diels Alder cycloaddition at high temperature. The norbornadiene - quadricyclane system has been proposed for solar energy storage, and the solar assisted synthesis of norbornadiene would help reduce the carbon footprint over the life cycle. Synthesis of norbornadiene in this manner may also be of interest for greener processing of a missile fuel. Cyclopentadiene additionally finds applications in fine chemicals syntheses which would expand the utility of the approach.



Small community scale solar dryer

Solar dryer technology is simple and therefore easily adoptable by the community and food processing sector. In general a solar dryer is an enclosed unit which allows the solar insolation to pass through a glazing and get absorbed. The heated surface in turn heats up a draft of air which then flows across the food item and leads to its drying. A new indirect type of solar dryer was designed, fabricated and tested for drying of food products. The drying of various food products could be achieved with about half the time duration taken for open sun drying. Details are given in chapter-7.

Case study in Ganga Sagar, Sundarbans, West Bengal

Such a dryer is installed in Sagar Islands of Sunderbans, West Bengal. The usual practice of drying the fish locally is in the open seashore and there are chances of contamination, spoilage, loss due to birds and insects, whereby the price fetched is quite low. As a case study, before the installation of the solar dryer, Rashida Bibi, a casual labour in a *Sutki Khati* (where the drying activity is taken up) was earning Rs. 100/- per day, almost only 7-10 days each month and earned only Rs.6000/- in a period of 6 months. After the installation of the CSMCRI dryer, she has been using the facility to dry the Bombay duck fish which is available from September to February – it takes three days for the 2 kg dry fish to be ready and she has been able to sell the same at Rs. 250 / kg. She could earn about Rs.12500/- during this 6 months period (which was only Rs. 6000/- before). The better price fetched was because of the quality and appearance of the finished dried fish.

Energy efficient community scale PV-RO systems with higher output

Although the use of solar photovoltaic (PV) is an attractive option to run community scale reverse osmosis (RO) units in localities devoid of electrical grid connectivity, an important constraint in the promotion of solar powered desalination is the high cost of power generation through the use photovoltaic modules. The major fraction of the total cost of a PV-RO system is taken up by the PV modules and as a result the cost of water from the PV-RO system increases substantially. Efforts are needed to decrease the power requirements from the PV array to run community scale RO units and save every joule of energy going as waste in the form of the RO reject water pressure.

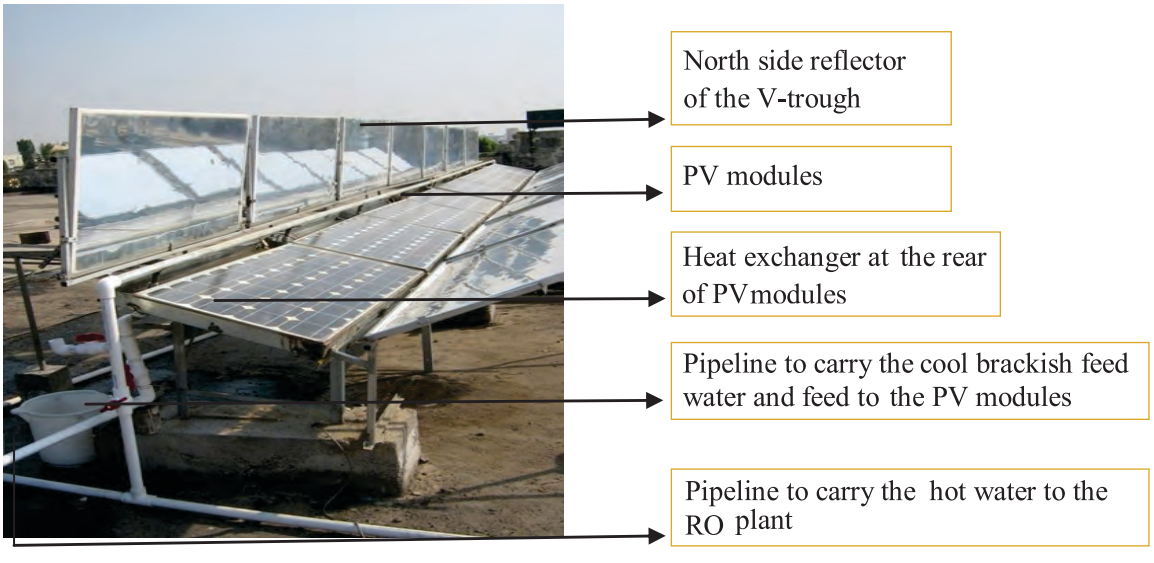
Energy efficient community scale PV powered RO desalination unit has been developed, such effectiveness brought about by:

(i) Use of V-trough concentrated photovoltaic system having multiple photovoltaic modules. More specifically, arranging the modules in the form of long rows with overall aspect ratio $\geqslant 8$ in order to boost the electrical energy output over a day using North-South reflectors without recourse to any tracking, and only through seasonal adjustments of the reflector angles following computational methods.

(ii) Using direct contact heat exchanger fitted on the underside of the PV modules for active cooling and use of RO feed water as heat exchange medium while taking due care to limit the temperature rise of feed water.

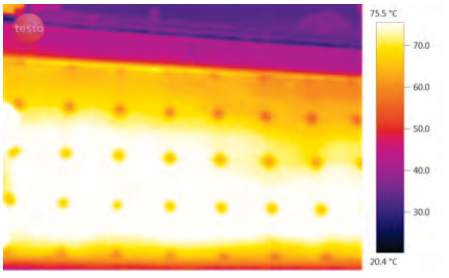
(iii) Enhancing permeate flux from RO unit through the rise in feed water temperature.

(iv) Use of a turgo-turbine for conversion of hydraulic energy in RO reject water into mechanical energy to operate the booster pump utilized in the RO unit and thus save expensive PV power.

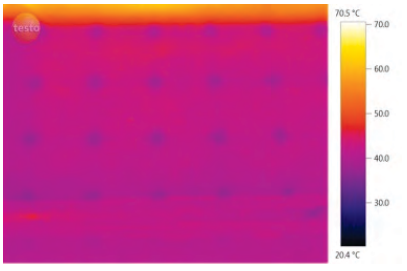




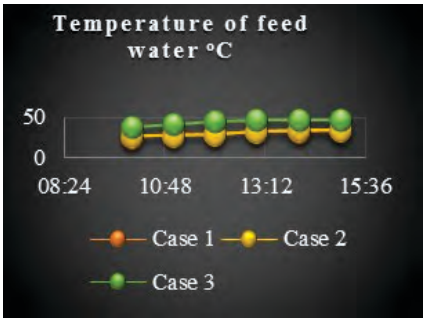
PV panel as such
Case 1

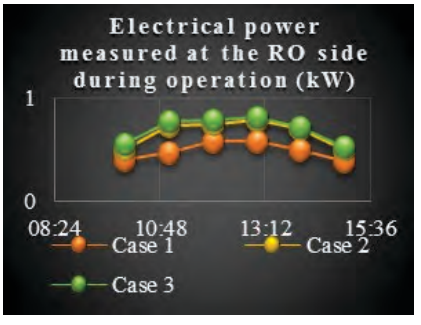


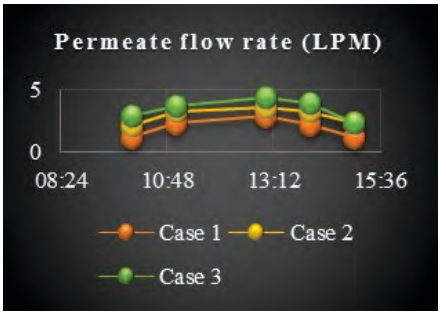
PV panel with V-trough reflectors
Case 2



PV panel with reflectors
& water circulation; Case 3





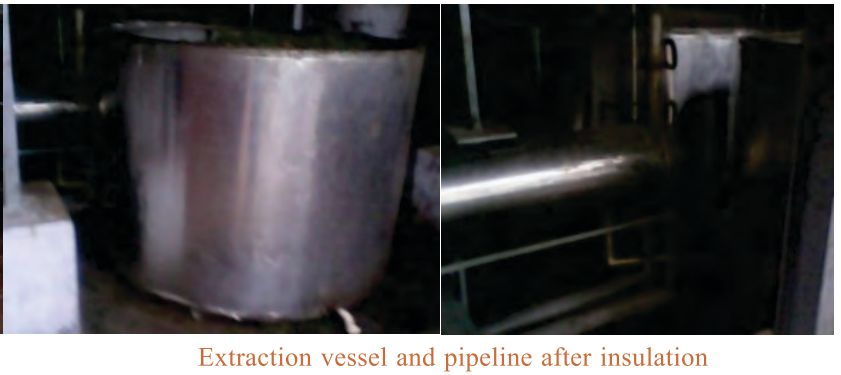


Upgradation of essential oil MSME cluster in Nilgiris, Ooty

One of the opportunities to improve oil extraction in an energy efficient manner was to provide hot insulation to all the vessels and pipelines to reduce heat losses. The scientists first started with prevention of heat losses from the boiler, pipelines and extractors. They contacted a hot insulation provider in Coimbatore and jointly identified the sites where the insulation was needed to be provided. In May – June 2013, proper insulation work was undertaken in a step by step manner. These included 1. Cleaning the surface to be insulated. 2. Fixing Lightly Resin Bonded Mattresses of 100kg/m^3 density, 50 mm thickness over the vessel and pipelines 3. Fixing and providing aluminium sheet of 24 gauge as cladding over the insulation with proper grooves and overlaps by means of self-tapping screws.



Non-insulated extraction vessel



Extraction vessel and pipeline after insulation

On 23 July 2013, the scientists received the results from HOPE foundation and the calculated energy saving was ca. 52%.

	Before insulation	After insulation
Fire wood consumption	200 kg per distillation	160 kg per distillation
Output production	7 kg per distillation	8.5 kg per distillation

प्रकरण 5
CHAPTER



बंजर भूमि अनुसंधान
Waste Land Research

बंजर भूमि अनुसंधान

बंजर भूमि अनुसंधान विभाग की गतिविधियां जेट्रोफा की उत्पादकता बढ़ाने के लिए तकनीकी कृषि में सुधार, पादप प्रजनन पहलुओं, सूक्ष्म प्रजनन प्रणाली में सुधार तथा आण्विक मध्यवर्तनों पर केन्द्रित हैं। लवणोद्भिद की खेती तथा उनकी नमक सहिष्णुता क्रियाविधि की आण्विक स्तर पर समझ पर भी विभाग ने कार्य किया है जिसके अंतर्गत जीन नियंत्रक कारकों तथा लिप्यंतरण संबंधी कारकों का अध्ययन किया गया। विभाग द्वारा एक अन्य महत्वपूर्ण पक्ष,जैव उद्विपक के रुप में कप्पाफायकस अल्वारेजी तथा ग्रेसीलेरिया इडुलिस नामक दो मैक्रो शैवाल प्रजातियों से प्राप्त समुद्री शैवाल रस (सैप) की प्रभावकारिता पर भारत के 20 राज्यों में बहुस्थानीय–बहुफसल परियोजना में शामिल नौ फसलों पर अध्ययन किया गया।

यह देखा गया कि जेट्रोफा की उपज प्रत्येक वर्ष में परिपक्वता तक नहीं बढ़ती क्योंकि यह बारिश से बहुत प्रभावित होती हैं। जेट्रोफा बीज की पैदावार,कम तथा अधिक वर्षा दोनों परिस्थितियों में नकारात्मक रुप से प्रभावित होती है। इसके अलावा अगर जेट्रोफापौधों के संस्थापन अवस्था के समयभूमि सुधार नहीं किया गया तो वयस्क जेट्रोफा पौधा उथली भूमि पर चक्रवाती हवा से झुक जाता है। उड़ीसा में चक्रवात से प्रभावित जेट्रोफा पौधों को पौधरोपण के आवश्यक उपायों को अपनाकर सफलतापूर्वक स्थापित किया गया। चयनितजननद्रव्य IC-565733 ने वर्ष 2012-13 में प्रति हेक्टर लगभग 2 टन बीज की उच्च उपज दी जो बाद के वर्ष में 1.2-1.3 किग्रा प्रति पौधा के क्रम में कम हो गई। IC-565734 तथा IC-5657350201भी अच्छे जननद्रव्यों में सम्मिलित किये गये।

उथले और चट्टानी मिट्टी वाली स्थिति में जल उपयोग दक्षता में सुधार हेतु विभिन्न कृषि उपाय विकसित किये गये, उनका परीक्षण किया गया तथा विभिन्न जल संचयन उपायों का भी परीक्षण किया गया। जेट्रोफा केक के प्रयोग के प्रभावों का परीक्षण करने के उदेश्य से एक दीर्घकालिक कृषि प्रयोग शुरु किया गया जिससे ज्ञात हुआ कि जेट्रोफा केक के प्रयोग से न केवल सक्षम पोषक तत्व परिवर्तन के लिए जिम्मेदार मिट्टी की एन्जाइमेटिक प्रवृत्तियों के अनुकूलन द्वारा बीज की उपज में वृद्धि होती है बल्कि CEC तथा जैविक कार्बन संचय के संदर्भ में भूमि की गुणवत्ता में भी सुधार भी होता है। भूमि के सूक्ष्मजैवीय सरंचना अध्ययन से ज्ञात हुआ कि एस्कोमाइकोटा जो इसके मूल निवास की मिट्टी में बहुतायत में था, जेट्रोफा उत्पादित मिट्टी में बेसिडियो माइकोटा तथा हाइट्रीडियोमाइकोटा में उच्च रुप से परिवर्तित पाया गया। जेट्रोफा के जीवनचक्र पर किए गए मूल्यांकन से ज्ञात हुआ कि ग्लोबल वार्मिंग क्षमता तथा यूट्रोफिकेशन जैसे पर्यावरणीय प्रभाव श्रेणियों के अंतर्गत यह अधिक पर्यावरण अनुकूल है।

तने के कलमों के माध्यम से विकसित जेट्रोफा संकर पौधों का उनके मातृ पौधों के साथ वनस्पति विकास तथा क्षेत्र में उत्तरजीविता का निरीक्षण किया गया। क्षेत्रीय परिस्थितियों में लगभग सभी संकर पौधे मातृ पौधों से श्रेष्ठ पाये गये और IC 565735 X IC 565739 संकर ने अधिकांशतः अच्छी वृद्धि दर्शायी एवं अच्छे उत्तरजीविता वाले पौधों में शीर्षस्थ रहे। जेट्रोफा कर्कस के प्रमुख संकर पौधों से शुद्ध बीज प्राप्त करने के लिए संकर पौधों में स्वसंकरण किया गया।संकर IC 565735 X IC 565739 में फलों का प्रतिशत अच्छा (>70%) था जबकि अन्य संकर पौधों में फलों का प्रतिशत 43 से 62% के बीच रहा। सभी मातृ पौधों ने बीज के आधार पर 30% से ज्यादा तेल तथा गूदे के आधार पर 55% तेल दर्शाया। IC 565735 X IC 565739 में सर्वाधिक तेल (बीज आधार पर 39.52% तथा गूदे के आधार पर 65.05%) पाया गया। अर्न्तजातिय संकरण के बाद पहली पीढ़ी में फ्लो–साइटोमेट्री के माध्यम से अध्ययनोपरान्त जीनोम के आकार में कोई महत्वपूर्ण बदलाव नहीं देखा गया।

श्रेष्ठ पौधों से 7000 तथा संकरित पौधों से 75 संवर्धित कलियाँ ऊतक संवर्धन सुविधा से तैयार तथा बहुगुणित की गईं। तीन वर्ष तक उपसंवर्धन के दौरान बिना हानि 6-12 तक तनीय कलियाँ प्रति पौधा प्राप्त हुईं। इन विट्रो पर्ण पुनुद्भवन से भी सफलतापूर्वक संवर्धन तैयार किया गया। संवर्धन का सूखना, पत्तियों का मुरझाना, शिराओं का पीला होना, अचानक सूखने लगना, संवर्धन का सफेद/बेरंग होना तथा कभी कभार ऊतकों में सूजन आदि बाधाओं का सामना करना पड़ा जिसे दूर करने की आवश्यकता थी। सूक्ष्म प्रवर्धित पौधों को क्षेत्र में रोपित किया गया और वे सफलतापूर्वक स्थापित हो गये। उपसंवर्धन की विभिन्न प्रावस्थाओं (5वीं/10वीं/20वीं पीढ़ी) पर, ऊतक संवर्धन की आनुवंशिक स्थिरता के मूल्यांकन के लिए आरएपीडी, आइएसएसआर, एसएसआर या फ्लो–साइटोमेट्री जैसी आण्विक

तकनीकों द्वारा परिणाम प्राप्त किये गये जिसने ऊतक संवर्धित उत्थानिक पौधों की आनुवंशिक स्थिरता का समर्थन किया तथा जेट्रोफा के उत्कृष्ट जीनोटाइप का बड़े पैमाने पर बहुगुणन के लिए पूर्व पौधों के दो भिन्न पूर्वोक्त उत्पत्तियों का उपयोग करके विकसित किये गये पुनःजनन प्रणाली की विश्वनीयता का प्रदर्शन किया।

जेट्रोफा की उपज में कवकीय रोगों के कारण भारी कमी को ध्यान में रखते हुए उसे वर्धित रोग सहिष्णुता प्रदान करने के लिए JcPR10a जीन के साथ जेट्रोफा तथा तम्बाकू के ट्रांसजेनिक पौधे विकसित करने का प्रयास किया जा रहा है। जेट्रोफा कर्कस से संरक्षा लिप्यंतरण कारक– JcWRKY विलगित किया गया। ट्रान्सक्रिप्ट विश्लेषण से ज्ञात हुआ कि सैलीसायलिक एसिड, मिथाइल जेटमोनेट, निर्जलीकरण तथा कॉलर रॉट कवक मेक्रोफोमिया के अनुक्रिया में JcWRKY ट्रान्सक्रिप्ट का आरोही नियंत्रण होता है, हालांकि महत्तम अभिव्यक्ति सैलीसायलिक एसिड के कारण हुई जिसने रोगसहिष्णुता के लिए अर्जित प्रतिरोध को बढ़ाने में अपनी भूमिका को परिलक्षित किया। JcWRKY पुनःसंयोजक प्रोटीन के साथ जेल गतिशीलता शिफ्टजांच ने PR-1 (रोगजनन संबंधित–1) तथा iso1 (आइसोएमाइलेज–1को कोड करने वाले) संवर्धकों के W-box के साथ बंधन को दर्शाया। जिसने रक्षा संबंधित जीन को नियंत्रित करने में अपनी भूमिका तथा शर्करा संकेतन में अपनी सहभागिता दिखाई।

पौधों के लिए जैवप्रेरक के रुप में सैप की क्रियाविधि पर अध्ययन ने पौटैशियम के अतिरिक्त चतुर्थ अमोनियम यौगिकों (ग्लायसिन बिटाइन तथा कोलीन क्लोराइड) को सैप की प्रभावकारिता बढ़ाने वाले मुख्य योगदानकर्ता की भूमिका को दर्शाया। इसके अलावा, साइटोकाइनिन के साथ जिबरेलिक एसिड–3के प्रतिरोधी प्रभाव को भी दूर किया गया जिसने बायोमास की उत्पादकता में सुधार लाने में अधिक प्रभावोत्पादकता दर्शायी। यह देखा गया कि अध्ययन की गयी फसलों में सैप के उपयोग से अनाज की तुलना में दलहन (कालाचना तथा हरा चना) की उपज में अधिक वृद्धि हुई। इसके अतिरिक्त यह पाया गया कि सैप के प्रयोग से विभिन्न फसलों के कार्बोहाइड्रेट स्तर में उल्लेखनीय सुधार हुआ।

लवणोद्भिद पर शोधकार्यों के अंतर्गत संस्थान के सॉल्ट फार्म, भावनगर में एक लवणोद्भिद जननद्रव्य पार्क स्थापित किया गया, जिसमें गुजरात के समुद्रीतट पर बढ़नेवाली लवणोद्भिद की 18 विविध प्रजातियों को एकत्रित एवं संवर्धन करके स्थापित किया गया। वनस्पतिजन्य नमक तैयार करने के लिए बायोमास के अधिक उपयोग की वजह से हो रहे सेलीकॉर्निया ब्रेचीएटा तथा लवणोद्भिद के उन्मूलन को रोकने के लिए, हमारे द्वारा किये गये प्रयास के अंतर्गत गुजरात के समुद्रतट दीव, निंगाला, सरतानपर तथा विक्टर पोर्ट पर सेलीकॉर्निया को सघन रुप से उगाया गया। इसके अतिरिक्त अंकुर प्रत्यारोपण का उपयोग करके सेलीकॉर्निया ब्रेचीएटा की कायिक भ्रूण उत्पत्ति तथा पादपकों केइन विट्रो पुनःउत्पादन हेतु एक प्रणाली विकसित की गई।

कायिक भ्रूण उत्पत्ति की विकसित प्रणाली से श्रेष्ठ जीनोटाइप की वंशवृद्धि, जैव सक्रिय यौगिकों का इन विट्रो उत्पादन तथा नमक उत्तरदायी जीनों का कार्यात्मक गुण निर्धारण सुगम होगा। लवणोद्भिद पर दूसरे कार्यों के अंतर्गत सेल्वाडोरा पर्सीका के नोडल तनीय भागों से आधारभूत सूक्ष्म प्रवर्धन प्रणाली विकसित की गई है। इसके अलावा इन वीवो तथा इन विट्रो पद्धति में पनप रहे सेल्वाडोरा पर्सीका के ऊतकों में डीएनए मिथाइलेशन, मिथाइलेशन बहुरुपता में परिवर्तन के स्तर तथा मिथाइलेशन बहुरुपता का आकलन करने के लिए मिथाइलेशन–संवेदनशील AFLP (MS-AFLP) मार्कर नियोजित किया गया। डीएनए मिथाइलेशन तथा जीनोम की बहुरुपता में भिन्नता, दो अलग–अलग वातावरण में पनप रहे पौधों के जीनोम की सुघट्यता प्रदर्शित करती है।

संवेदनशील पौधों को तनाव सह्यता प्रदान करने के उद्देश्य से लवणोद्भिद के तनाव–उत्तरदायी जीनों/लिप्यंतरण कारकों की पहचान करना एक अन्य उद्देश्य था। नमक सहिष्णुता के लिए पौधों की कुछ प्रजातियों (सेलीकॉर्निया ब्रेचीएटा और एल्युरोपस लागोपॉइडिस) का संभावित जीन संसाधन के रुप में उपयोग करने का प्रयास किया गया। सेलीकॉर्निया से SbMYB44 लिप्यंतरण कारक विलगित किया गया और पौधे के विकास की विभिन्न प्रावस्थाओं में इसकी अभिव्यकित का विश्लेषण किया गया। इसी तरह एल्युरोपस लागोपॉइडिस से AlHKT जीन को पौधे के नमक स्राव के आण्विक क्रियाविधि के अध्ययन के लिए विलगित किया गया।

Wasteland Research

The discipline of wasteland has made valuable contributions in the field of bio-salinity research by investigating use of sea water for growing crops and plants on coastal sand dunes in the past. The research activities dealing with cultivation of non-traditional oil yielding plants of industrial importance in marginal lands and sand dunes are also going on. Currently, the research activities of the discipline are mainly focused on areas related to agronomy, plant breeding, micro-propagation, molecular biology intervention for disease control in Jatropha. The activities on halophytes cultivation and their response to salt tolerance are being studied at molecular level by understanding the regulation of different genes and transcription factors involved in abiotic stress tolerance.

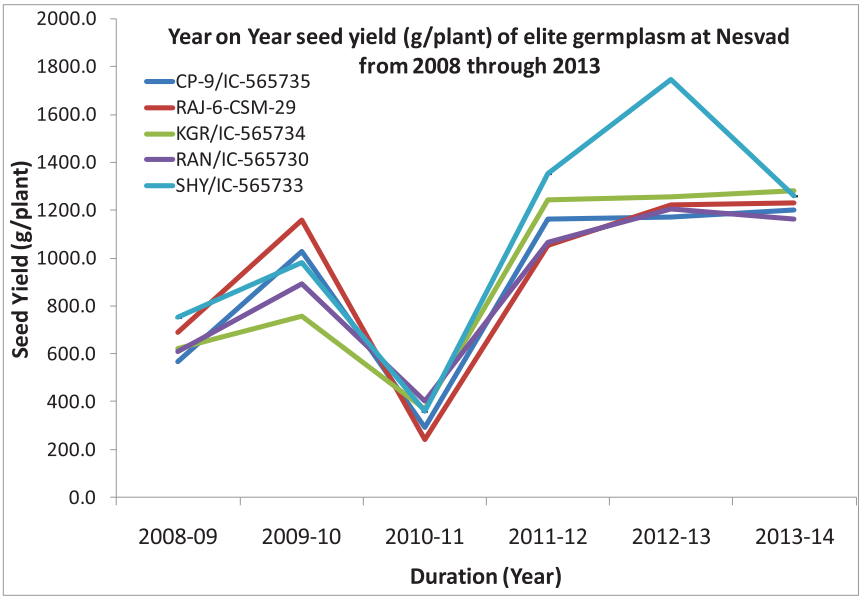
Agronomy

Yield-on year performance of selected elite accessions and correlation with weather

The institute has identified few accessions whose yields have been found superior year after year by use of proper agro-technology. The performances of some accessions had been consistently good over a period of years, at Gujarat and other place (Orissa state) and formed the basis of selections in the ongoing research project for testing them over a large scale. Following figure depicts year-on-year seed yield at Neswad field (planted in 2007-08 at 3m x 3m spacing) of 5 such shortlisted accessions found to yield consistently higher. Optimal agronomic inputs were provided to the plants of these germplasm.

It may be noted that the seed yields may not increase with every passing year until they become mature and start giving a consistent yield; there may be setbacks due to unfavorable seasonal conditions. Such conditions prevailed in 2010-11, when due to higher number of rainy days with relatively higher intensity coupled with unseasonal rainfall (in November 2010) beyond normal monsoon season, the normal flowering flushes were washed out and subsequent flushes delayed. The harvest was thus affected on account of little flowering and therefore little yields were realized as compared to earlier year. However, the yields recovered in the subsequent year (2011-12).

In 2013-14, it was found that the seed yield per plant, rather than increasing with the increasing age of the plant (2007 planted), was maintained with respect to previous year levels or was decreased. The highest reduction was found in the accession which recorded highest yield in the previous season, i.e.IC-565733 (Shyamlaji) when the rainfall was scanty (381.5mm). The seed yield ranged from 1.2-1.3 kg/plant for the different accessions. This year experienced high rainfall and the yield dipped as also happened in past during 2010-11 when rainfall exceeded 790 mm. Thus it is concluded that yield of Jatropha is associated with climatic uncertainties.



Year on year seed yield of elite accessions of Jatropha at Neswad, Gujarat

Development of innovative agronomic techniques for higher water use efficiency

An innovative agro-technique known as drip-in-sand technique for higher water use efficiency was developed. In this technique water was let in through dripper into a vertical column, dug from surface to the bed rock, filled with coarse sand so as to enable water percolate into deeper layers of the soil at a faster pace before lateral and upwards redistribution occurs. This prompted roots to penetrate deeper to explore water and nutrients. There was marked improvement in height, canopy, girth, secondary branching, biomass weight, and total root length by drip-in-sand technique.



Drip in sand technique in Jatropha

Use of natural heights in hillocks for making reservoirs for gravity irrigation

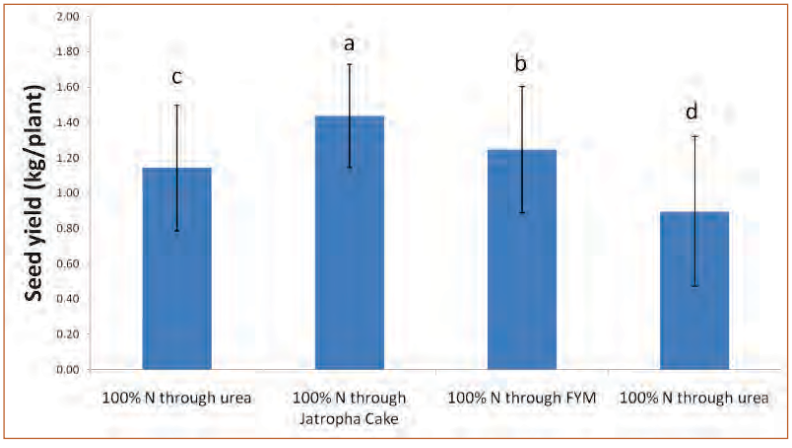
Wastelands existing in Bhavnagar possess numerous hillocks which were advantageously used to create reservoir for gravity irrigation. To make it cost effective the stones obtained by excavation of hillock were used for its construction and connected with irrigation pipeline for irrigation as shown below.



Making of reservoir for gravity irrigation system

Utilization of Jatropha cake in Jatropha plantation

A long term experiment is being undertaken from 2008 onwards in order to evaluate the effect of different inorganic and organic sources f nutrients. In this experiment, N was applied @ 100 kg/ha (through urea/cake/Farmyard manure) or 50% (through urea). It was observed that the use of Jatropha cake significantly increased soil carbon sequestration. The biochemical studies carried out at periodic intervals round the year showed an improved profile of the enzymes arylsulphatase, acid and alkaline phosphomonoesterases and glycosidase by the use of organic amendments viz., Jatropha cake and farm yard manure (FYM) as compared to when inorganic mineral fertilizers were only used (shown below). There was enhancement in microbial biomass carbon as well.

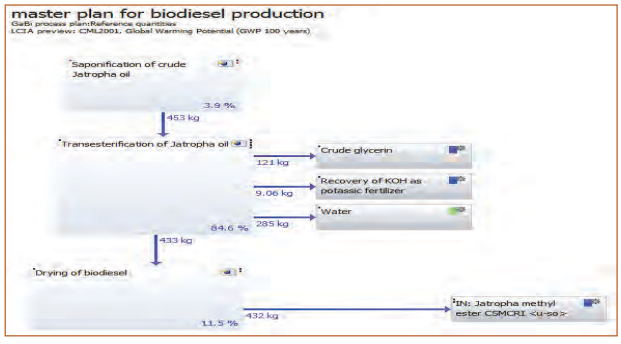


Effect of Jatropha cake, FYM and inorganic fertilizers on seed yield of Jatropha

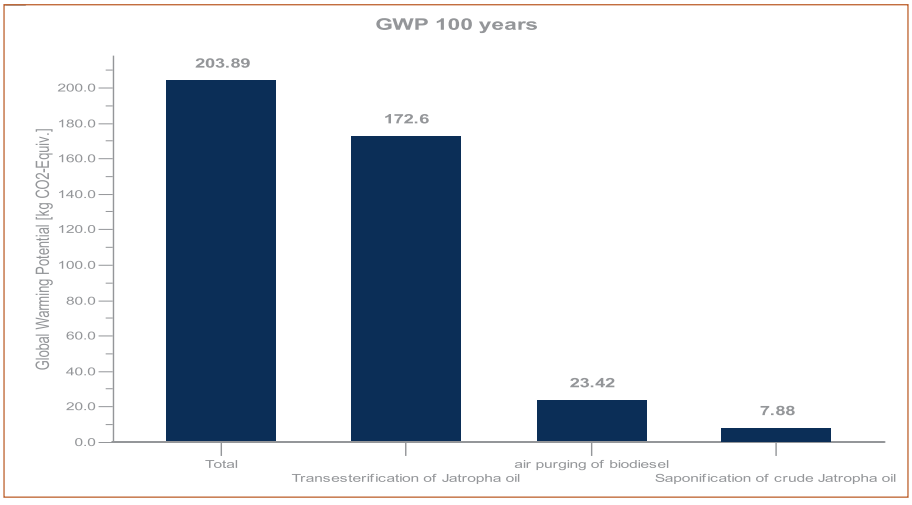
This led to better nutrient cycling leading to better availability of nutrients from soil to plants which ultimately resulted in better seed yields with the highest (1.44 kg/plant) found in cake treated plants followed by that (1.25 kg/plant) obtained by FYM treated ones in the year 2013-14.

Life cycle assessment for Jatropha biodiesel process

The life cycle assessment (LCA) of Jatropha cultivation process was carried out in 2012-13 and 2013-14 for Jatropha methyl ester (JME/biodiesel) production process (according the CSMCRI patented process). LCA was done for all the steps comprising of saponification, trans-esterification and drying of biodiesel by air purging. Global Warming Potential (GWP), Acidification Potential (AP), Eutrophication Potential (EP) and Ozone Depletion Potential (ODP) was determined for the entire process. The overall impact towards GWP was only 204 kg CO_2-Equiv for 432 Kg. biodiesel production which was very less when compared with other biodiesel production processes. Further the low GWP calculated earlier for Jatropha cultivation on wastelands integrated with that for the above biodiesel production process makes the entire process an environmental friendly process due to low carbon footprint when compared to biodiesel made from other vegetable oils.



LCA Modeling of JME



Global warming potential (GWP) of Jatropha biodiesel production process

Soil microbial diversity shift as affected by transformation of shallow and rocky wastelands to *J. curcas L.* plantation

A study was undertaken to draw comparison of microbial diversity between native undisturbed soil of barren rocky wasteland and soil drawn from rhizosphere of *J. curcas* plantation subsequent to 24 months after the effected land use change. Nuclear rDNA from metagenomic DNA was isolated by PCR using 16S and 18S specific primers, sequenced and identified using BLAST. It was observed that the microbial community diversity was higher and more evenly distributed in native soil as compared to Jatropha rhizosphere. This was evident from higher Simpson's diversity index and Shannon's index for native soil as compared to Jatropha rhizosphere for both fungi and bacteria.

Further, there was a prominent diversity shift from Ascomycota, found more abundantly in the native soil, to Basidiomycota and Chytridiomycota in Jatropha rhizosphere. The transformation from barren land to Jatropha cultivation with recommended agricultural practices also brought about a marked decrease in population of several fungal pathogens such as *Alternaria alternata*, *Bagnisiella examinans* and *Gibberella fujikuroi* which are known to cause rot diseases in *J. curcas* and other host plants. There was a striking increase in members of Proteobacteria as well as Bacteroidetes in rhizosphere soil as compared to that in native soil. In contrast, there was a decrease in Acidobacteria, Chloroflexi community in nutrient amended Jatropha rhizosphere soil.

Damage to Jatropha plantation at Odisha due to cyclone and its rehabilitation

Rehabilitation of damaged Jatropha plantation at Berhampur (Odisha) due to cyclone in October 2013 was carried out done by the division, details are provided in chapter-7.

Efficacy of *Kappaphycus* and *Gracilaria* sap on productivity of crops

Efforts were made for validating the efficacy of *Kappaphycus* and *Gracilaria edulis* saps through multi-locational, multi crop trials in collaboration with 43 Agricultural Institutions across 20 states of India. It also aims to underpin the active components in the sap. The project has an outlay of Rs 11.61 Crores and has been funded by Council of Scientific and Industrial Research, New Delhi.

Understanding mechanism of seaweed sap action on crop plants

A 3-year study was continued to understand the factors present in *Kapppahycus* sap responsible for enhancement of crop and biomass yield. Pristine sap contained choline and glycine

betaine, and these were detected in similar amounts in all the sap variants made by selectively removing growth hormones auxin or gibberellin. GA_3-free sap (a new formulation developed/filed for patent) showed increased photosynthetic activity which translated into 26% increase in corn stover yield compared to pristine sap. The study constitutes the first report of enhancement of performance of a natural seaweed plant stimulant towards increasing plant growth through simplification of its composition.

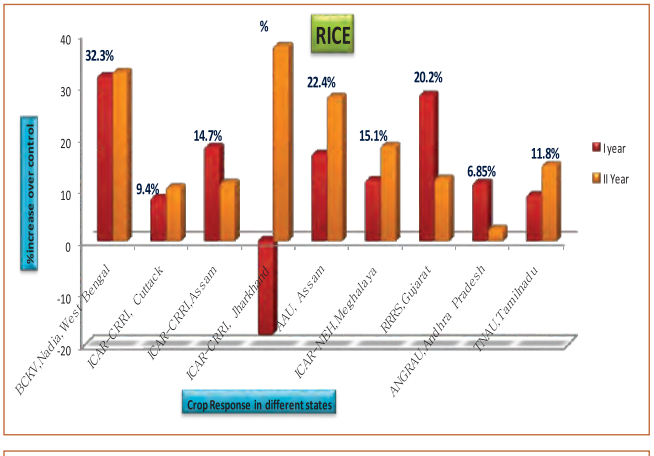
In another study, it was found that the *Kappaphycus* sap modulates the activities of stress alleviating enzymes and helps more tolerance towards water stress as substantiated by the decreased levels of malondialdehyde content and increased APX activities in sap treated maize plants.

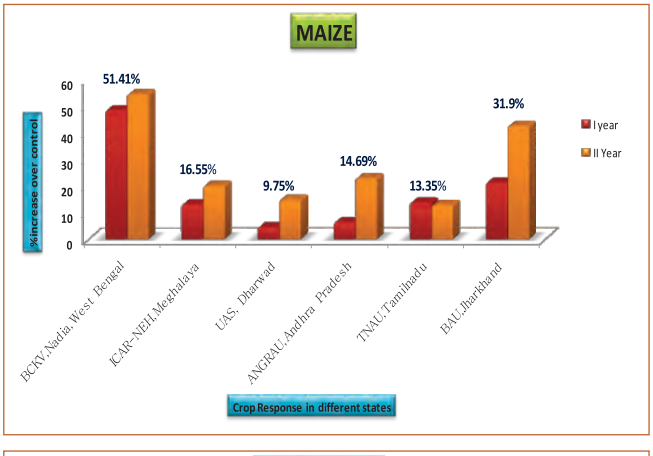
Further, work was done towards energy computations for making fuel intermediates, agricultural nutrients and pure water from *K. alvarezii* seaweed.

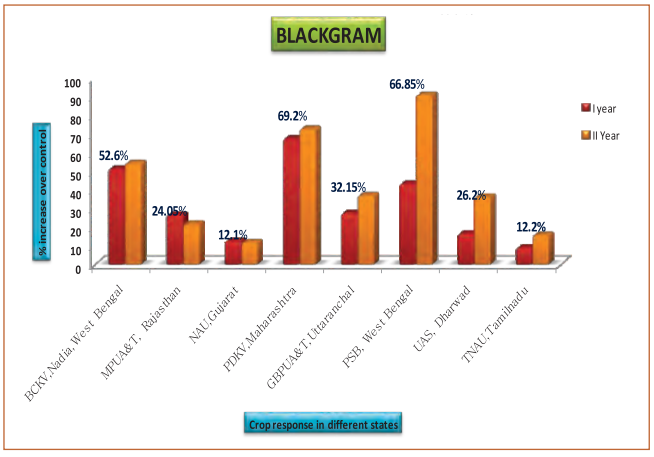
Results of multi-locational multi crop trials

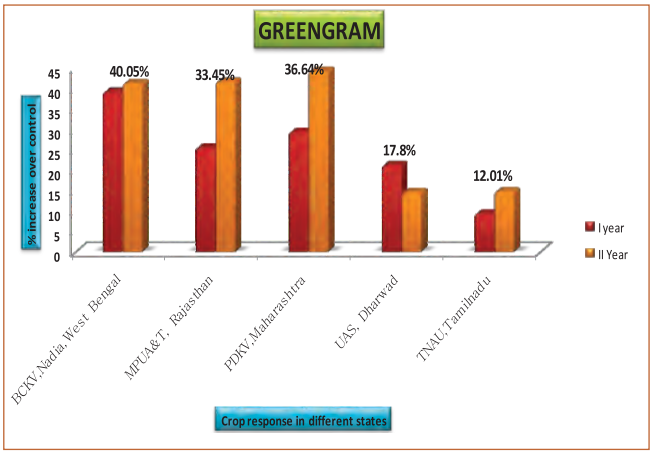
The results of several trials using *K.alvarezii* and *G.edulis* saps showed >20% yield increases. The results depicted in figure show the average increase in yield of rice, maize, black gram, green gram, soybean and sesame across different states of the country due to foliar spray of *K sap*. Similar increases were also found in *G* sap (but not being depicted). In all cases control is water spray + recommended dose of fertilizers (RDF) and the increases are over and above RDF for the respective crops.

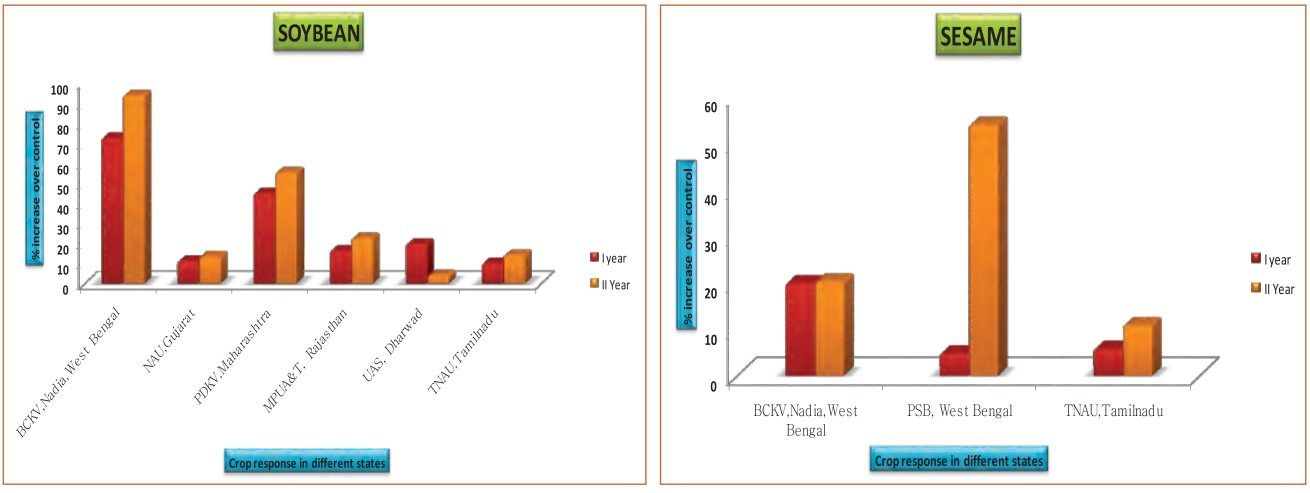
Apart from these studies, there were improvement in potato and sugarcane as well. It was found that grain quality in terms of carbohydrate content was improved by application of seaweed sap. Further, it was noticed that the pulses were more responsive to sap treatment than cereals. Thus it provides an opportunity to improve the pulse yield in India without increased use of chemical fertilizer, thus with a favorable carbon footprint.











Mean increases in yields of different crops due to foliar spray of neat *Kappaphycus sap*

Jatropha Breeding

Growth and survival of Jatropha hybrid cuttings after initial years of field transplanting

Hybrid lines developed through stem cuttings were monitored for their vegetative growth performance and survival at 12 and 24 months of field planting. Considerable differences were noticed among various hybrids in height, canopy, number of branches, stems girth and survival per cent during 1st and 2nd year of plant growth.

In the first year cross IC 565735X IC 565739 showed maximum plant height, plant canopy and number of branches (115.52 cm, 225.64cm and 24.56, respectively, whereas stem girth (72.9mm) was highest in its reciprocal cross IC 565739X IC 565735. Field survival was maximum (82.6%) in IC 565737X IC 565736 cross.

During the evaluation of second year performance cross IC 565735X IC 565739 also top ranked for plant height (246.69cm), plant canopy (510.22cm) and number of branches (39.50). Stem girth (89.4mm) and field survival (80.10%) were found maximum in IC 565737X IC 565736) as shown in the table.

Growth and survival of hybrid cutting in field during first and second year

Cross combination	A: 12 month growth				
	Height	Canopy	Branches	Stem girth	Survival
IC 565730X IC 565731	105.40	215.22	19.78	68.51	78.75
IC 565733X IC 565734	105.89	190.15	21.23	57.80	75.60
IC 565736X IC 565737	100.35	201.10	18.90	69.33	65.38
IC 565737X IC 565736	109.77	215.24	23.40	64.56	82.56
IC 565739X IC 565735	103.00	210.86	19.83	72.89	78.91
IC 565735X IC 565739	115.52	225.64	24.56	72.50	77.52
Mean	106.7	209.3	21.4	67.0	75.8
S.D.	5.4	12.4	2.3	5.7	5.9
CV (%)	5.0	5.9	10.5	8.5	7.8

Cross combination	24 month growth				
IC 565730X IC 565731	205.54	410.50	30.41	79.50	77.40
IC 565733X IC 565734	220.46	500.45	36.00	86.00	75.56
IC 565736X IC 565737	225.30	480.55	35.63	88.50	64.02
IC 565737X IC 565736	230.45	440.87	37.11	89.40	80.10
IC 565739X IC 565735	210.78	390.00	34.58	85.70	76.50
IC 565735X IC 565739	246.69	510.22	39.50	89.00	76.80
Mean	223.9	454.1	35.4	85.9	74.3
S.D.	14.7	49.3	3.0	3.7	5.6
CV (%)	6.6	10.9	8.5	4.3	7.6

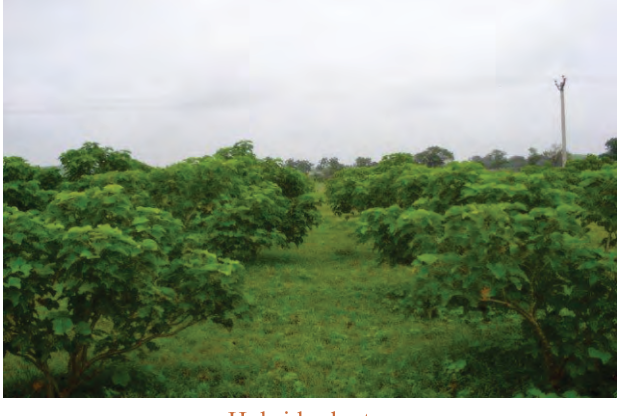
Superiority of Jatropha hybrids over their parents for growth parameters

Growth related traits in six hybrids were observed during second year and compared with their respective parents for four agronomic traits i.e. plant height, plant canopy, number of branches and stem girth. Almost all the hybrid plants surpassed both parental accessions in these traits in our study as clearly visible in the figure.

one i.e. between IC 565737 and IC 565736 accessions. Out of the six cross-combination groups, four showed a considerable enhancement in most of the characters studied in their hybirds even in reciprocal manner especially for plant canopy when compared to parental performance. Graphic performances of these four superior



Parent plants

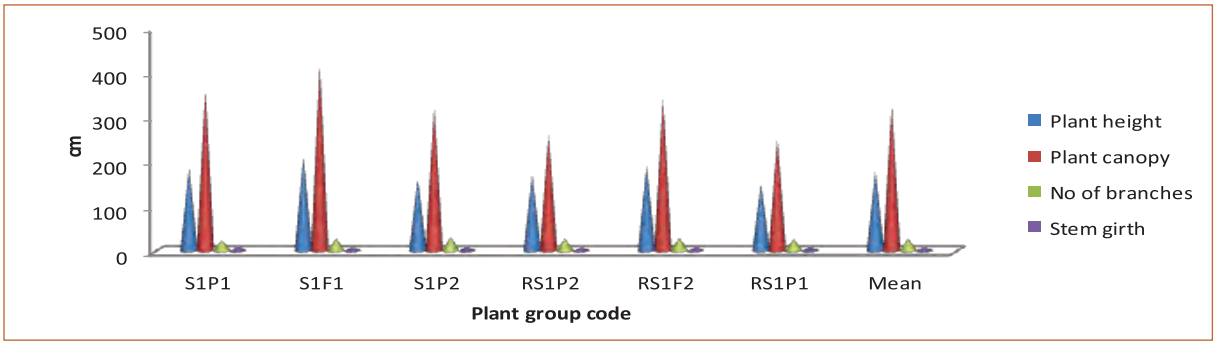


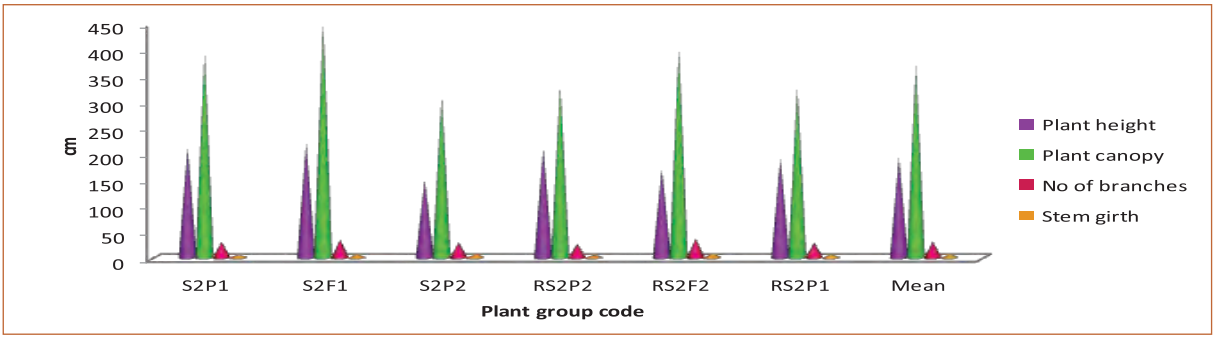
Hybrid plants

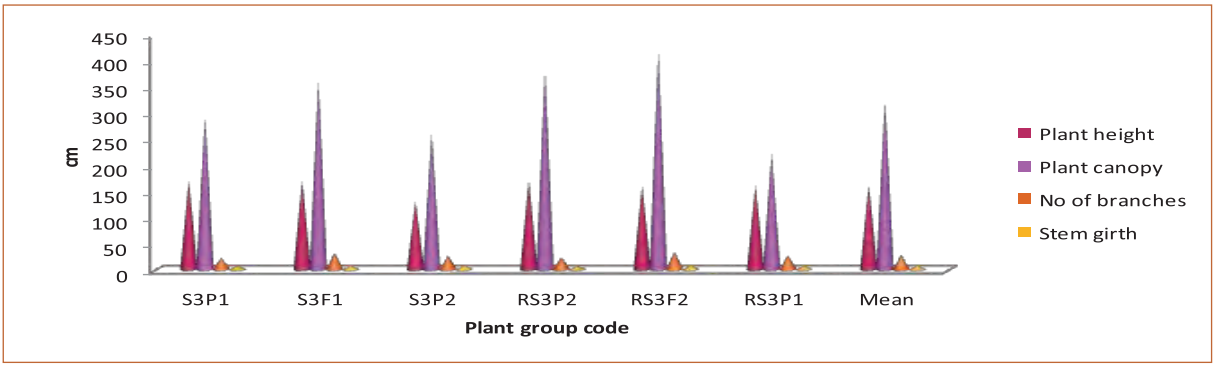
Two years old parental and hybrid plants derived from hybrid cuttings

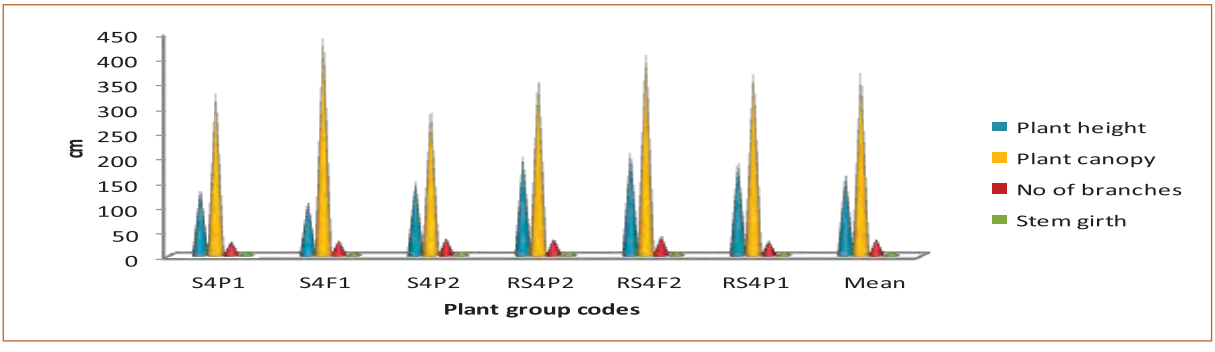
Overall mean for all the traits were highest in the second set representing the performance of parents (S2P1,S2P2,RS2P1 and RS2P2) and their F1s (S2F1&RS2F2 of a cross between IC 565735 and IC 565739 accessions followed by the fourth

hybrid groups for growth traits are shown inthe figure.Pooled mean performance of all the plant groups in individual sets for four growth traits is also represented in their respective graphs.





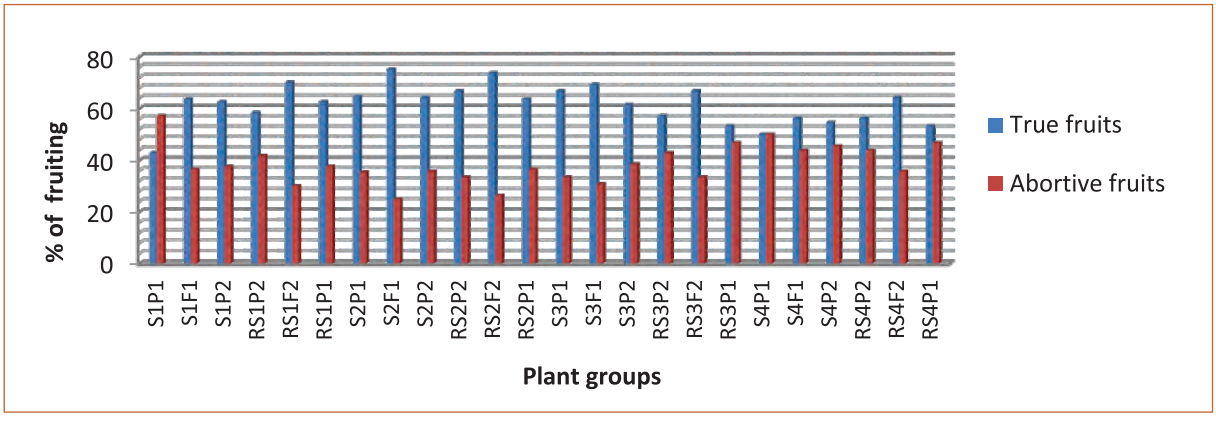




Comparative performance of *J. curcas* hybrids along with parents

Selfing of parental and hybrid lines to have pure seeds in identified Jatropha hybrids

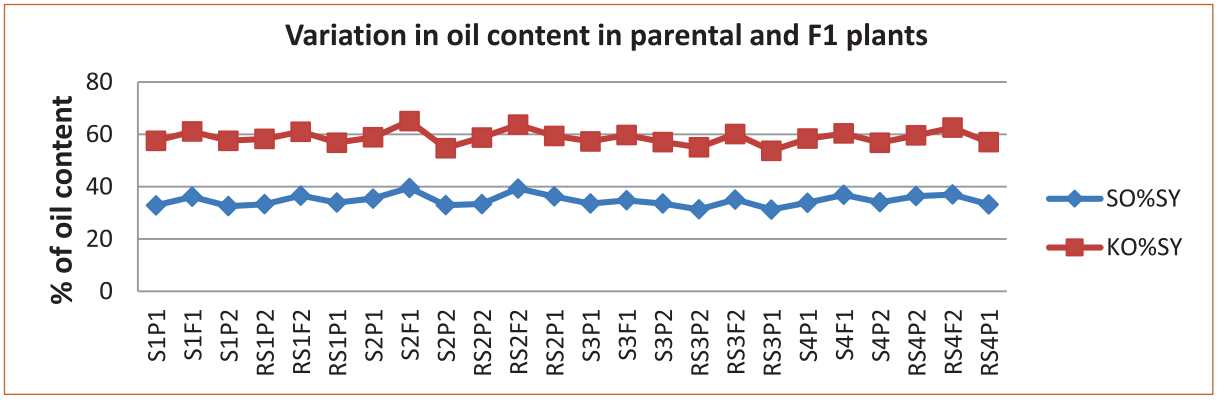
A total of 37 inflorescences from F1s and parental plants were covered with bags before anthesis for self-pollination in four sets of plant groups. Out of 331 female flowers from these groups, 197 could set true fruits i.e. only 59.51% fruits were true and remaining 40.49% were abortive after selfing. It was observed that in second group, the percentage of true fruits was good ranging from 63.64 to 70.00% whereas in rest of the three groups, it was between 42.86 to 62.50% as shown in the figure.



SO%SY-Seed oil percentage for second year harvest;KO%SY-Kernel oil percentage for second year harvest Variation in oil % of various hybrid groups on seed and kernel basis

Estimation of oil content on seed and kernel basis in Jatropha hybrid cuttings

A comparative study was undertaken to estimate the oil content based on seed and kernel in leading Jatropha parental and hybrid seeds collected from second year harvest. Almost all the parental plants showed more than 30% oil on seed basis and 55% on kernel basis. Most of the F1 plants showed a considerable increase in oil content based on seed as well as kernel basis as compared to their parental plants as shown in the figure.Highest oil content was observed in S_2H_1 i.e. IC 565735 X IC 565739 (39.52% on seed basis and 65.05% on kernel basis) followed by its reciprocal cross RS_2H_2 i.e. IC 565739 X IC 565734 with 39.29% and 63.66% on seed and kernel basis, respectively.



Variation in oil % of various hybrid groups on seed and kernel basis

Developing half-diallels from elite and wild accessions of *J. curcas*

To assess the combining ability of various genotypes as suitable parents for hybridization, effort was made to make half-diallels from six year old existing germplasm of *J. curcas*. Seven accessions representing Gujarat, Maharashtra and Odisha states along with one exotic selection were selected as parents based on their previous year's record related to yield and oil content to produce 28 possible F1 hybrids and 8 selfings in *J. curcas*. Morphological data was also recorded to observe their present growth behavior during current year under present field conditions (see table). The half-dialled sets of 28 Jatropha crosses were made as five F1 plants per cross as well as five plants from each parent growing in a RBD plot.

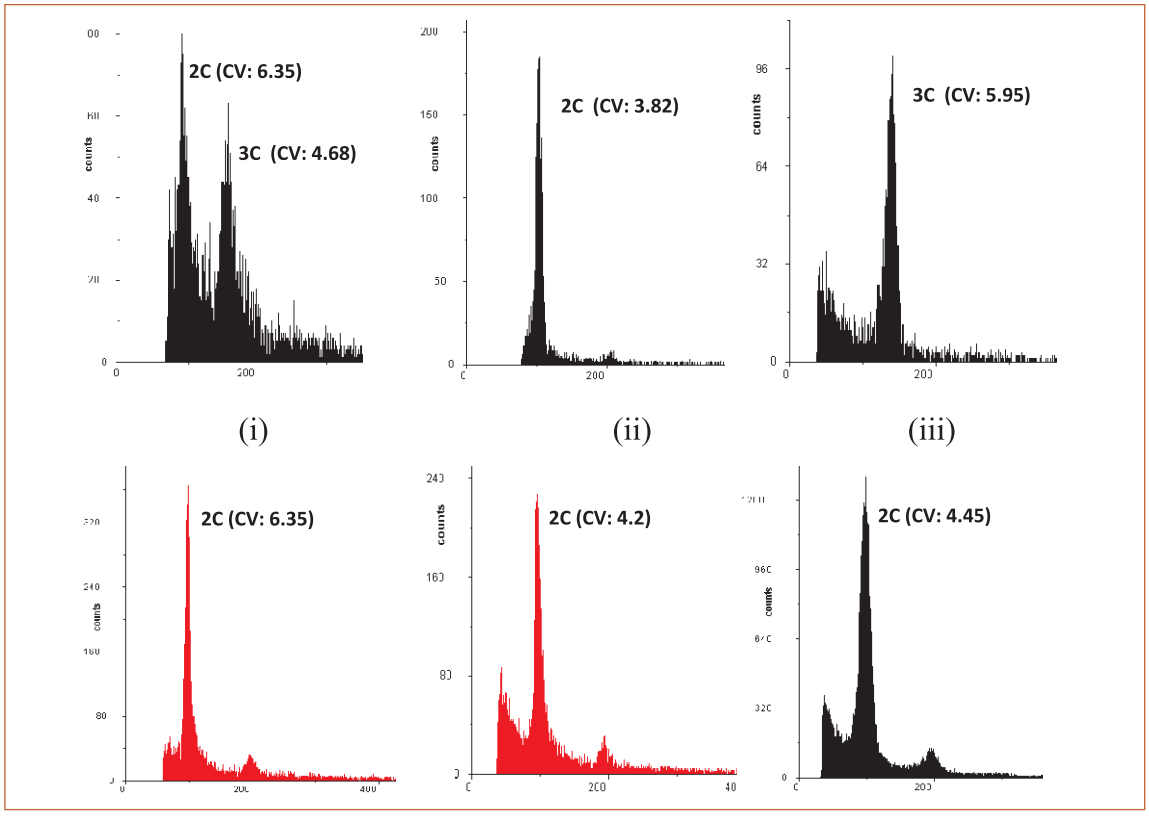
Growth performance of selected elite and wild accessions

S.N.	Germplasm	Plant Height (cm)	Plant Canopy (cm)	Stem girth (mm)	No of primary branches	1° Branch Diameter (mm)	No of secondary branches	2° Branch diameter (mm)
1	Exotic	234.4	166.5	138.1	4.2	65.7	10.3	36.0
2	KGR	247.8	163.5	145.2	2.2	90.3	6.7	48.3
3	Ranpur	244.4	190.8	156.2	3.3	85.7	8.4	45.3
4	Chikhali	237.8	186.1	149.2	2.7	90.1	8.1	46.5
5	Zanjmer	183.9	160.0	126.8	3.1	70.7	7.8	41.9
6	Akola	225.6	173.9	138.4	3.0	78.5	8.4	44.8
7	PCM	227.8	175.6	149.4	2.8	75.9	7.4	44.1
8	SKNJ	152.5	133.8	135.3	3.1	61.8	7.6	38.2
9	Shyamlaji	268.8	156.9	166.4	3.3	92.3	8.0	54.0
10	Raj-4	252.0	168.0	134.8	2.6	92.8	7.9	54.8
11	Raj-6	252.2	171.1	132.6	2.7	87.8	7.2	53.1
12	Shaktipeeth	229.3	163.0	142.9	2.9	85.6	7.8	50.6
13	Buret	246.3	153.0	133.8	3.1	83.4	8.8	48.4
14	CP-9	243.0	147.0	152.0	2.7	95.2	7.7	54.5
15	Amblimal	245.6	141.1	142.8	2.3	89.0	7.8	50.9

Maximum plant height (268.8 cm) and stem girth (166.4 mm) was observed in Shyamlaji while plant canopy was maximum (190.8 cm) in Ranpur. Highest number of primary (4.2) as well as secondary branches (10.3) was recorded in Exotic variety. CP-9 and Raj-4 showed maximum diameter of primary (95 mm) and secondary branches (54.8mm), respectively.

Estimation of Nuclear Genome Size of Jatropha hybrids using Flow Cytometer Analysis (FCA)

Generally hybrid plants have genomes of intermediate size between their parents but there are some exceptions indicating that the genome size of crosses may not always be located exactly halfway between the values of their respective parents and even may be closer to the smaller genome. After analyzing the amount of nuclear DNA in 8 parents (0.85-0.88 pg/cell) and 4 hybrids (0.85-0.86 pg/cell) of *J. curcas*, no significant variations in genome size were detected with typical diploid nature (2C) in the first generation after intraspecific hybridization. Flow cytographs taken for one of the cross-combination is shown in the figures(iv-vi) along with internal standards (i-iii).



(i) 2C and 3C at channel 100 & 150; (ii) 2C - diploid and (iii) 3C - triploid; iv) IC565735 (Female parent); v) IC565739 (Male parent) and (vi) IC565735 X IC565739 (Hybrid)

Micropropagation

Generation, multiplication and maintenance of cultures of elite accessions of *J. curcas*

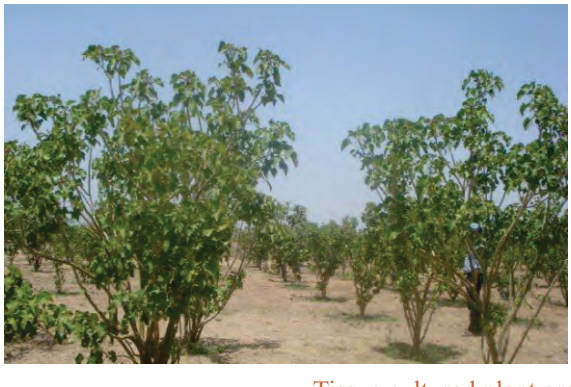
New cultures were established in the year 2012-2013, fresh shoots were collected from field-grown elite plants and greenhouse maintained cutting from elite plants each month (January to December). Culture response varied in the field and greenhouse plants (see tables). Greenhouse plant responded better than field plants. Approximately 7000 multiple shoot bud cultures of different elite plants and 75 multiple shoot bud cultures of hybrid plants were generated through repeated subculture. Cultures of more than three years old were constantly sub-cultured and numbers of multiple shoot buds were found to be 6-12 per explant, with no decline in number of

multiple shoot buds. From *in vitro* established shoot cultures, the leaves were used as explants and more than 800 cultures (700 cultures from elite plant culture and 100 from hybrid culture) were generated through direct *in vitro* leaf regeneration. The cultures with multiple shoot buds were kept for shoot elongation. Drying of cultures, curling of leaves, yellowing of veins, sudden drying, turning of cultures in white/colorless tissues and sometimes swelling of tissues are major bottlenecks during tissue culture of Jatropha. It was also observed that lengthy/long time interval for culture elongation was also one the drawback.

Plant material collected from field and Greenhouse of CSIR-CSMCRI

Month	Field		Green House	
	Shoot bud response (%)	Culture Survival (%)	Shoot bud response (%)	Culture Survival (%)
January	70	20	-	-
February	71	20	-	-
March	85	90	90	90
April	90	90	90	90
June	90	90	90	90
July	85	65	85	90
August	85	65	85	90
September	70	65	85	80
October	70	50	60	80
November	65	40	55	80
December	65	20	55	80

Approximately 300 rooted tissue cultured plants well established in nursery. In 2011-12 tissue culture plants were transplanted in the field at CSIR-CSMCRI experimental site Bhadrawal, Gujarat. They have established well and are in the early growth phase. Their growth data under field conditions is as below as of 2013.





Tissue cultured plant growing at Bhadraval site

Accession no.	No. of branches/plant			
	Height (cm)	Primary	Secondary	Tertiary
IC-565731 (planted in 2011	120	2	3	3
	150	3	5	5
	100	1	3	3
	140	3	4	4
	100	2	3	3
	100	1	3	5
	100	1	2	-
	90	1	3	5

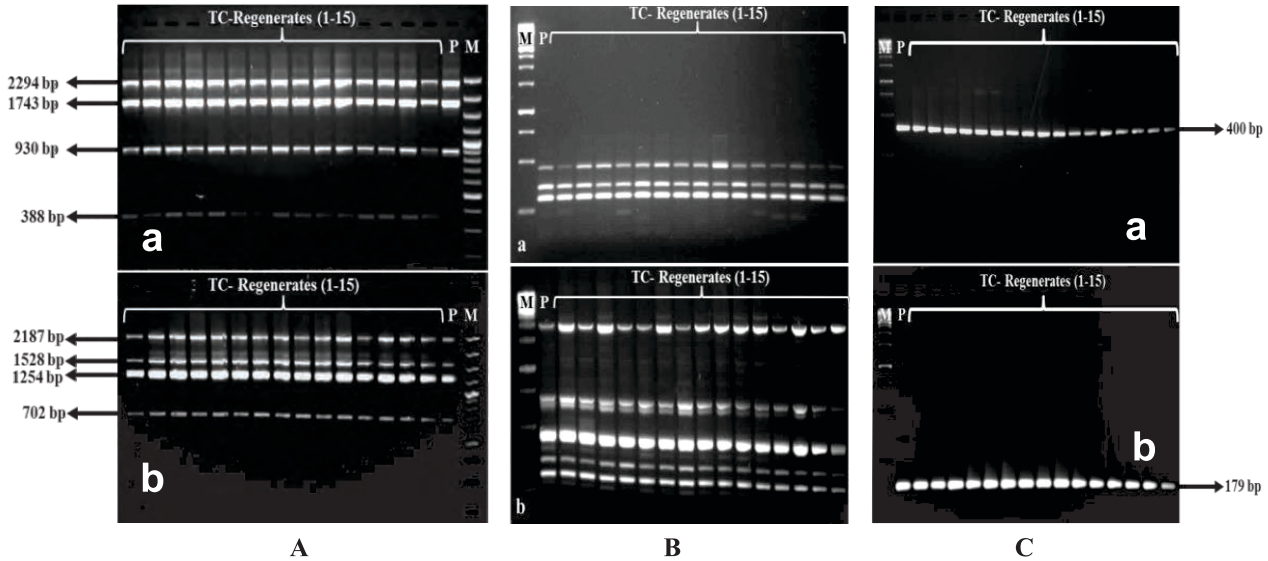
Economization of *in vitro* multiplication protocol of *J. curcas*

Elite plants growing in *Jatropha* experimental fields at Chorvadla and Nesward (Bhavnagar) were selected on the basis of yield performances during the couple of years. The explants were collected in the months of March – June and multiple shoot cultures were established. Multiple shoot bud cultures were established from elite genotypes (4000-4500). *In vitro* derived leaves were also used for culture generation from multiple shoot cultures (1500-2000). Attempts were made to root the elongated shoots both *in vitro* and *ex vitro*. The rooted plants were acclimatized by slow and gradual exposure from culture room conditions to *in vivo* conditions.

High cost is one of the major constraints for large-scale multiplication of Jatropha. To economize the *in vitro* multiplication attempts were made to replace the use of SRL branded sucrose with commercially grade sucrose (Daurala Sugar Works, Meerut U.P.). It was found that SRL brand (3.0%) sucrose can be replaced with Daurala sucrose (4.0%) for economization of multiplication of *J. curcas* and thislead 55-60% cost reduction for Jatropha multiplication.

Genetic stability evaluation of axillary shoot bud proliferated and leaf regenerated tissue culture regenerates

Attempts were made to evaluate the reliability of *in vitro* propagation methods for elite genotypes of *J. curcas* L., that maintain genetic integrity of tissue culture (TC) regenerates among two regeneration systems developed through direct shoot bud regeneration using nodal/apical shoot segments (Protocol- A) and *in vitro*-derived leaves (Protocol- B) as explants. RAPD, ISSR, SSR molecular markers and flow cytometery (FCM) were employed to evaluate genetic homogeneity in TC-regenerates at different passages of subcultures. RAPD markers showed genetic homogeneity till 5th generation TC-regenerates of both protocols. ISSR markers showed genetic stability of leaf regenerates (Protocol- B) at 10th generation. FCM analysis of TC-regenerates till 10th generation in protocol- B and till 20th generation in both protocols showed stability of ploidy level. SSR assessment of TC-regenerates at 20th generation in both protocols confirmed genetic homogeneity. The results confirmed the genetic stability of the TC-regenerates and demonstrated the reliability of the regeneration systems developed so far using explants of two different origins, for large-scale multiplication of elite genotypes of Jatropha.

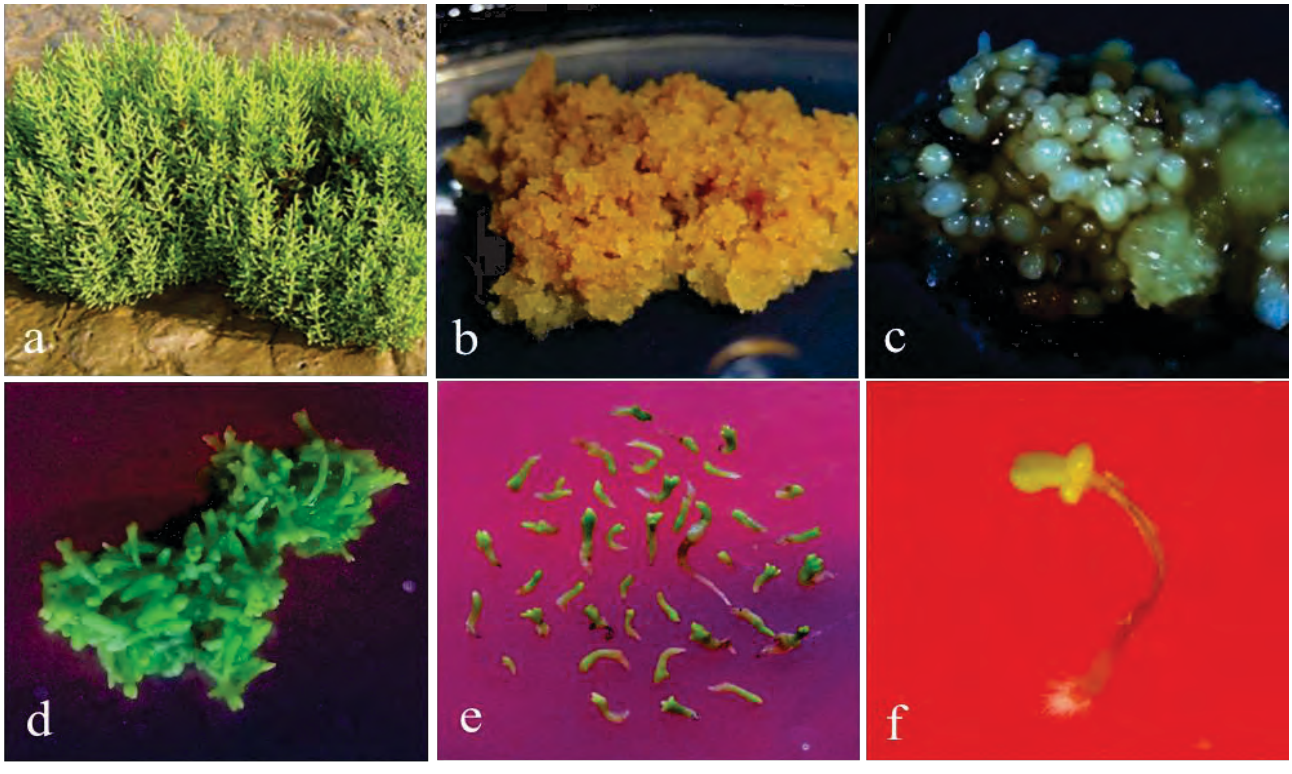


A B C

A) RAPD fingerprints of 5th generation TC-regenerates of protocol- A with opL- 1 (a) and protocol- B with opO-5(b) primer. Lane M 100 bp DNA ladder; P- mother plant and 1-15 are TC regenerates **B)** ISSR fingerprints of 10th generation TC-regenerates of protocol- B using ISSR- I (a) and L (b) primer. Lane M- 1 kb DNA ladder; P- mother plant and 1-15 are TC regenerates **C)** SSR fingerprints of 20th generation TC-regenerates of protocol- A with JCMNS- 196 (a) and protocol- B with JCMNS- 68(b) primer. Lane M- 1 kb DNA ladder; P- mother plant and 1-15 are TC regenerates.

Somatic embryogenesis in *Salicornia brachiata* Roxb.

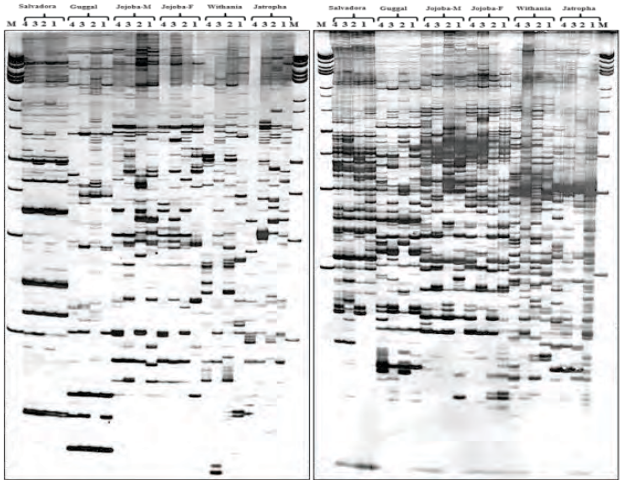
A protocol for somatic embryogenesis and *in vitro* plantlet regeneration of *S. brachiata* (an important resource for salt stress responsive genes) has been attempted using seedling explant. The explants produced callus on MS medium containing 2,4-dichlorophenoxyacetic acid (2,4-D) and subsequently somatic embryos. The mature somatic embryos germinated on hormone free MS medium and produced somatic seedlings.The somatic seedlings were grown on PGR free medium and then transferred on sterile soil for further acclimatization. The somatic embryogenesis system developed would facilitate multiplication of elite genotypes, *in vitro* production of bioactive compounds, and functional characterization of salt responsive genes.



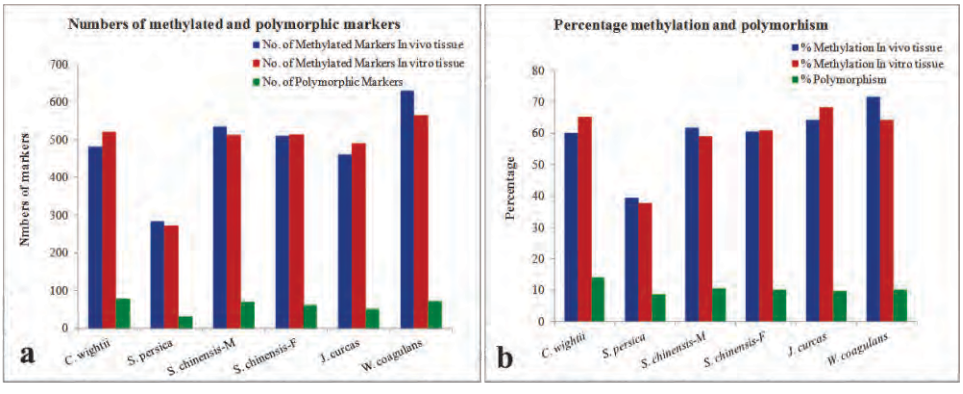
Somatic embryogenesis in *Salicornia brachiata* (a) Plants of *Salicornia brachiata* under natural conditions; (b) Embryogenic callus cultures; (c) Globular somatic embryoids; (d) Cotyledonary stage somatic embryos in cultures; (e) Development of somatic seedlings; (f) A somatic seedling.

Evaluation of methylation in plant tissue under *in vitro* and *in vivo* environment

Methylation-sensitive AFLP (MS-AFLP) markers were employed to assess DNA methylation, degree of alterations in DNA methylation and methylation polymorphism in plant tissues growing *in vivo* and *in vitro*. Percentage methylation in genome obtained was higher in *in vivo* grown tissues of *S. persica*, *S. chinensis* - M and *W. coagulans*; and in *in vitro* grown tissues of *C. wightii*, *S. chinensis* - F and *J. curcas*. The percentage polymorphism in methylated DNA obtained was 8.71% in *S. persica*, 9.81% in *J. curcas*, 10.10% in *S. chinensis* - F, 10.26% in *W. coagulans*, 10.66% in *S. chinensis* - M and 13.98% in *C. wightii*. The difference in DNA methylation and polymorphism in genomes reflect the plasticity in genomes of the plants growing under two different environments. The results suggest possibility of involvement of these fragments in the dynamic processes regulating plant growth and development under prevailing growth conditions.



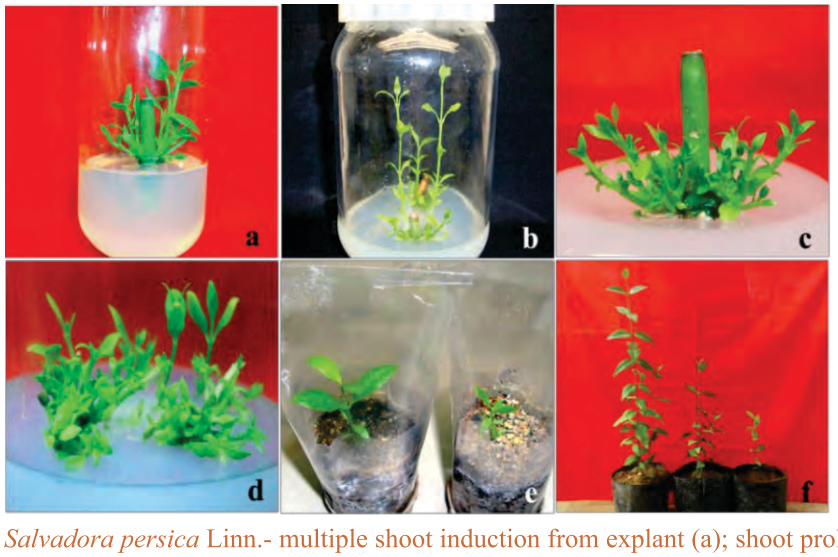
Methylation-sensitive fingerprints of *in vivo* and *in vitro* growing tissues using MSAP 10 (a) and 17 (b) primer. Lane M represent DNA ladder; 1 - 4 methylation-sensitive profile of a plant. Odd number lanes were cut with *Msp* I and even number lanes were cut with *Hpa* II.



Numbers of methylated, non-methylated and polymorphic markers (a) and percentage methylation and polymorphism (b) in *in vivo* and *in vitro* derived tissues.

Micropropagation protocol for *Salvadora persica L.*

A basic micropropagation protocol for mature tree of *Salvadora persica* Linn. was developed. The fresh nodal shoot segments were used as explants, 10-15 multiple shoot were achieved per culture vessel**.** The elongated shoots were rooted both *in vitro* and *ex vitro*. The rooted plants were acclimatized under culture room and greenhouse conditions. Hardened clones were transplanted under natural conditions in pot culture premises and salt farm in halophyte Germplasm Park.

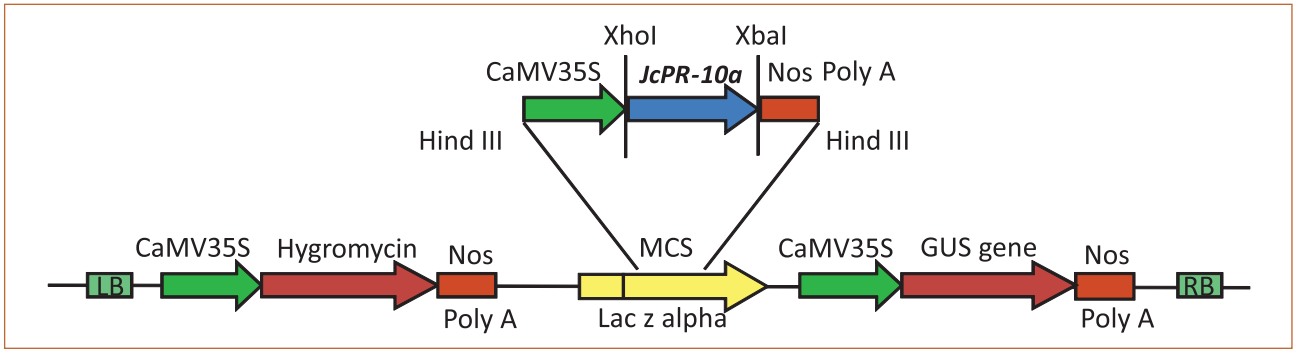


Micropropagation of *Salvadora persica* Linn.- multiple shoot induction from explant (a); shoot proliferation by repeated transfer (b, c); multiplication of shoots (d), *ex vitro* rooting (e) and acclimatized plants (f) of *Salvadora persica* Linn.

Molecular Biology

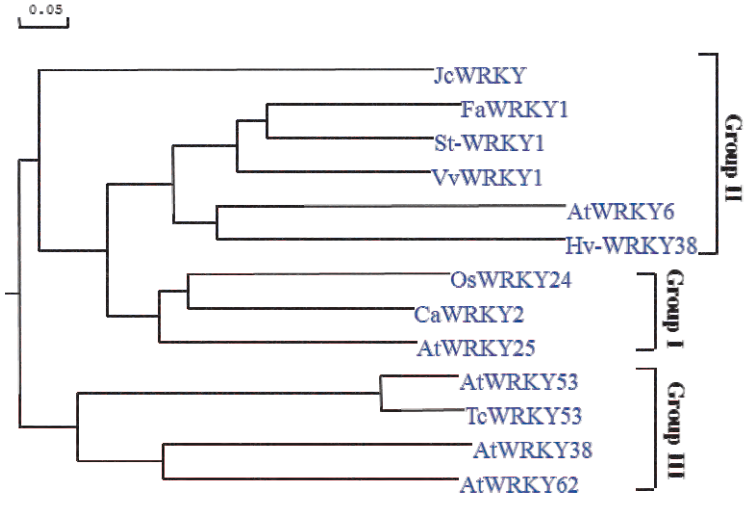
Enhancing stress tolerance in *Jatropha*

Jatropha shows large variation in seed and oil yield depending upon quality of planting material, soil, climate, agro-practices adopted and different biotic stresses subjected by nature. Among the biotic stresses, many pests and diseases have been reported to be the cause of yield uncertainties. These diseases include collar rot, leaf spots, seedling blight, anthracnose, fruit rot, and seedling stem rot caused by fungus, while viral infestation has also been observed. Towards enhancing disease resistance in *Jatropha*, earlier we have characterized JcPR10 a gene for its antifungal activity against *Macrophomina*, suggesting that JcPR10 a can serve as an important candidate to engineer disease resistance in plants, and therefore an attempt is being made to develop the transgenic *Jatropha* and tobacco plants with JcPR10a for imparting enhanced disease tolerance.

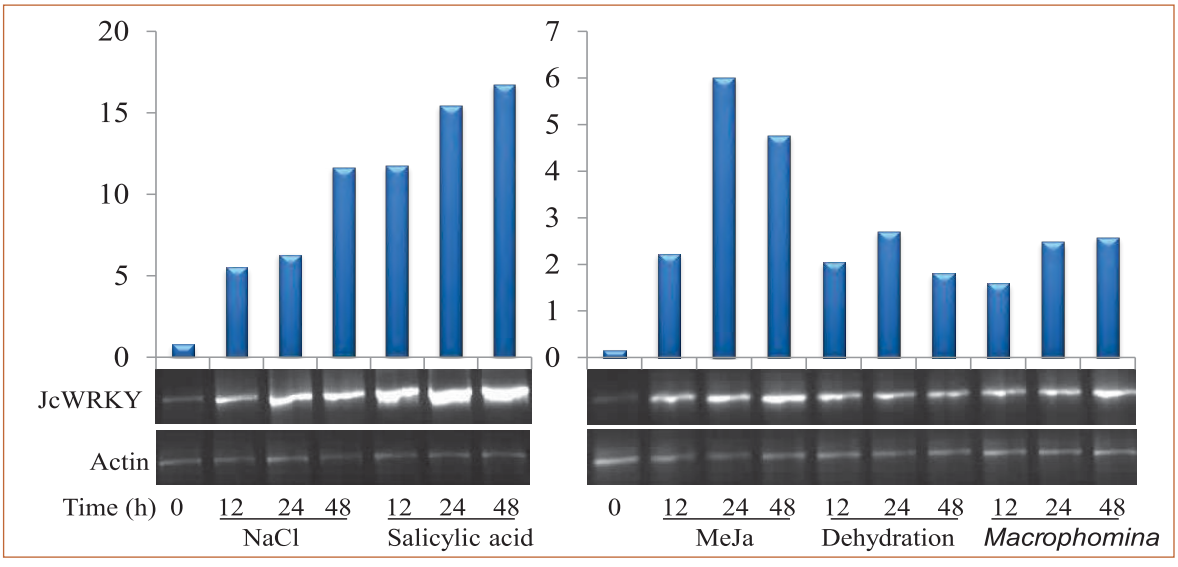


Map of pCAMBIA1301 vector harbouring JcPR-10a gene

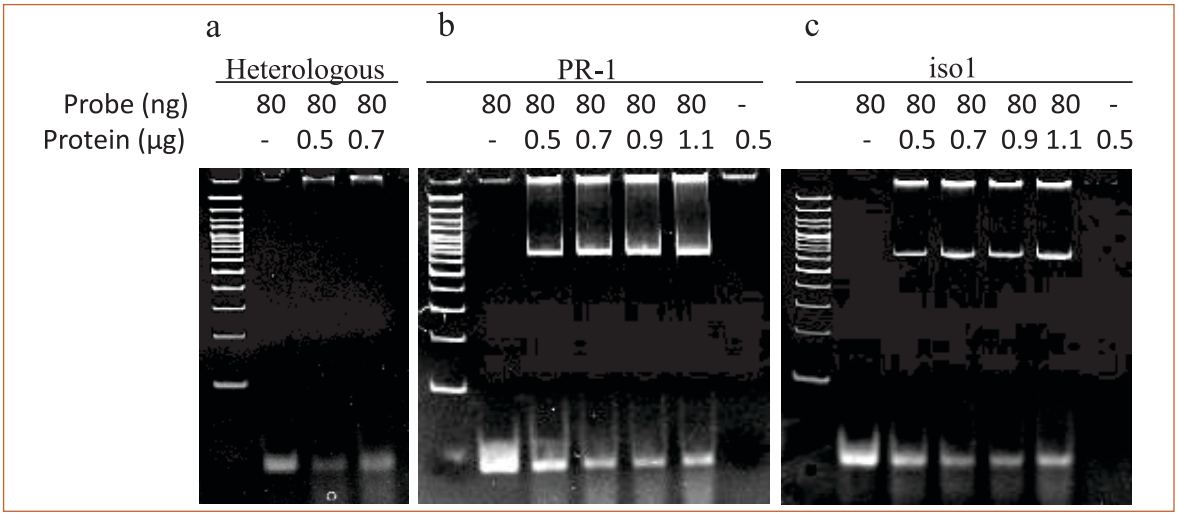
The WRKY family of TFs are one of the best-characterized classes of plant defense transcription factors and are at the forefront of research on plant defense responses. A JcWRKY transcription factor has been isolated from *J. curcas*. The *JcWRKY* gene has an ORF of 693 bp, encodes a 230 amino acids protein with estimated molecular mass of 25.25 kDa. JcWRKY shows close homology to FaWRKY1 and St-WRKY1. The transcript analysis revealed that *JcWRKY* transcript gets up regulated in response to salicylic acid, methyl jasmonate, dehydration and collar rot fungus *Macrophomina*,however, maximum expression is observed under salicylic acid, highlighting its role in enhancing systemic acquired resistance (SAR) for disease tolerance. The Gel mobility shift assay carried out with JcWRKY recombinant protein showed binding to W-box of PR-1 (pathogenesis related-1) and iso1 (encoding isoamylase1) promoters thus revealing its role in regulating the defense-related genes and an involvement in sugar signaling.



Relationship among WRKY proteins is represented by phylogenetic tree of amino acid sequences constructed using DNAMAN software. Scale represents the branch length. The sequences used are from JcWRKY (KC191643), FaWRKY1 (EU727547), StWRKY1 (AJ278507), VvWRKY1 (AY585679), AtWRKY6 (AF331712), HvWRKY38 (AA548544), OsWRKY24 (BK005027), CaWRKY2 (DQ402421), TcWRKY53 (EF053036), AtWRKY25 (NM_128578), AtWRKY38 (NM_ 122163), AtWRKY62 (NM_120268), AtWRKY53 (NM_118512).



Transcript analysis of *JcWRKY* gene at 250 mM NaCl, 2.5 mM salicylic acid, 100 µM methyl jasmonate, dehydration and *Macrophomina* fungus for 12 h, 24 h, 48 h duration. Graphs over each gel figure show the relative value of *JcWRKY* against the actin gene to show the quantitative increase in the expression levels.



EMSA study showing binding of JcWRKY protein with heterologous probe (a), and W-box elements of PR-1 promoter (b) and iso1 promoter (c).

The viral infestation in *J. curcas* plants growing in our experimental field stations hampers the growth and yield of the plant. There are reports of Begomovirus infection in *J. curcas* in India. A population of whiteflies (*B. tabaci*) is also noticed in the Jatropha growing areas, therefore it is correlated that white fly is the main causative agent for spreading the viral disease. Therefore, biodiversity of viruses in infected Jatropha plants (accessions IC565735, IC565733, IC565739, IC565730, IC565731) at different field stations is being analysed using primers of Vir A genome.

Halophytes for economic utility (agronomic potential), reclamation of wastelands/ salt farms and as a potential gene(s) resource

Establishment of halophyte Germplasm Park

An attempt was made to develop the halophyte park and greening of salt farm. The seedlings of 18 different species of halophytes growing in some sites of Gujarat coast such as Dholera, Bhavnagar, Victor Port, Jafrabad and Diu were collected. The collected halophytic plant species were planted in the salt farm. Initially the soil modification was augmented for the establishment of plant which proved very successful. These plants are being irrigated with

diluted sea water (6000 ppm). Some of the plants are growing luxuriantly.

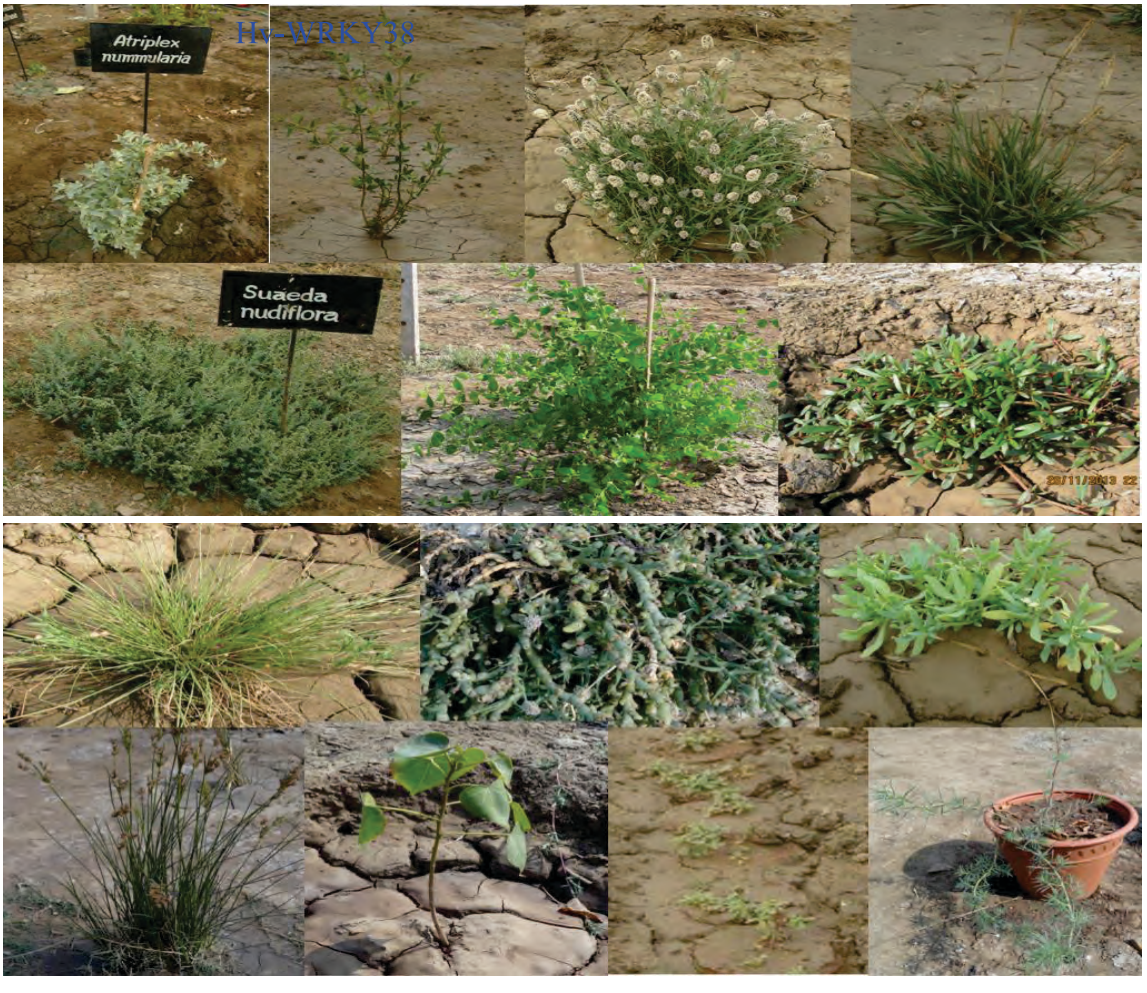
The greening of salt farm was performed by planting 608 plants of *Salvadora persica* (local name "Peelu") in soil pits of the border of salt pans after modification by adding fresh soil. Out of 608 plants only 246 plants survived (approx. 40.46 %) as shown in table.The mortality of *Salvadora* seedlings was due to heavy rain during September 2013.

Different halophytic plant species growing at the salt farm

S. No.	Halophyte species	S. No.	Halophyte species
1	*Atriplex nummularia*	10	*Heliotropium curassavicum,*
2	*Avicennia marina*	11	*Juncus rigidus,*
3	*Aeluropus lagopoides*	12	*Thespesia populnea,*
4	*Heleochloa setulosa*	13	*Portulaca oleracea,*
5	*Suaeda nudiflora*	14	*Suaeda monoica.*
6	*Salvadora persica*	15	*Atriplex stocksii,*
7	*Sesuvium portulacastrum*	16	*Cressa cretica,*
8	*Scirpus cernuus*	17	*Heliotropium bacciferum*
9	*Arthocnemum indicum*	18	*Salvadora oleiodes*

Greening of salt farm by plantation of *Salvadora persica*

Total plants planted in Block	Live plants	Dead plants	Survival %
608	246	362	40.46





Halophytic plant species growing in halophytic park at ESF, Bhavnagar



Transplanted *Salvadora* seedlings on both sides of the ESF ponds and near heap

Densification of *Salicornia*

Significant work has been done to restore the *Salicornia* vegetation by densification at some sites of Gujarat. Details are provided in the table below and also in chapter-7 of this reports.

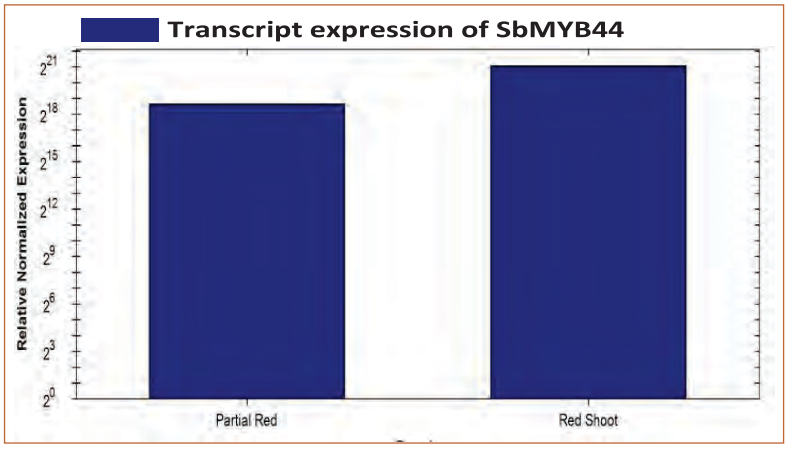
Serial number	Sites densified	Seeds/spikes spread	Plants/Quadrat	Plants/ha
1	Diu	16	238.1±350.0	23,81,000
2	Ningala	25	77.4±41.22	7,74,000
3	Sartanpar	16	99.2±64.03	9,92,000
4	Victor port	18	154.2±82.38	15,40,000

Population density of *Salicornia* at densified sites

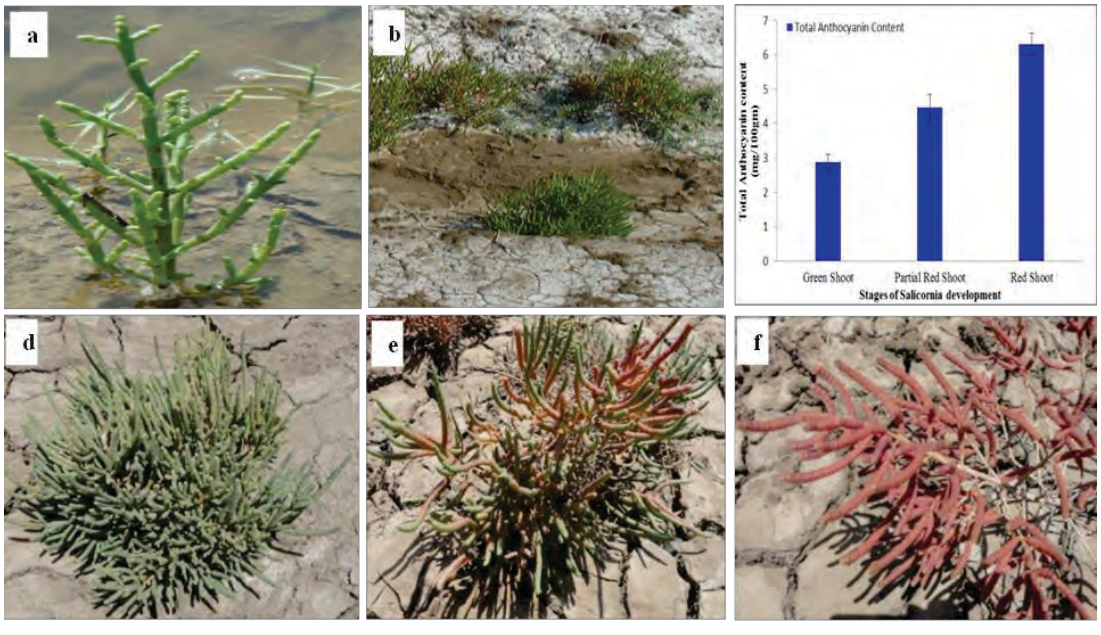
Potential gene(s) resource

The halophytes have unique genetic potential allowing them to grow in saline wastelands. Identification of stress-responsive genes/transcription factors from such species, have the potential to confer stress tolerance to sensitive plants. Efforts were made to utilize few plant species as a potential gene resource for salt tolerance.

S. brachiata Roxb. (Amaranthaceae) is a leafless, annual, succulent, obligate halophyte growing abundantly in the coastal salt marshes in Gujarat, India. The SbMYB44 transcription factor (TF) of cDNA 810 bp long encoding for R2R3 type MYB TF was isolated from Salicornia. The amino terminal extremity of SbMYB44 contains the conserved R2R3 imperfect repeats involved in binding to target DNA sequences. SbMYb44 TF possess three helix in both R2 and R3 repeats, highly conserved and evenly distributed W residues in the DNA binding domain, which are important for forming the hydrophobic core and maintaining three dimensional structure of the MYB repeat. SbMYB44 belongs to subgroup 22 according to Dubos classification because of its similarity with AtMYB44 and AtMYB70. The partial red and red shoots showed higher transcript expression of SbMYB44, compared to green plants showing its involvement in plant development. The expression analysis reveals that SbMYB44 was expressed higher in red tissues than partial green tissue as shown below.

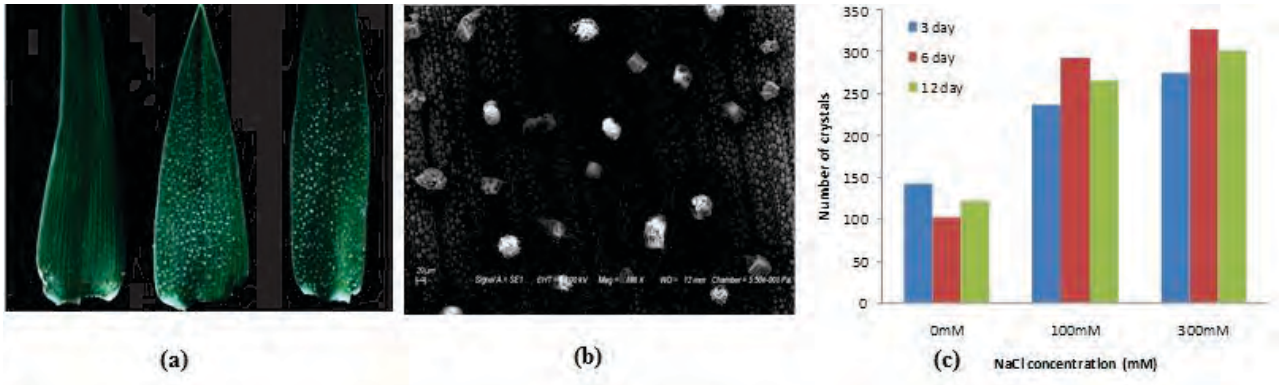


Transcript Expression of SbMYB44 in response to partial red and completely red shoots



a, b. Natural saline habitat of S. brachiata. (c-f) Total Anthocyanin content in different development stages of *S. brachiata*.

Aeluropus lagopoides (Linn.) Trin. Ex Thw. (Poaceae) is a salt-secreting rhizomatous perennial forage plant commonly growing in coastal areas of Gujarat. Its foliage shows little variation in salt content despite a three-fold increase in soil salinity in summer, possibly due to salt secretion through leaf glands. We have observed salt crystals at different salt concentrations on the entire surface of the plant. Increase in number of crystals with increase in salinity was observed, maximum number of crystals was observed in 300 mM NaCl treated plants, however, a further higher concentration of NaCl proved detrimental for its growth. SEM analysis was undertaken to study the salt crystals on leaf surfaces at different salinity.

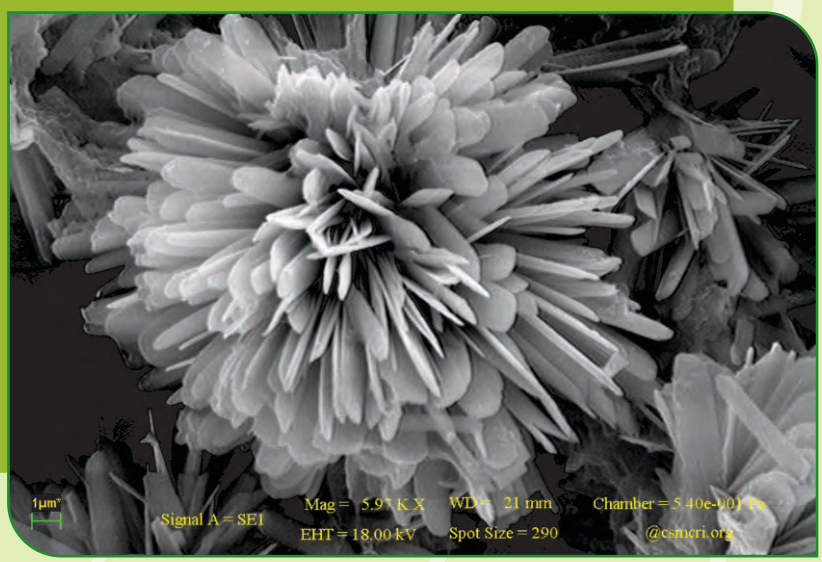


a) Salt excretion on adaxial leaf side of Aeluropus lagopoides plants treated with 0, 100 and 300 mM NaCl observed with stereomicroscope; (b) SEM micrographs of salt crystals observed on adaxial leaf surface; (c) Graph showing number of crystals at different concentrations of NaCl

The molecular mechanism of salt tolerance in Aeluropus is being studied by characterization of different transcription factors and genes (HKT, Rab7 and NAC). HKT gene plays an important role in maintaining ion homeostasis. AlHKT2;1 gene from Aeluropus lagopoides has been isolated using leaf cDNA by 5' and 3' RACE. The AlHKT2;1 ORF is 1581 bp long with 5' UTR of 310 bp, and 3' UTR of 156 bp and shows homology with the PhaHKT2;1 gene from halophyte, Phragmatis australis.

Rab7 is a small GTP-binding protein, which is involved in intracellular vesicle trafficking (endocytosis) from late endosome to the vacuole. Endocytosis participates in the cell's reaction to extracellular stimuli by desensitizing, down-regulating or recycling receptors and membrane proteins. Partial length Rab7 gene fragment of (408 gene + 208 UTR) is isolated by 3'RACE from *Aeluropus*.

प्रकरण 6
CHAPTER 6



विश्लेषणात्मक विभाग एवं केन्द्रीकृत उपकरण सुविधा

Analytical Division and Centralized Instrument Facility

विश्लेषणात्मक विभाग एवं केन्द्रीकृत उपकरण सुविधा

महत्वपूर्ण विश्लेषणों के लिए आण्विक संवेदक

क्विनोलोन, कूमेरिन, रोडामाइन तथा प्रकाश सक्रिय धातु संयोजनों जैसे प्रतिदीप्तिशील इकाईयों को समाविष्ट करते हुए कैलिक्सरीन आधारित प्रतिदीप्त आण्विक संवेदकों की श्रृंखलायें संश्लेषित की गईं और कई धातु आयनों के साथ इन प्रतिदीप्त–आयनोफोर्स की आयन–बाइडिंग गुण की जांच की गई। इन नये आण्विक संवेदकों ने Hg^{2+}, Pb^{2+}जैसे विषाक्त धातु आयनों तथा Fe^{3+} तथा Cu^{2+} जैसे संक्रमण धातु आयनों के साथ सुदृढ़ अंतःक्रिया की। डाइपीक्रीलामाइन की सहायता से F^-, OAc^- तथा $H_2PO_4^-$ जैसे विषाक्त ऋणायनों का वर्णमितिक संवेदन भी किया गया। डीएफटी गणना समर्थित विस्तृत क्रियाविधिक अध्ययन भी किया गया।

जलीय तथा गैर जलीय माध्यमों में उच्च चयनात्मकता तथा संवेदनशीलता के साथ Hg^{2+}, Pb^{2+}, Co^{2+} तथा Cu^{2+} के वर्णमितिक खोज के लिए विविध आयनोफोर्स से कार्यान्वित स्वर्ण नैनोंकणों का बड़े पैमाने पर उपयोग किया गया। इस मान्य प्रक्रिया की क्रियाविधि की जांच करने हेतु विस्तृत स्पेक्ट्रोस्कोपिक तथा माइक्रोस्कोपिक अध्ययन किये गये। जल में से फ्लोराइड के तेज उद्ग्रहण तथा एल्युमिना पुनरुत्पादन के लिए सक्रिय एल्युमिना का उपयोग करके परिचालन में आसान फ्लोराइड विहिनीकरण यूनिट विकसित की गई।

जल परिक्षेपणीय डीहाइड्रोएसकॉरबिक एसिड लेपित Fe_3O_4 सुपरपैरामेग्नेटिक नैनोंकण विकसित किये गए और इसका उपयोग भारित चुंबकीय प्रतिध्वनि इमेजिंग (एमआरआई) के लिए किया गया। इनकी मानव रक्त कोशिकाओं के प्रति क्षमता की भी जांच की गई।

बहुलक समन्वय तथा उनके अनुप्रयोग

काइरल समन्वय बहुलकों के संश्लेषण के लिए विभिन्न संश्लेषित पद्धतियॉ विकसित की गईं और इनका गुणनिर्धारण एकलक्रिस्टल एक्स–रे अध्ययन तथा स्पेक्ट्रोस्कोपिक विधि द्वारा किया गया। इन पदार्थोंके प्रकाश–संदीप्त गुण की जांच की गई और उनमें से कुछ का उपयोग दृश्य प्रकाश का उपयोग करके पानी में से दूषित रंग पदार्थों को हटाने के लिए किया गया। कई प्रणालियों के लिए हाइड्रोजन बंध तथा क्षीण सुप्रामॉलेक्युलर अंतःक्रिया की खोज की गई। एक प्रणाली में समसरंचनात्मक Zn तथा Co के लिए नितान्त काइरल क्रिष्टलीकरण प्राप्त किया गया, जिसने काइरल प्रेरणादायी एजेन्ट की उपस्थिति में एक पूर्ववर्ती काइरल में से स्वविभेदन तथा होमोकाइरल क्रिस्टलीकरण के बारे में परिज्ञान तथा समझ प्रदान की।

प्लास्टिक चिप इलेक्ट्रोड तथा उनके अनुप्रयोग

हमने विभिन्न अनुप्रयोगों के लिए, सरल–घोल कास्टिंग पद्धति द्वारा ग्रेफाइट तथा पॉली (मिथाइल मेथाक्राइलेट) के संमिश्रण से एक सस्ती, बहुपयोगी, डिस्पोज़बल प्लास्टिक चिप इलेक्ट्रोड विकसित किया है। इस दृष्टिकोण से, जैव निम्नीकरणीय (बायोडीग्रेडेबल) बहुलक (पॉली लैक्टिक एसिड) का उपयोग करके बायोडीग्रेडेबल प्लास्टिक चिप इलेक्ट्रोड का निर्माण किया गया। इसके अलावा, वैद्युत विश्लेषण संबंधी अनुप्रयोगों के लिए संघटित इलेक्ट्रोड कार्टिज बनाने के अंतिम लक्ष्य के साथ एक और डिस्पोजेबल सॉलिड स्टेट प्लास्टिक चिप रेफरन्स इलेक्ट्रोड विकसित किया गया। सोने के स्पटर लेपन द्वारा क्वायर फाइबर इलेक्ट्रोड भी बनाये गये और नियमित विद्युतरासायनिक प्रयोगों के द्वारा इनकी उपयोगिता सिद्ध की गई। हमने पॉलीएनीलीन की अंतः स्थापित चैनलों के साथ नवीनतम संघटित कैथोड के उपयोग द्वारा सॉलिड–स्टेट बैटरी में कैथोड तथा एनोड के बीच की निष्क्रिय परत को क्षीण करने हेतु एक विधि भी विकसित की है, जिससे निष्क्रिय परत में सरलता से आवेश हस्तांतरण हो सके।

कम्प्यूटेशनल अध्ययन

औद्योगिक दहन प्रक्रिया के दौरान निर्मुक्त CO_2 के निर्धारण के लिए कार्बनिक सुपर बेसेस तैयार किये गए। 1251.4 किलो जूल प्रति मोल का उच्च प्रोटान–आकर्षणयुक्त पैरासायक्लोफेन आधारित

कार्बीन्स का उपयोग करके सुपरबेस के एक नये वर्ग की पहचान की गई। 301.9 किलो कैलोरी प्रति मोल का प्रोटान आकर्षण प्राप्त करने के लिए कार्बीन्स आधारित कार्बनिक सुपरबेस के अन्य वर्गको डिजाइन किया गया। ये अणु तीन स्वतंत्र प्रोटॉनेशन साइटयुक्त हैं जो आजतक किसी भी शोध–साहित्य में उल्लेखित नहीं हैं। इन्ट्रामॉलिकुलर $H^{+}....\pi$ इंटरेक्शन का उपयोग कर प्रथमबार सिलीलेन सुपरबेस तैयार किये गये।

सोडियम क्लोराइड क्रिस्टल के लिए बार्बिटयुरिक एसिड को एक नयेक्रिस्टल–प्रवृत्ति परिवर्तक के रुप में खोजागया, जो सोडियमक्लोराइड के लिए विषमकोण, दशफलक तथा अष्टफलक क्रिस्टल प्रेरित करने का प्रथम उदाहरण है। एजा–क्राउन लिगेण्ड के साथ लिथियम आयन के बंध के लिए विभिन्न विलायकों के प्रभाव का अध्ययन किया गया। इलेक्ट्रॉन स्नेही संयोजन प्रतिक्रिया में सही चयनशीलता की पूर्व सूचना में विलायक संकरण की भूमिका का अध्ययन किया गया जिससे ज्ञात हुआ कि π-फेसेस की फेशियल विकृति चयनशीलता के लिए महत्वपूर्ण है। अप्राकृतिक बेसेस के साथ डीएनए बेसेस के अयुग्मन का भी परीक्षण किया गया और पाया गया कि अनुरुप कीटो और आयनित रुपों की तुलना में अयुग्मन डीएनए के प्रति 5-हेलो-युरेसील के इनोलरुप ने उल्लेखनीय स्थिरता दर्शायी। डीएफटी गणना से भी ज्ञात हुआ कि चक्रीय डाइएमीन्स, रैखिक डाइएमीन्स की तुलना में डीएनए के AT और GC युग्म के साथ बेहतर अन्योन्य क्रिया दर्शाते हैं।

जलीय माध्यम में फ्लोराइड आयन की पहचान के लिए प्रतिस्थापित बोरेज़ीन्स एक नये अभिग्राहक के रुप में पाया गया है। सोमन अवरोधित AChE की कालिक क्षय की प्रक्रिया के कुछ जटिल लक्षणों पर भी गणना ने प्रकाश डाला। मॉडल प्रणाली के साथ की गई गणना से ज्ञात हुआ कि पिनाकोलिलसमूह का तथा मिथाइल स्थानांतरण एकसाथ होता है। टैबुनसंयुग्मित AChE का विभिन्न औषधियों के साथ पुनःसक्रियन को क्रियान्वित किया गया। निर्मित की गई नई दवाN-(पिरीडीन–2–वाइएल)–हाइड्रोक्सीलामाइन, ध्रुवीकरण में सक्षम सातत्य विलायक संकरण मॉडल के साथ जलीय अवस्था में टैबुन संयुग्मित AChE को पुनःसक्रिय करने में पारंपरिक आक्जाइम औषधियों की तुलना में विशेष प्रभावी पायी गई। ओर्गेनोफोस्फरस अवरोधित AChE की कालिक क्षय की प्रक्रिया को उलटने के लिए डाईमिथाइल (पिरीडीन–2–वाइएल) सल्फोनियम आधारित आक्जाइम को एक पॉट विलयन दिया गया जिससे प्रौढ़ AChE अभिवर्तन को भी पुनःसक्रिय किया।

कार्बनिक रंजक अणुओं की श्रेणी से प्राप्त किये गये रंजक–सुग्राहित सौर कोषों की उनकी इलेक्ट्रॉनिक सरंचनाओं तथा अर्धसंवेदी टाइटेनियम डाइऑक्साइड सतह के बाइंन्डिग के पहले तथा बाद में की अवशोषण वर्णक्रम का परीक्षण के लिए, ऊर्जा रुपांतरण दक्षता को परखा गया।

विश्लेषणात्मक सेवायें और विधि विकास

विश्लेषणात्मक विभाग एवं केन्द्रीकृत उपकरण सुविधा 35 बड़े उपकरणों से युक्त हैं, जिनका उपयोग सभी आंतरिक परियोजनाओं को विश्लेषणात्मक सेवायें तथा बौद्धिक निवेश प्रदान करने के लिए किया जाता है। उपकरणों के खाली समय का उपयोग बाह्य उपयोगकर्ताओं, विशेष रुप से विभिन्न विश्वविद्यालयों के शोधछात्रों, शैक्षिक संस्थानों तथा उद्योगों को विश्लेषणात्मक सेवायें प्रदान करने में किया जाता है। बाह्य उपयोगकर्ताओं को विश्लेषणात्मक सेवायें भुगतान के आधार (सीएसआईआर द्वारा अनुमोदित विश्लेषण शुल्क) के दर पर प्रदान की जाती हैं हालांकि, इस क्षेत्र में अनुसंधान तथा विकास कार्यों को प्रेरित करने के लिए शोधछात्रों को सामान्य दर पर 75% छूट दी गई है। समर्पित वैज्ञानिकों तथा तकनिशियनों का एक समूह इन उपकरणों के परिचालन तथा रखरखाव और संस्थान के अनुसंधान एवं विकास कार्यों के लिए आवश्यकता होने पर नई विश्लेषणात्मक पद्धतियों के विकास में कार्यरत है। केन्द्रीकृत सुविधा के अंतर्गत उपलब्ध उपकरणों तथा उनके द्वारा विश्लेषित नमूनों की संख्या की संक्षिप्त सूची एक अलग अनुभाग में दी गई है (अंग्रेजी संस्करण)।

तकनीकी तथा उपकरण रखरखाव सेवाएं

संस्थान के सभी विभागों के विभिन्न उपकरणों की मरम्मत और रखरखाव का कार्य किया गया।

नये उपकरणों की स्थापना तथा उसे क्रियाशील करना

तरल नाइट्रोजन सयंत्र,इमेजिंग सुविधा के साथ एफटी–आईआर स्पेक्ट्रोमीटर, पीएक्सआरडी, आइसोथर्मल कैलोरीमीटर, MALDI TOF-TOF का पुनःस्थापन, उष्मा विश्लेषक (टीजीए, डीएससी तथा डीएमए), स्पेक्ट्रोफोटोमीटर (सिमाड्ज़ू), 3–पी सर्वो स्टेबीलाइजर, 30 केवीए यूपीएस, माइक्रोस्कोप, सेंट्रीफ्युज मशीन, एसओपी संयत्र में उपकरण।

पानी और आर्द्रता विश्लेषण

पेय जल के मानक मापदंडो के लिए विभिन्न स्रोत्रों से प्राप्त पानी के नमूनों का विश्लेषण किया गया। जेट्रोफा बीज तथा सूक्ष्म शैवाल से बायोडीज़ल, आयनिक तरल, तेल और मेथेनॉल के विभिन्न भागों आदि के लगभग 220 नमूनों की आर्द्रता का विश्लेषण कार्ल–फिशर पद्धति द्वारा किया गया।

ताजे तथा खारे पानी में उपस्थित NO_2^--NO_3^- ऋणायनों का विश्लेषण

पर्यावरण समूह से बड़ी संख्या में प्राप्त नमूनों में फॉस टेकेटर द्वारा NO_2^--NO_3^- की मात्रा का विश्लेषण किया गया। केंद्रीकृत उपकरण सुविधा अंतर्गत विभिन्न उपकरणों के उपयोग द्वारा विकसित विश्लेषण पद्धतियों का विवरण अलग अनुभाग में दिया गया है (अंग्रेजी संस्करण)।

Analytical Division and Centralized Instrument Facility

Centralized instrumental facility under Analytical Science Division was created in 2002 with the aim to bring all the major instruments of the institute under one umbrella to provide equal opportunity to all the users of the institute to use the facility for their work. Since its formation, Analytical Science Division has been rendering analytical services and intellectual input to all the in-house projects. The spare times of the instruments have also been utilized to render analytical services to the outside users, mainly for Ph. D. students from various universities and academic institutions. For outside users, analytical services were provided on payment basis (rate for analytical charges was approved by CSIR), however for Ph.D. students 75% discount on normal rates were offered to promote R & D activities of this region. This centralized facility has started with a few instruments and subsequently every year new instruments have been added according to institute's requirement and at present there are 35 major instruments. A group of dedicated scientists and technicians are involved in maintenance and operation of these instruments and also to develop new analytical methods as and when required for institute's R & D activities. We also have done modification of many existing methods for better results.

The list of instruments available under centralized facility during the reporting period, and the number of samples analyzed with these instruments are summarized and given below. For the record, we have calculated the value of the service rendered during the year on the basis of normal charges as approved by CSIR.

As mentioned above, in addition to routine analytical services, we were also involved in analytical method development and modification of existing methods for better results. Highlights of some of the work are given below.

List of instruments in the centralized facility under Analytical Science Division

S. No	Instrument	Make/model
1	FT-NMR (500 MHz)	Bruker, Avance II 500
2	FT-NMR (200 M Hz)	Bruker, DPX-200
3	FT-IR	Perkin Elmer, GX- FTIR
4	FT-IR-Raman	Nicolet FT-IR, NXR FT-Raman
5	CHNS/O Analyser	Perkin Elmer, Series II, 2400
6	Inductive Coupled Plasma Spectrometer (ICP)	Perkin Elmer, Optima 2000
7	X-ray Fluorescence Spectrometer (XRF)	Bruker AXS, S4 Pioneer
8	Ion Chromatograph (IC)	Dionex DX-500
9	Single Crystal XRD	Bruker Smart Apex CCD
10	Powder XRD	Philips X'pert MPD System
11	Thermal Analysers (TGA, DSC, DMA)	Mettler Toledo
12	Surface Area Analyser	Micromeritics, ASAP 2010
13	Particle Size Analyser	Malvern Mastersizer 2000
14	Scanning Electron Microscope (SEM)	LEO 1430 VP
15	Transmission Electron Microscope (TEM, 200 KV)	JEOL, JEM 2100
16	Tensiometer	Data Physics
17	Rheometer	Anton Paar
18	Spectrofluorimeter (two)	Horiba Jobin, Fluorolog, Edinberg, Model FLSP920
19	Spectrophotometer (UV-VIS-NIR, two)	Varian cary500, Shimadzu, UV3600
20	Circular Dichroism (CD) Polarimeter	Jasco, J-815
21	Isothermal Calorimeter (ITC)	Microcal ITC 200

S. No	Instrument	Make/model
22	LC-MS	LC (Waters), Mass (Micromass)
23	MALDI-TOF	4800 plus
24	HPLC (two)	Waters (Allience)
25	GC	Thermo, Trace-GC Ultra
26	GC-MS (with head space analyzer)	Shimadzu, QP-2010
27	Total Organic Carbon Analyzer (TOC)	Elementar, Liqui TOC
28	Biodiesel Rancimat	Metrohm 873
29	Atomic Force Microscope	NT-MDT, ModelNtegra Aura
30	Time Correlated Single Photon Counting instrument (TCSPC)	Edinburgh Instruments, Model: OB920

Sample analyzed during April, 2012 – March, 2013

Name of the instrument	Total samples analyzed
FT-NMR [500 MHz]	^{1}H=2893, ^{13}C=1278, ^{31}P=19,
	^{7}Li=34 others = 60; Solid: ^{1}H=35,
	^{13}C=98, ^{31}P=7, ^{29}Si=31, others 5
FT-NMR [200 MHz]	H=2877, C=1172, ^{31}P=7
FT-IR	2512
CHNS/O Analyser	1274
Inductively Coupled Plasma Spectrometer (ICP)	2345
X-ray Fluorescence Spectrometer (XRF)	255
Ion Chromatograph (IC)	411
LC-MS	3075
MALDI-TOF/TOF	357
Powder XRD	515
Single Crystal XRD	160 (151solved)
Thermal Analyses (TGA, DSC, DMA)	TGA=690, DSC=458, DMA=168
Surface Area Analyser (BET)	278
Particle size Analyser	33
Scanning Electron Microscope (SEM)	2557
Transmission Electron Microscope (TEM)	585
Tensiometer (Goniometer)	364
Rheometer	223
Spectrofluoremeter (Horiba and Edinburgh)	2081
Spectrophotometers (Varian and Shimadzu)	7919
CD Polarimeter	358
Isothermal Calorimeter (ITC)	138
HPLC (Waters & Shimadzu)	5244
GC	1044
GC-MS	2721
Total Organic Carbon Analyzer (TOC)	840
Atomic Force Microscope	270
Time Correlated Single Photon Counting Inst. (TCSPC)	44

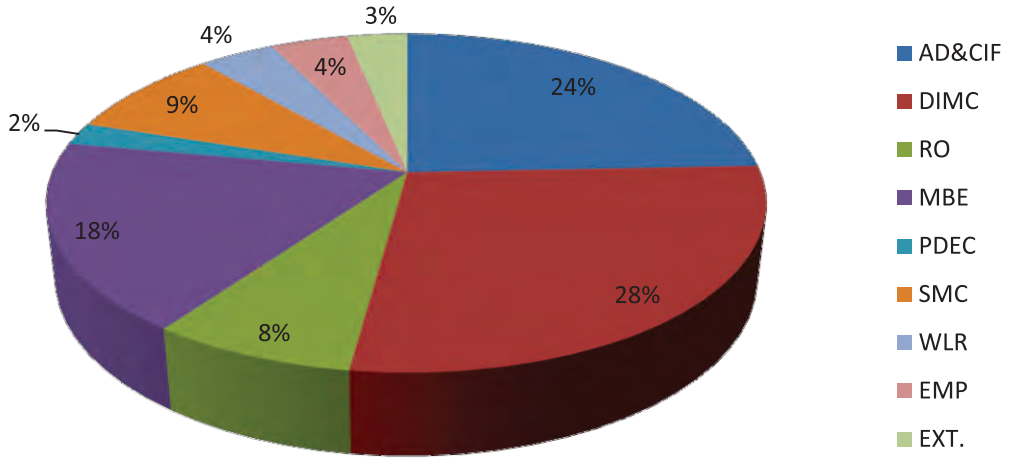
For the record, we have calculated charges for analytical services rendered using all the instruments mentioned above on the basis of normal rate (as approved by CSIR) and the total amount is Rs. 14,60,95,480 /-

Sample analyzed during April, 2013 – March, 2014

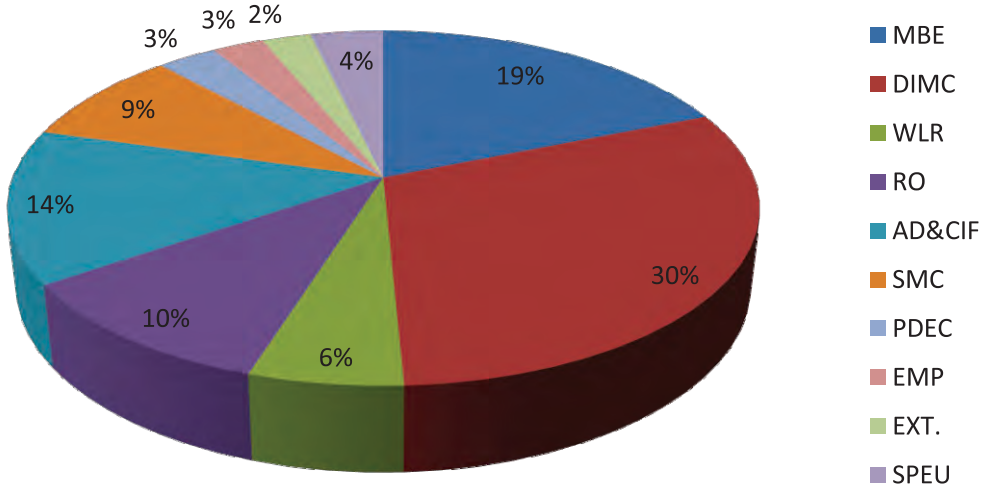
Name of the instrument	Total samples analyzed
FT-NMR [500 MHz]	^{1}H=2398, ^{13}C=1364, ^{31}P=41,Si=7, others = 161; Solid: ^{1}H=20, ^{13}C=113, ^{31}P=4, ^{29}Si=14, others 3
FT-NMR [200 MHz]	^{1}H=4960, ^{13}C=1218, ^{31}P=21, Others=2
FT-IR	3151 (ATR-129, DRIFT-16)
FT-IR Imaging & ATR	446 (Imaging-75, ATR-371)
CHNS/O Analyzer	1677
Inductively Coupled Plasma Spectrometer (ICP)	3799 (elements-12077)
X-ray Fluorescence Spectrometer (XRF)	608 (Ele. 6614)
Ion Chromatograph (IC)	588
LC-MS	2023
MALDI-TOF/TOF	969
Powder XRD	1690
Single Crystal XRD	102 (99 solved)
Thermal Analyses (TGA, DSC, DMA)	TGA=909, DSC=521, DMA=265
Surface Area Analyser (BET)	235
Particle size Analyser	33
Scanning Electron Microscope (SEM)	1417
Transmission Electron Microscope (TEM)	600
Tensiometer (Goniometer)	1313
Rheometer	153
Spectrofluoremeter (Horiba and Edinburgh)	3763
Spectrophotometers (Varian and Shimadzu)	8043
CD Polarimeter	425
Isothermal Calorimeter (ITC)	500 h
HPLC (Waters & Shimadzu)	9300
GC	117
GC-MS	2631
Total Organic Carbon Analyzer (TOC)	1024
Atomic Force Microscope	440
Time Correl. Single Photon Counting Inst. (TCSPC)	82 h

For the record, we have calculated charges for analytical services rendered using all the instruments mentioned above on the basis of normal rate (as approved by CSIR) and the total amount is Rs.15,92,03,320/-

Distribution of Values of Analysis Charges Carried out by various Departments



For 2012-13, total values of analysis charges is Rs.14,60,95,480/-



For 2013-14, total values of analysis charges is Rs. 15,92,03,320/-

Technical and instrument maintenance services

- Repairs and maintenance of various units/equipment in Analytical Science and other disciplines in the institute were carried out.
- SOP project: study of P&ID diagrams provided by the consultant, reworking, identification of instrument components, sizing, material selection and quantity from P&ID diagrams to bring down the overall cost of the project, incorporation of programming flexibility at our end and HART based field devices and procurement.
- Arrangement for fabrication of linear speed control system for casting of membrane at 2-15 m/min and coating of membranes at 0.2-0.5 m/min at a very nominal cost.
- Operation and maintenance of EPABX and liquid nitrogen plant were carried out.
- Temperature controlled heated air arrangement for fast curing of membranes in membrane coating machine.
- Designed circuit of audio and visual annunciation for conductivity check in RO-ED unit.
- Incorporation of flow and level automation in RO plant.

- Developed temperature controlled heating arrangement device for reaction vessel.
- Arrangement for I-V data logging for OEM potentiostat
- Designed time-based tracking system for humidity dryer unit by worm geared motor arrangement.
- Sizing of batteries and MPPT and their installation
- Programming of PLC for oxygen concentrator.

Installation and commissioning

Liquid nitrogen plant, FT-IR spectrometer with imaging facility, PXRD, isothermal calorimeter, reinstallation of MALDI TOF-TOF, thermal analyzers (TGA, DSC and DMA), spectrophotometer (Shimadzu), 3-P servo stabilizer, 30KVA UPS, microscope, centrifuge machine, instruments in SOP plant.

Water and moisture analysis

Water analysis: Water samples received from various sources (85), mainly from outside agencies/users were analyzed for standard parameters for drinking water.

Moisture analysis: About 220 samples of different kinds such as biodiesel from Jetropha seeds and micro algae, ionic liquids, oil and methanol's different fractions etc. were carried out by Karl-Fischer method.

Method development on moisture analysis: The samples of pyrolysis oil were water soluble and were also reactive with methanol, which is required as a solvent in KF titration, to produce water as a reaction product and hence the existing method was not suitable for the analysis. In order to measure moisture of such typical samples a method was developed, checked its reproducibility by repeated experiments and then used for unknown sample analysis. This established method gave reproducible and satisfactory results for the samples.

Analysis of NO_2-NO_3 anions in fresh and saline water: A large number of samples obtained from environmental group were analyzed for their NO_2-NO_3 content using Foss Tecator.

Analytical Method Development and Improvement of Existing Analytical Methods

Analysis of the constituents of urinary calculi of dog using powder X-ray diffraction, FT-IR, SEM and TGA

Analytical techniques to determine constituents of urinary stones of a number of dogs of different breed and age, obtained from the College of Veterinary Science and Animal Husbandry (India), has been carried out. Analysis by powder XRD, IR and TGA suggest the presence of pure phases such as calcium oxalate monohydrate, struvite and calcium carbonate and also mixed phases containing calcium oxalate hydrate, struvite, whewellite and weddellite in these urinary calculi. The morphology of the constituents has been investigated by optical and scanning electron microscope. Activation energy and order of reaction for thermal elimination of H_2O, CO and CO_2 have been determined.

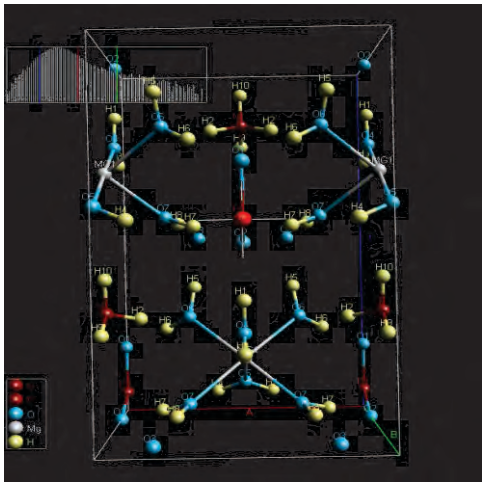
Structure solution from powder XRD data using a charge-flip method

Super flip algorithum is best suited for the solution of well resolved uncontaminated powder X-ray diffraction pattern. An attempt has been made to solve the structure of sodium chloride crystallized with brine having varied salinity at various locations. Powder pattern was obtained using the slow scan rate. Peak search followed by the search match was performed. Initial guess for lattice parameters was obtained using the unit cell parameters of the matched phase. This initial guess was used to do indexing of the powder pattern. Indexing was done using Treror method. Powley fit was performed to decompose the powder pattern into single diffraction intensities.

The set of parameters refined in the least squares process include the integrated intensities, cell dimensions and parameters for modeling the background and peak shape. At the end of refinement of various parameters satisfactory goodness of fit was obtained for each of the three measurements. Charge flipping option (which uses the super-flip algorithm) is further used to do abinitio structure determination. Upon convergence, 3D electron density map is obtained along with the list of electron density.

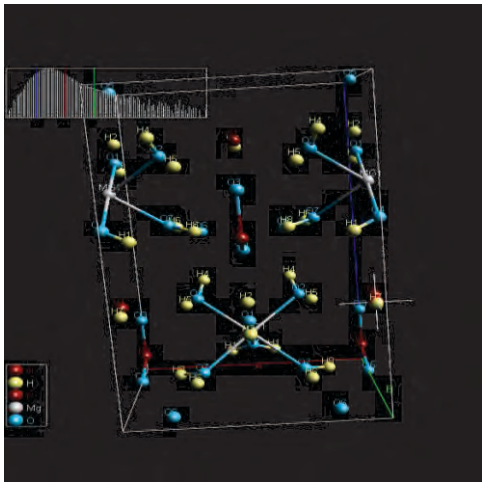
Structure of Struvite ($MgNH_4PO_4$ $6H_2O$) containing urinary stones from two Dog

Using the above described approach, structures of these two struvite (UC-HC-10, UC-PTH-5) containing stones have been determined. The structures obtained are shown here (*final refinement is in progress*).



UC-HC-10

R (expected)/ %: 1.39272
R (profile)/ %: 7.09386
R (weighted profile)/ %: 9.90536
GOF: 7.11225



UC-PTh-5

R (expected)/ % : 1.58393
R (profile)/ % : 5.09408
R (weighted profile)/ % : 7.301
GOF : 4.60958

^{7}Li-NMR study for Li^+ binding ligands

^{7}Li-NMR spectra were recorded for the Li^+ binding ligand and Li^+ ion interaction with ligand were clearly observed in the spectra. Shift in Li-chemical shift were observed on addition of ligand in Li^+ salt solution which suggests the binding of Li^+ with ligands.

Temperature invariance of NaCl solubility in water

The growth and stability of salt-water clusters have been experimentally studied in aqueous solutions of NaCl, KCl, and NH_4Cl from dilute to near-saturation conditions employing dynamic light scattering (DLS) and zeta potential measurements. In order to examine cluster stability, the changes in the cluster sizes were monitored as a function of temperature. Compared to the other cases, the average size of NaCl-water clusters remained almost constant over the studied temperature range of 20−70 °C. Information obtained from the temperature-dependent solution compressibility (determined from speed of sound and density measurements), multinuclear NMR (^{1}H, ^{17}O, ^{35}Cl NMR), and FTIR were utilized to explain the cluster behavior.

Multinuclear NMR (^{1}H, ^{17}O, ^{35}Cl NMR) spectra of salt (NaCl, KCl and NH_4Cl) saturated aqueous solution were recorded at six different temperature (25, 35, 45, 55,65, 75 ^{0}C) and their ^{35}Cl solid state spectra were recorded at room temperature. These multinuclear NMR spectra were used to explain the cause of NaCl water cluster stability as cluster of other salts.

Solid-state NMR to study conversion of tetraborate to monoborate

Solid-state NMR was applied to study conversion of tetraborate to monoborate in a borate laden LDH. ^{11}B NMR spectra were used to determine the ratio of tetrahedral to trigonal borate and 3QMAS spectra was used to monitor exchange between the two. Role of water molecules in the conversion was probed by the ^{1}H spin echo NMR spectra (*J. Phy. Chem. C. (2013), 117, 6578*).

Central metabolite pathways of Indian seaweeds were profiled by NMR spectroscopy

Metabolites were identified by peak assignment and 2D correlation experiments and their relative abundance in different weather and habitat was projected to form the metabolic pathways. Seaweed metabolomics was reviewed in the context of functional genomics (*RSC Advances (2013), 3, 7037; Adv.Bot. Res. (2014), 71, 31*).

Diffusion ordered spectroscopy (DOSY) - NMR study for enantiomeric recognition

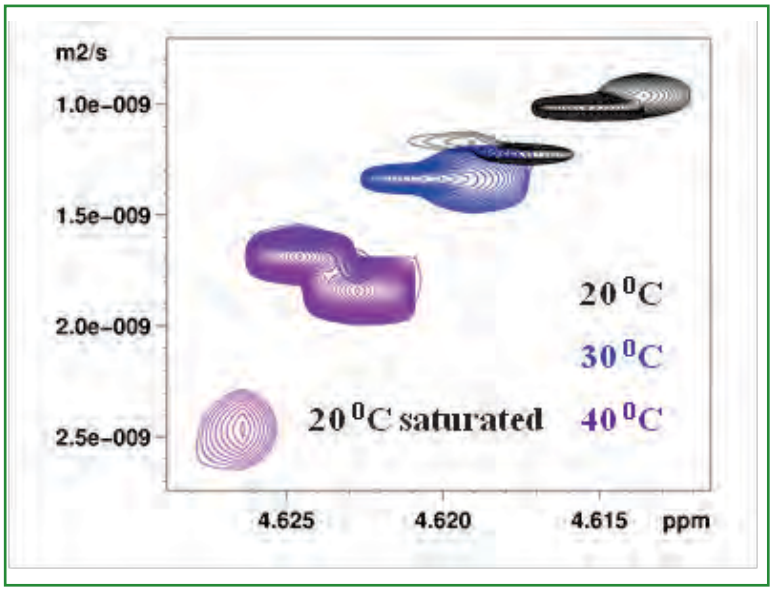
Two dimensional DOSY-NMR experiments were performed to investigate the enantiomeric recognition capability of BCD (β-Cyclodextrin) with phenylalnine (Phe) and association capability of BCD with enantiomers was investigated based on the self-diffusion value of free and associated enantiomers. It was observed that BCD has large association capacity towards the L enantiomer as compare to their D enantiomer.

DOSY- NMR analysis of salt water cluster

DOSY spectra of NaCl saturated aqueous solution recorded at three different temperatures, representing the diffusion value of water molecule of water cluster. Higher diffusion value observed for NaCl system suggesting that water molecules construct a bigger and tightly packed water cluster by means of NaCl molecular bridging.

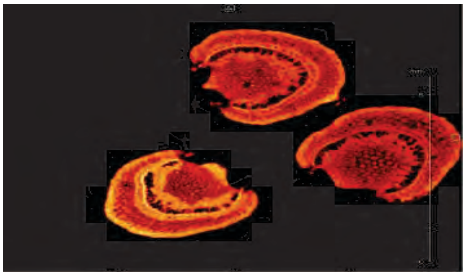
^{1}H and 2D-DOSY NMR investigation for the understanding of structure of water in saturated Na_2SO_4 salt solution

Water structure associated with salt cluster has an importance because of dependency of salt solution properties on water structure. Variable temperature ^{1}H NMR and 2D-DOSY NMR experiment performed for the deep understanding of the water structure in 10 ^{0}C, 20 ^{0}C and 30 ^{0}C Na_2SO_4 saturated water solution, are shown in the figure. ^{1}H NMR analysis shows a least variation in chemical shift for 30 ^{0}C saturated salt solution with the increase of sample temperature which reveals the presence of least quantity of four and three coordinated structured water in 30 ^{0}C saturated salt solution i.e. destructuring of water increases with increase of salt concentration. It is noticed from 2D-DOSY (two dimenstion-diffusion ordred spectroscopy, shown in the figure) NMR for 20^{0}C saturated water solution that water associated with salt cluster has 3 to 4 kind of diffusion values which is due the existence of 3 to 4 kind of stable water environment in the solution.



MRI imaging for the understanding of viral impact on plant

MRI image of healthy (H) and two curly tip viral infected tomato plant stems (I_1 and I_2) of two different stages were acquired at 500 MHz. A significant reduction in signal intensity and anatomical changes were observed in xylem and phloem region of the stem, suggesting that viral is imparting their effect on these regions.



ICP-OES instrument has been extensively used for metal ion analysis

Screening of the metal ions present in e-waste: Using acid digestion method, suitable sample of e-waste was prepared to screen analytes like Ni, Cr, Fe, Al, Cu, Zn, Ag, Au, Pd, Pt, and Li. Quantitative information of these analytes could be useful to design and develop systems for their selective separation. Concentration of economically important metal ions like Li, Sr, Pt, K, Mg were determined in the sources like bittern systems, seawater, seaweed sap. Mineral potential (B, Se, Zn, Cu, Fe etc) of several seaweed extracts was obtained with ICP-OES instrument. Mapping of lithium and strontium in oilfield water of cambay basin, Gujarat: The investigation of lithium and strontium concentrations in produced oilfield water was accomplished by ICP instrument. There is considerable variation in lithium and strontium in oilfield water samples collected from oil and gas producing fields of Gujarat. Water samples collected from various beaches (somnath, porbandar, mandvi, suvali, hazira, dandi,, kutch) was analyzed for toxic metal ions to assess current level of the pollution. Salt tolerance study: The balance of Na and K is important in halophytes grown under different stress was determined with ICP-OES instrument.

XRF has been extensively used for the following analysis

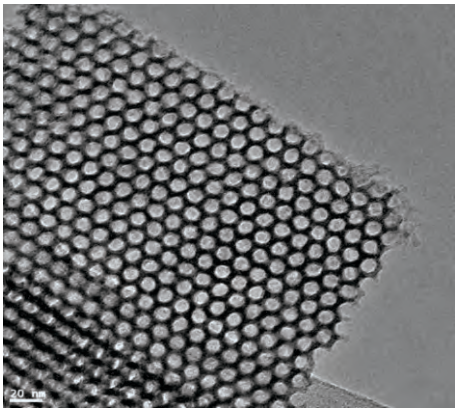
For elemental analysis of solid sample, XRF spectrometry is an appropriate and non-destructive analytical technique. This technique was used for rapid analysis of macro (P, K, Ca, Mg, S) and micronutrient (B, Zn, Mn, Cu, Fe, Na, Cl) in plant samples belonging to soyabean, green gram, black gram, maize, rice etc. These crops were grown under foliar spray of seaweed sap with its different concentration (2.5 to 15%). Comparison of elemental uptake was done between controlled vs treated plant. Powdering of the dried plant specimen with an advanced ball mill offers suitable particle size, homogeneity and rapidity to prepare samples for XRF analysis. In this work, seaweed sap is tested as plant growth stimulant as a part of multi-locational and multi-institutional trials with some of the agricultural institutes. With this technique, uptake study of macro and micronutrient in different crop upon foliar application of seaweed sap was done. XRF spectrometry continued to determine essential (P, K, Ca, Mg, Fe, Na, Cu) and toxic metals (Cr, Cd, Hg) in soil samples. It reveals nutritional health of the soil and the level of contaminants present in it.

WD-XRF method for analysis of micronutrient

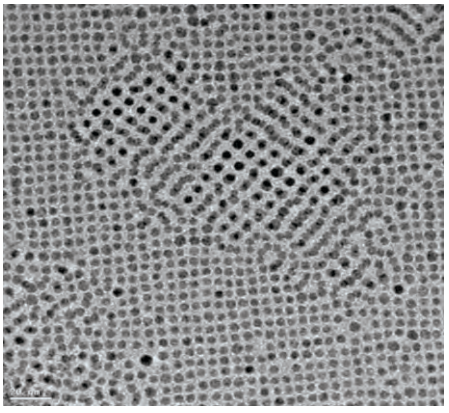
XRF based method for rapid analysis of macro and micronutrient uptake in maize grain upon foliar application of seaweed sap formulations is developed. Institute's seaweed sap formulation was tested as an option for fertilizer against chemical-based fertilizer. This work is a part of multilocational and multinstitutional trial of seaweed sap as a plant growth stimulant (*J. Indian Chem. Soc. (2013), 90, 2023, invited article*).

Activities in SEM & TEM facilities

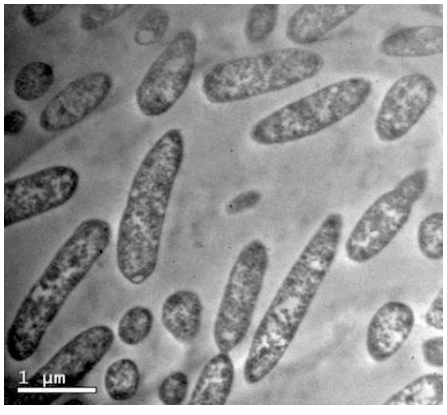
A large number of high resolution images of various samples from different disciplines and outside users have been generated using SEM and TEM. SEM images such as fiber cellulose (samples were received from Sri Lanka), TEM images of hydroxyl apatite and metal oxide based nanoparticles (samples from IIP, Dehradun) etc. were recoded.



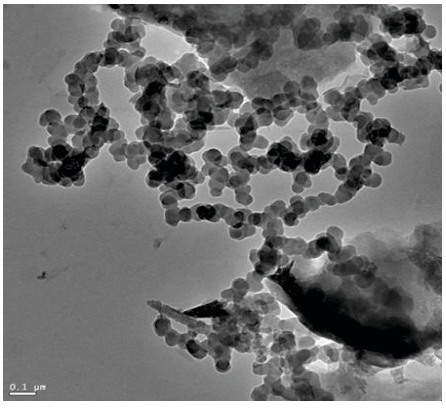
Hexagonal pores with ordered structure in silica



Regular arrangement of particles in CdS-CdTe complex

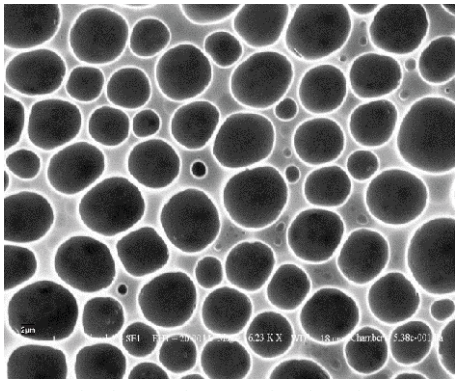


Cross section of Bacteria after microtome

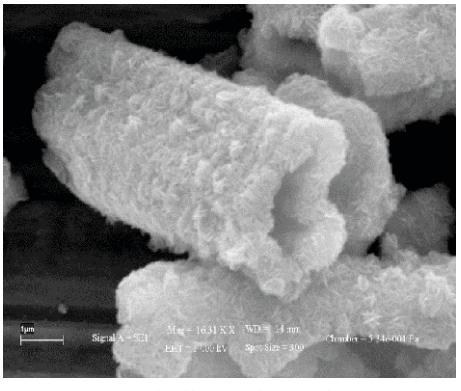


DNA Strands

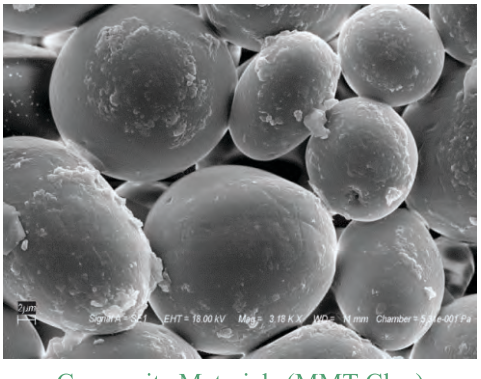
A few selected TEM images



Block copolymer of poly-ethers



ZnO hollow micro tubes



Composite Materials (MMT-Clay)



Zinc Selenide coated on zinc oxide core

A few selected SEM Images

Electrochemical method of loading TEM grid

Several methods have been practiced for the loading of samples on the TEM grid. This included most prominent disperse & drop method, milling, etching, sectioning etc. although these methods are not so efficient for transferring of electroactive materials deposited on a working electrode. We developed an electrochemical method of loading TEM grid using TEM grid itself as working electrode. The TEM grid was purchased for this purpose and polyaniline was electrochemically deposited and imaged using three electrodes system, potantiodynamically. Apart from imaging undisturbed, as deposited morphology, we were able to get additional but very significant information using this method.

Method development for sample preparation for TEM using microtomy

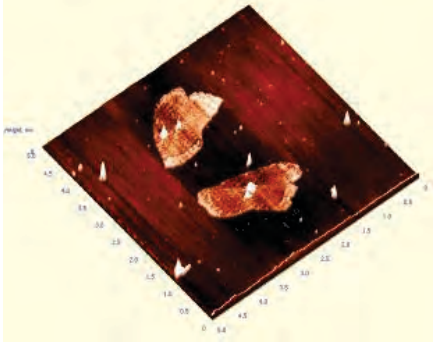
Crosssectioning of microalgae followed by imaging by TEM was carried out. Microalgae culture was centrifuged and fixed in osmium tetroxide and glutaraldehyde solution. Fixed cells were embedded in spur's resin and ultrathin sections were taken using an ultra -microtome. Sections were loaded on copper grid and post stained with Uranyl acetate and lead citrate. Sections were finally observed under 200Kv in TEM

Atomic Force Microscope for surface characterization

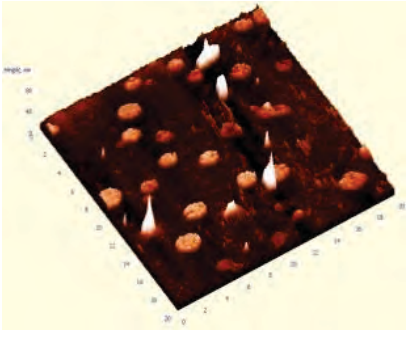
AFM images of different samples were taken by NSG 01 silicon probe with semi contact mode and 100 µm universal scanner head on Ntegra Aura SPM model (NT-MDT Moscow).

The morphology of the Agarose with ionic liquid

The surface morphology of the complex formed by agarose with ionic liquid (3 mM) revealed by the AFM images 5 µm x 5 µm frame 3D (right) shows interaction between a neutral biopolymer and surface active ionic liquid.



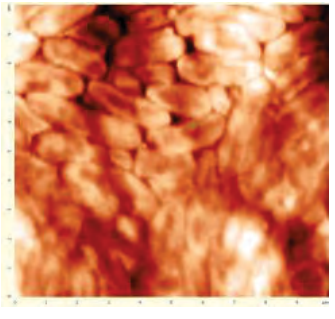
The morphology of the Chitosan microparticle with ionic liquid



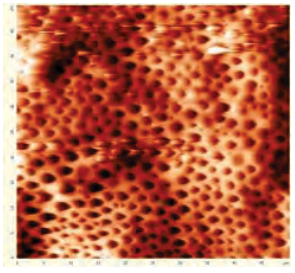
The surface morphology of the Chitosan microparticle with ionic liquid above critical micelle concentration of the ionic liquid in chitosan solution. The AFM images 5 µm x 5 µm frame and 3D (right) shows interaction between a neutral biopolymer and surface active ionic liquid.

Characterization of bacterial biofilm

Through AFM images of bacterial biofilm, the structure and complexity of biofilm can be analyzed. The difference in biofilm structure at different time interval like 6 hour, 12 hour, 18 hour and 24 hours were analyzed. The surface topography of 10 µm x 10 µm frame 2D (right) is shown in the image.

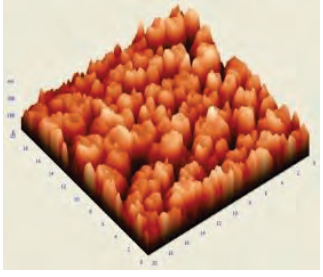


Characterization of block copolymer



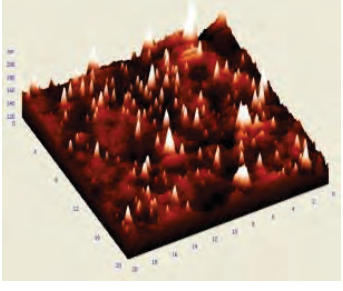
Fluorine containing monomer unit is used in the preparation of polyether. It forms a self-assembled structure with dihalobenzophenone which is useful in various industrial applications. AFM images 50 µm x 50 µm frame 2D (right) shows a surface morphology of above described thin film.

The roughness and surface morphology of composite membrane



The surface morphology of composite membrane formed by polysiloxane and PVA revealed by the AFM images 20 µm x 20 µm frame 3D (right). These membranes show the variation in polysiloxane quantity.

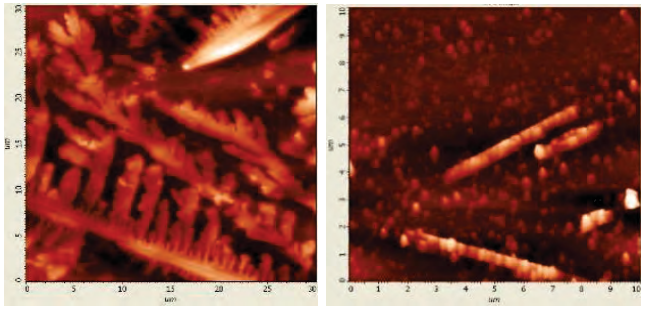
Characterization of composite thin film membrane



Composite thin film membrane prepared using polysulfon and supported poly amide was scanned for surface morphology, average roughness, peak height and peak to peak distance by Atomic Force Microscopy. AFM images 20 µm x 20 µm frame 3D (right) shows a surface morphology of above described thin film.

The roughness and surface morphology of Bacterial strain by AFM

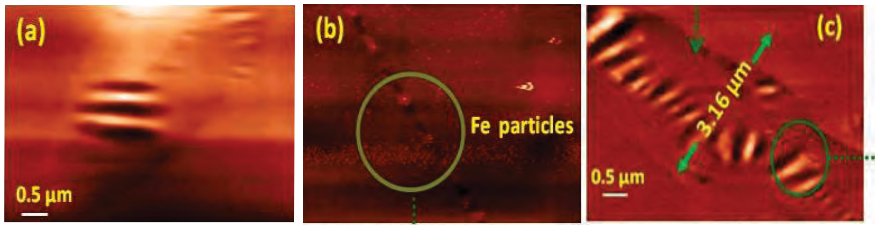
Bacterial strain namely *E.coli,* was grown in the presence and absence of 5 mg/mL of dual functionalized DNA hybrid material. The AFM image of the bacterial colonies before and after treatment shows distinct change in the morphology of the bacterial colonies. For example the bacterial colony of *E-coli* showed thread like morphology with height about 44 nm (fig size 30x 30 µ, left, 2D). After treatment with the hybrid material, perhaps due to the cell ruptures the bacteria cells the morphology changed with the height about 500 nm (fig size



10x 10 µ, right, 2D). Bacterial cells showed clear changes in morphology after treating with dual functionalized DNA hybrid material through AFM images.

Dual functionalized DNA based material in a biodeep eutectic solvent

The three dimensional surface morpho-logy of the dual functionalized DNA based hybrid material was investigated by AFM. The DNA regenerated from the deep eutectic solvent was found to have double stranded structure with inter helical distance of ca. 2 µm (Fig. a). The Fe_3O_4 particles of height 25 nm were found to have orderly



arranged in the hybrid (Fig. b). The periphery of the DNA consisting of phosphate showed presence of metal ions, which may be the Ti sheets (Fig. c).

FT-IR, DRIFT measurement

Diffuse Reflectance Infra-Red Fourier Transform (DRIFT) spectroscopy was used to differentiate between Brönsted and Lewis acidity by the measurement of pyridine adsorbed SZ samples using the DRIFT Selector accessory incorporating an environmental chamber assembly. The spectra were recorded at room temperature in the range of 700–4000 cm^{-1} and after *in situ* heating at room temperature (~27°C) to 450°C under dry N_2 flow. It is worthy to note that when the calcination temperature of sample increased the Lewis acid sites peak intensity decreased significantly.

FT-IR, ATR measurement

FT-ATR technique has been used for characterization of functionalized membrane samples. These membranes were used for electro-membrane processes mainly in electrodialysis of salts and in fuel cell application. For the characterization of chitosan membrane crosslinked in 10% Sulphuric acid, ATR technique is used. We found that the chitosan was sulphonated in presence of sulphuric acid and the sulphonated functional group found by ATR-IR.

Estimation of bromide and sulphate in common table salt

The presence of bromide and sulphate in table salt and in high purity solar salt was quantified by ion chromatography. The higher concentration of bromide in table salt creates toxicity and also having much sulphate and bromide in high purity solar salt poses serious problems for industrial application (*J Indian Chem Soc*. 2013, *90*, 2063, *invited article*).

Estimation of iodine, lithium and strontium content of oilfield water

The occurrence of iodine, lithium and strontium in the India's oil-field waters is poorly understood and inadequately represented in the literature. The objective of this work was to illustrate where iodine, lithium and strontium rich formation waters occur in Oilfield brines of Cambay basin, Gujarat. Therefore, the quantitative assessment of iodine, lithium and strontium content of oilfield water in the Cambay basin of Gujarat was carried out with the help of ion chromatography (*J Geolog Soc Ind. (2014), 83, 669*).

Bromide and bromate analysis by ion chromatography for green brominating process

The analysis of anions (Br^-,BrO_3^-) was accomplished by ion chromatography using conductivity detector. Column used for anion was AS HC 11 with 30 mM NaOH eluent with external water mode regeneration. The current applied to suppressor for anion (ASRS 300 Ultra) was 100 mA. Injection loop used for anion was 10 µl and flow rate for anion analysis was 1.5 ml/min. Calibration plot was achieved by proper dilution of 1000 ppm stock solution of mixed salt of NaCl and Na_2SO_4 for anion (Cl^-, SO_4^{-2}).

Ion chromatographic analysis for the resin adsorption selectivity for anions

The resin synthesized by RO discipline was checked for selective adsorption of anions like nitrate and sulphate. Initially the stock solution of equimolar concentration of sodium nitrate and sodium sulphate prepared and a linear calibration curve was plotted for different concentration of nitrate and sulphate through ion chromatographic conductivity detection using AS 11HC column with 30 mM NaOH as mobile phase. Then both anion salt solutions were mixed up to 100 ml in different ratios and treated with resin for a time period and the filter of all the solution were checked for the selectivity of nitrate and sulphate by the ion chromatography. It was found that the resin was preferably adsorbing the nitrate over sulphate.

Characterization of distilled cow urine by ion chromatographic

The sulphate, chloride and ammonium ions were analyzed in distilled cow urine to understand its composition. The distillation was achieved through conventional as well as by solar still.

Selectively study for alkali metal ions by ion chromatographic

Different alkali and alkaline earth metal ion (Li^{+}, Na^{+}, K^{+}, Mg^{+2}, Ca^{+2} and Sr^{+2}) salts were treated with organic complexing agent and their selectivity was checked by ion chromatography and found the selective order as follows: $K^{+} >> Na^{+} > Ca^{+2} > Mg^{+2}$.

Sulphate content in agarose extraction (from Indian seaweeds)

The agarose was extracted from red seaweeds using some ionic liquids and was characterized by Ion Chromatography for the sulphate content. Agarose is biopolymer mainly used in biomedical applications and as food thickener. Agarose has very interesting properties such as biocompatibility, biodegradability, non-toxicity etc.

TGA analysis of ionic liquids

TG-MS was used for analysis of ionic liquids based advance materials. The confirmation of ILs thermal stability and fractionation at different temperature was done by TG-MS techniques. For e.g. BmimCl, Choline based ILs degradation temperature was done by TG and their fractionation was done by MS techniques.

TGA analysis to measure oxygen storage capacity (OSC)

This measurement was carried out using cyclic thermo gravimetric analysis (TGA). In brief, oxygen gas and reductive hydrogen gas are alternately introduced into a commercial TGA system; the mass changes of the samples are then measured and converted to OSC. These measurements were carried out at 400°C. For pre-treatment, each sample is heated in an oxygen-rich environment to remove the organic stabilizers and subsequently heated in 5% hydrogen (N_2 balance) to reduce the surface. The mass change in response to alternating oxidative and reducing environments indicates the cycles of oxygen uptake and release.

DSC measurementto evaluate heat capacity of ionic gel

DSC of ionic gel sample was measured to know heat capacity. Here first step was blank run, then a sapphire was put and this experiment was run again then gel sample was put in place of sapphire and we got heat capacity of samples.

Dissolution behavior of Cellulose in Deep Eutectic Ionic Liquids by TGA and DSC

Cellulose is the most abundant polysaccharides in the nature. Cellulose form crystalline and hydrogen bonded supramolecular structure making Cellulose insoluble in water and most common organic solvents but can be dissolved in deep eutectic ionic liquids. To study the dissolution behavior, the cellulose was dissolved in deep eutectic Ionic Liquid solvents under different methods and conditions. The DSC of cellulose with and without deep eutectic ionic liquid was done from 0 to 600 deg Celsius at 5 deg/min heating rate and found the different endothermic peak showing characteristic differences.

DMA analysis of agarose gel

DMA analysis was carried out to measure the elastic (E) modulus and loss factor (Tan delta) as a function of time. For this compression test was carried out using 3.0 × 2.0 mm/mm2 dimension of gel sample, at frequency of 1 Hz, at 25◦C under nitrogen atmosphere. Result of this study indicates a typical viscoelastic behaviour of gel material with predominance of storage modulus (G) and low tan delta ~ 0.1. DMA analysis also confirmed that gel prepared from the native agarose (tan delta ~ 0.40) and Agr-GAEst (tan delta ~ 0.1) shows properties like viscoelastic materials. This result also revealed that Agr-GAEst based gel is more elastic compared to the native agarose gel.

Degradation products of trimethoprim and sulfamethoxazole drugs using HPLC PDA

Trimethoprim and sulfamethoxazole drugs are bacteriostatic antibiotic. As an effluent, it has great concern. In the institute, work is going on for their adsorption, desorption and photo catalytic degradation to remove and recover the same. This helps in waste water treatment as well as recovery of valuable drugs. We have developed appropriate HPLC PDA method for its detection and quantification. This method helps to find out new efficient pathway for waste water remediation and recovery of drug. C18 column was operated at 400C @ 1/ml of mobile phase flow rate. Methanol and phosphate buffer was used as a mobile phase in isocratic mode operation. They were detected at 254 nm.

HPLC method for analysis of plant pigment

Existing RP HPLC-PDA method has been modified for plant pigment analysis. Better resolved peaks were obtained with this modified method. Dichloromethane, methanol and water were used as mobile phase in isocratic mode. TSK gel column used as stationery phase to achieve the best separation. Peaks were monitored at 437 nm.

Herbicide analysis using HPLC

Nowadays, farmer is using lots of pesticides and herbicide to protect their crops from the insect and unwanted plants/grass. All the pesticides contaminate the portable water and fertile land at rainy season. At the same time, pesticide manufacturing unit have problem with their hazardous effluent water. To solve this kind of problem, our institute has developed different membrane to remove pesticide contaminant from water. We have developed RP HPLC method for the accurate estimation of Diuron and Isoproturon at the ppb level. Reverse phase C18 column and acetonitrile-water (with buffer) has been used as a mobile phase. Peaks were monitored at 254 nm.

Catechol estimation at lower level using HPLC

Low level detection of catechol is difficult using DAD detector (HPLC-DAD). We have set a new HPLC method for low level detection of catechol. Acetonitrile-water (80:20) with 0.3% formic acid was used as a mobile phase and peak was monitored at 315 nm (emission). 0.005 ppm of catechol was detected with accuracy.

Plant pigment analysis using HPLC

Current HPLC-DAD method was modified for plant pigment analysis using C18 column. Better resolved peaks were obtained with modified method. Ammonium acetate buffer and methanol was used as a mobile phase and C18 column as a stationery phase. Peaks were monitored at 437 nm. ~ 90 samples were analyzed using the same method.

Drugs adsorption and desorption study

Sulfamethoxazole and Trimethoprim drug adsorption-desorption and degradation study were carried out using HPLC DAD method. Using C18 column as a stationary phase, peaks was monitored at 254 nm. Acetonitrile-methanol-water (40:40:20) was used as a mobile phase. ~ 500 samples were analyzed using the same method.

Plant growth regulator analysis

Analytical method has been developed using HPLC for the accurate detection of IAA at low concentration using internal standard in plant samples. PGR was analyzed using C_{18} column and peaks were monitored at 315 nm (emission). ~ 70 samples were analyzed using the same method.

HPLC method for estimation of Ciprofloxacin (antibiotic) in the drug delivery system

Ciprofloxacin was loaded in polymer with intense to test mask. Amount of drug loading in different polymer, isotherm study and drug release (delivery) was measured using HPLC system. HPLC method was developed with the modification to estimation of Ciprofloxacin (antibiotic) with the linearity up to 0.2 ppm level ($R^2 = 0.999$). Estimation of Ciprofloxacin is also possible using UV-Visible spectrometer, but it is laborious, time consuming and give erroneous result.

SPE-HPLC analytical method for the estimation of cysteine

Direct HPLC estimation of cysteine in blood plasma is difficult due to presence of unwanted component like protein and others. We developed SPE-HPLC analytical method for the accurate estimation of cysteine. HLB 6 SPE cartridge was used for the sample purification and PICO-Tag derivatization method for the HPLC estimation. Peak was monitored at $\lambda_{max} = 254$ nm.

Drugs delivery study by HPLC

HPLC method was developed for monitoring of the drug release study of ciprofloxacin. C-18 reverse phase column and acetonitrile and water were used as a mobile phase. Peak was monitored at 254nm. Calibration curve was prepared with good fitness ($R^2 \geq 0.999$).

Estimation of fumaric acid in apple juice (Tropicana)

Apple juice contains fumaric acid and its recommended concentration must be below 5.0 ppm (Tropicana). For the estimation of fumaric acid it is necessary to remove other phenolic impurity through Solid Phase Extraction (SPE). It is a tedious job and the recovery of the acid is also problematic. We have developed a direct and simple HPLC method for the estimation of fumaric acid in apple juice. For that, Supelcogel 610H column was used and it was operated at 0.5 mL min^{-1} flow rateofsulphuric acid containing water. Peak was monitored at 210 nm. Calibration curve for fumaric acid was generated with the $R^2 = 0.999$.

Residual solvent (impurity) identification using GCHSMS for Gulbrandsen

We have developed GCHSMS method for the residual solvent identification in solid polymer sample. We used RTX 5, 30 m x 0.25 mm x 0.25 uM column as a stationary phase and helium gas as a carrier gas.

Identification of flavonol in seaweed sap using LC-MS

Identification of flavonol in seaweed extract was carried out in positive and negative ionization mode using ESI-MS. The methanolic solution of seaweed sap was analyzed using ESI-LCMS. A flavonol quercetinin was detected from ESI positive mode mass spectra. The peak due to querecetin was further analyzed by recording MS/MS analysis in ESI positive mode. The mass fragment peaks were matched with available reported data which confirmed the presence of the compound querecetin in the seaweed sap.

Metabolite identification study using LCMS/MS

Extracts were prepared from the different part of medicinally important plant *Plantagoovata* (Isabgol). Shoots, leaves and seeds were selected for the preparation of extract. Extract were purified and subjected to LC-MS analysis for the identification of important metabolites. MS/MS fragmentation study was also performed for further metabolomics identification. Study will provide a comprehensive metabolite profiling of isabgol which can be further utilized for the bio-prospection studies.

Identification and quantification of bio fuel molecules

LC-MS method was developed for identification and quantification of Biofuel molecules such as hydroxymethyl furfural (HMF), Gamma valerolactone and dimethyl furan (DMF) in two seaweed samples (*Sargassum tanerimum*, Ulva faciata) employing ESI-MS and tandem mass spectrometry. The quantification of the above molecules was done using suitable internal standards employing ESI-MS /MS technique.

Analysis of glycine betaine in different crop plant

Glycine betaine in crop plant (Maize, Jatropha & pearl millet) was analyzed in LC-MS in order to determine the effect of different sap formulation. The identification work of Glycine betaine was performed using tandem mass spectrometry technique. For quantification work, choline chloride was used as internal standard .The result was used to correlate crop yield response with the intrinsic Glycine betaine concentration when the formulations were facial sprayed on the above crop.

Quantification of auxin in *Cucumis sativa* plant sample

In this study, LC-MS method developed for standardizing the effect of the auxin inhibitors on the regeneration of the *Cucumis sativa.* For this objective, detection of auxin was carried out in *cucumis sativa* plants in presence and absence of auxin inhibitors using LCMS/MS. Further, determination of auxin concentration was performed from peak area of samples and standards using HPLC chromatogram.

Identification and quantification of hydroxy methyl furfural (HMF) and levulinic acid in green seaweeds using ESI-MS

Hydroxy methyl furfural (HMF) and levulinic acid were extracted from two green seaweeds Ulva fasciata and Ulva lactuca. The organic extracts containing the above constituents were characterized using ESI-MS followed by MS/MS. The quantification of the constituents was further carried out in ESI-MS using suitable internal standards.Cholines were extracted from *Kappaphycus alverazii* sap and were identified as well as quantified using ESI-MS. The spectrum given below shows the presence of choline in Gibberellin free Kappaphycus sap sample.

Quantification of trimethylglycine(TMG) in crop plants by ESI-MS

Quantification of trimethylglycine (TMG) in maize, tomato and guar plants treated with different formulation of liquid seaweed fertilizer (LSF), was carried out in ES-MS. For the quantification study, Chlorocholine-chloride (MW-158.07), was used as internal standard. Standard curve using intensity ratio of mass peak vs concentration of TMG was made by different known dilutions between 0.6 to 200 ppm of trimethylglycine with a constant 10 ppm addition of internal standard. With Respect to the standard curve, trimethylglycine is being quantified in extracts of above mentioned crop plants. The data has been used for optimization of LSF formulation for application.

Study of polydimethylsiloxane (PDMS) membrane using MALDI-TOF mass spectrometry

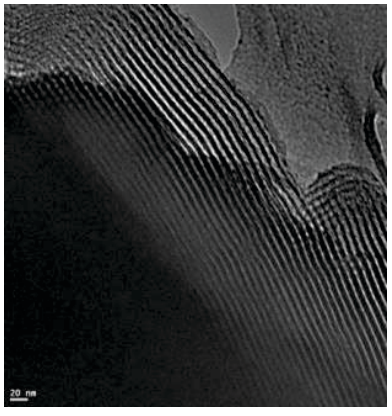
In this study crosslinking properties of poly(dimethylsiloxane)hydroxyl terminated polymer with poly(methylhydroxysilane) (PMHS) and the catalystdibutyl-tindilaurate (DBTDL) was studied using MALDI-TOF massspectrometry. The PDMS and PMHS were taken in ratio 1:10 with catalyst for mass spectrometric studies. CHCA MALDI matrix was used for preparation of spots on the MALDI plate. Mass spectrum with mass distribution up to m/z 3000 was achieved. Further study is under progress using other MALDI matrix such as DHB and dithranol.

Synthesis of polyaniline nanostructures by liquid-liquid interfacial electrochemical polymerization – template free method

Synthesis of nanostructured polyaniline and other conducting polymer is generally done by chemical methods in which templates (porous materials or micelles) are used. A different approach is adopted where the nanostructures can be assembled at the organic/aqueous interface or in solution controlled by the diffusion rate of the monomers at the interface. In these experiments we obtained different morphologies of polyaniline grown through diffusion of monomer across chloroform/aqueous and CCl_4/aqueous interfaces using three electrode potentiostatic method.

Coating of porous materials with conducting polymers

This work mainly includes fusion of high surface area materials like porous silicate or aluminosilicate (SBA-15,MCM-41) with some conducting polymers or metal oxides so that the material should have conductivity as well as high surface area. The monomer was filled in the pores of the mobil crystalline materials (MCM-41) or Santa Barbara amorphous type material (SBA-15) and polymerized *in-situ*. TEM images of SBA-15 and its dispersion composite with polyaniline is shown in the accompanying figure.



Analysis of double fortified salt

We received Double fortified salt samples from National Program Manager, New Delhi for the analysis of various parameters like moisture, chloride content, HCl insoluble matter, Fe content, phosphorous, total iodide and sulphate content. This sample was analysed successfully.

Molecular Sensors for Important Analytes

- A series of calix [4]arene-based fluorescent chemosensors containing quinoline as fluoregenic unit have been synthesized and the ion-binding property of these fluoroionophores has been investigated. Out of a large number of cations and anions, Hg^{2+}, Pb^{2+}, Fe^{3+} and Cu^{2+}, F^- and HSO_4^- exhibited strong interactions. The DFT calculations show that the formation of a new excimer band is due to modulation of frontier molecular orbital energies upon complexation with metal ions (*New J Chem. (2012), 36, 988*).
- A family of calix-crown hybrid molecules incorporating crown ether of different sizes as ionophore has been synthesized and their competitive complexing and extracting ability towards alkali and alkaline earth metal ions exhibited that two of them can form strong complexes with Na^+ and K^+. Molecular structures of these complexes were established by single crystal X-ray study, association constants were also determined (*Inorg Chem Commun. (2012), 22, 85*).
- A number of molecular receptors containing ruthenium(II)/rhenium(I) bipyridine moiety as fluorophore and crown ether as ionophore were synthesized and cation binding study exhibited strong binding with Pb^{2+}, Cu^{2+}, Hg^{2+} and Na^+. From luminescence titration data, binding constants and stoichiometry of the complexes were calculated. Cation binding property was also investigated by electrochemical study (*Polyhedron. (2012), 43, 104*).
- A series of calix[4]arene-based fluorescent chemosensors were synthesised incorporating ethylene glycol units as binding sites and coumarin as fluorescent probe. Ion-binding study of these fluoroionophores revealed strong complexation with Fe^{3+}, Cu^{2+} and Ca^{2+}, binding constants were valuated and DFT calculations were carried out to rationalize the observed fluorescence behaviours (*Polyhedron. (2013),50*, 592).

- Calix-dithiocarbamate modified gold nanoparticles has been developed, which exhibited distinct colour change from pink to blue, detectable by naked-eyes, in presence of Co^{2+} ion with detection limit of 10^{-9} M. The same material has also been used for electrochemical sensing of Co^{2+} in aqueous media, which exhibited a detection limit of 10^{-12} M (*Sensor Actuat B. (2014), 191, 757)*.

- A facile strategy for the preparation of water soluble gold nanoparticles functionalized by dithiocarbamate derivative of calixarene and its application for selective colorimetric detection of Hg^{2+} in aqueous media has been developed. Detail studies revealed that the visual colour change from red to violet is due to assembly of gold nanoparticles into arrays through the bare surfacesby dipole-dipole interaction.For practical application, this new material is successfully tested for detection of Hg^{2+} in drinking water as real sample (*Colloids and Surfaces A: Physico Eng Aspects. (2014), 455, 122*).

- Calixarene functionalized gold nanoparticles have been prepared, which exhibited sharp colour change from dark brown to green and blue, detectable by naked-eye, in presence of Cu^{2+} and Pb^{2+} ions respectively. In case of Pb(II) the colour change is due to the inter particle plasmon coupling arising from the metal-induced aggregation of the nanoparticles and for Cu(II), it is because of the formation of AuCu alloy due to anti-galvanic exchange (*J Chem Sci*. (2014), *126*, 627).

- A smart colorimetric AND logic gate based on citrate stabilized gold nanoparticles using dopamine and $H_2PO_4^-$ as inputs, which operates in aqueous media with low concentration, is developed. This purple coloured aggregated gold nanoparticles also exhibited sharp colour change in presence of Hg^{2+}, on the basis of this observation a nonimplication logic gate system is demonstrated with Hg^{2+} and (dopamine+$H_2PO_4^-$) as inputs. It has also been used for quantitative analysis of Hg^{2+} in lake water (*Anal Methods*. (2014), *6*, 4551).

- Dipicrylamine has been exploited to investigate its capability as anion sensor and out of a large number of anions it exhibited strong interaction with sharp colour change, detectable by bared-eye, with F-, OAc- and H2PO4-. The rate constants of these complex formations have been determined and computational study suggests that F- ion binds with one of the phenyl carbon instead of the –CH hydrogen of DPA- (*RSC Adv. (2014), 4, 53273*).

- Water dispersible and biologically important molecule dehydroascorbic acid (DHA, capable to cross the blood brain barrier) coated Fe3O4 superparamagnetic nanoparticles were synthesized through one pot aqueous coprecipitation method under atmospheric air. T1, T2 and T2* weighted magnetic resonance imaging (MRI) and corresponding relaxivity of colloidally dispersed DHA-coated nanoparticle water phantom revealed a strong contrast enhancement in T2 and T2* weighted images. The compatibility of DHA-coated Fe_3O_4 nanoparticles towards human blood cells were examined (*J. Colloid Inter Sci.(2014), 430, 221*).

- DHA/ZnO/ZnFe2O4 Nanostructures having crystalline size below 20 nm were synthesized successfully. The MRI (magnetic resonance imaging) contrast study of this nanostructure material has been carried out using T1 and T2 weighted MRI imaging study (*Procedia Mater. Sci. (2014), 5, 198*).

- A rhodamine 6 G based sensor molecule has been designed and synthesized for selective detection of Cu^{+2} in aqueous solution. At physiological conditions this molecule possesses naked eye detection limit of 50 ppb and rapid detection limit of 5 s. This probe has turned on-off property and which also reversible in nature.

- Defluoridation employing activated alumina to design a small unit delivering fast fluoride uptake and regeneration of alumina using easy to handle chemicals has been developed. A setup comprising a column and a bottle aspirator was designed in-house wherein suspended bed operation was applied to reduce mass transfer resistance and pre-treatment with solid acid was performed to eliminate the influence of hydroxide and carbonate anions. Regeneration was performed using solid base, derived by interference profiling (*under process of patenting*).

Coordination Polymer and their Applications

- Synthesis of chiral coordination polymers by different synthetic strategies has been investigated. The, spontaneous resolution of mixed ligand CP $[Ni(SDB)-(BIX)]_n$ upon hydrothermal synthesis resulted in two enantiomorphs with opposite helicity (1P and 1M) has been unambiguously established by SXRD and CD spectroscopy and its photo-luminescent property also has been investigated (*Inorg Chem. (2012), 51, 9577)*.
- Syntheisis, comprehensive characterization, structural analysis, and photoluminescence behaviour of two 1D silver coordination polymers $\{[Ag(L1)(CH_3CN)][Ag(L1)(OTf)]-(OTf)\}_n$(1), $\{[Ag(L2)](OTf)(H_2O)\}_n$ (2) comprising of a new flexible organic linker bis(pyridine-3 or 2-ylmethyl)terephthalate (L1/L2) with isomeric ligands have been investigated. Both Ag^+ complexes showed room temperature photoluminescent property *(RSC Adv. (2012), 2, 8421–8428)*.
- In an attempt to investigate hydrogen bonding and weak supramolecular interactions in a variety of self-assembled supramolecular systems, organic salt α,α′-p-xylene-N,N′-bis(3-hydroxy-methylpyridinium) dichloride has been crystallized in two hydrated forms. The structural studies of both hydrates and their reversible inter conversion via solid−gas reactions and recrystallization experiments provide comprehensive information about cooperative hydrogen bonding behaviour of the chosen system (*Cryst Growth Des. (2012), 12, 556*).
- For the construction of multidimensional networks, three isostructural salts consisting of di cation (α,α′-p-xylene-N,N′-bis(3-hydroxymethylpyridinium) (L^{2+}), and tetrachlorometallates, $[MCl_4]^{2-}$ (M= Co(II), Zn(II) and Cu(II) in 2, 3 and 4 respectively) have been synthesised and their supramolecular interaction have been investigated (*J Mol Stru. (2012), 1013, 102*).
- In continuation of our quest for homochiral CPs, absolute chiral crystallization for the isostructural Zn and Co coordination polymeric enantiomorphs $[Zn(SO_4)(L)(H_2O)_2]_n$ and $[Co(SO_4)(L)(H_2O)_2]_n$ has been achieved in the presence of chirality induction agent. The Chiral CPs synthesised by the above mentioned strategy have been characterised by X-ray crystallography to assess the supramolecular helical arrangement of the network topology and various physico-chemical techniques including CD spectroscopy. This work has given insight and understanding of spontaneous resolution and homochiral crystallisation from achiral precursors in presence of chiral inducing agents (*J Am Chem Soc. (2013), 135, 15690*).
- In an attempt to of design and understand the photolueminecent properties, a number of mixed-ligand, divalent-metal coordination polymers containing dicarboxylate , flexible isomeric N-donor ligands and metal nodes (cobalt and zinc) have been synthesized via solvothermal methods, characterized and studied their photolueminecent behaviour . Photo luminescent study of the Zn complex exhibited excellent fluorescent emission in solid state at room temperature *(Cryst Growth Des. (2013), 13, 664)*.
- For the application of CPs towards removal of dye contaminants from water, mixed ligand CPs comprising of polycarboxylate and N-donor ligands with different metal centres have been synthesised. With this material, photocatalytic degradation (89%) of Metanil Yellow in aqueous solution was achieved using dilute hydrogen peroxide in the presence of visible light (*RSC Adv. (2014), 4, 7352*).

Plastic Chip Electrodes and their Applications

- We developed an efficient plastic chip electrode (PCE) fabricated from a composite of graphite and poly (methyl methacrylate) by a simple solution casting method and promoted as an economically inexpensive, multipurpose disposable electrode for various applications. The electrode was characterized for its physicochemical properties and successfully used in various electrochemical protocols, such as cyclic voltammetry,

stripping voltammetry, electropolymerization, electrowinning and amperometric sensing (*Provisional patent 1254DEL2014, dated: 09 May 2014; Analyst. 2014, 139, 5919*).

- We extended our approach towards making biodegradable plastic chip electrodes (BPCE) using a biodegradable polymer [poly(lactic acid)] instead of conventional polymer and graphite as filler. The BPCE thus prepared were found similar in performance as PCE in various electrochemical protocols. The kinetics of biodegradability of the BPCE was studied and compared with biodegradability of the pristine polymer used for its fabrication (*under process of patenting*).
- Another novel aspect of plastic electrodes was developing a disposable solid state plastic chip reference electrode (PCRE) with ultimate goal of making a unified electrode cartridge for electroanalytical applications. Hydrophobic ionic liquid was used as salt-bridge for fabricating such solid state reference electrode. The reference electrode was tested in potentiometry as well as voltammetry applications and thus an electrode cartridge was fabricated (*under process of patenting*).
- In view of the rapid growth of bio-based advanced materials for sustainable development, tailored made electrode material derived from renewable resources is of considerable importance. Natural fibres are useful candidate for this purpose. However, fabrication of fibrous electrodes using carbon fibre electrodes has some limitations and therefore coir fibres electrode were fabricated by sputter coating of gold and the usefulness of the electrode was established through regular electrochemical experiments (*ACS Sustainable Chem Eng. (2014), 2, 348*).
- Lithium is extensively used as anode materials in electrochemical cells. However, the magnesium systems are not so successful though both batteries are based on the same principles. Among various reasons for such a shortfall, one major reason is the formation of a passive barrier layer between electrodes which is insulating to both electrons and ions. To overcome the problem, several methods have been reported. We have developed a method of combating the passive layer between cathode and anode in solid-state batteries by use of innovative composite cathode with embedded channels of polyaniline allowing smooth charge transfer across the passive layer (*PCC. (2013), 15, 17758*).

Computational Study

- Organic superbases have been designed with bis-protonation sites bearing high pKa values. Such organic superbases can be suitable candidates towards the fixation of CO_2 released in industrial combustion processes *(Chem Commun. (2012),48, 5865)*.
- Barbituric acid is shown to be a new crystal-habit modifier for sodium chloride crystals. Two morphologies of salt crystals can be prepared separately with this new additive. This is the first example to induce rhombic dodecahedron crystals and octahedron crystals for NaCl *(Angew Chem Int Ed. (2012), 51, 11279).*
- The substituted borazines have been computationally investigated as new type of receptors for the recognition of fluoride ion in aqueous medium. The computational results were verified with experimental studies *(J Mol Graph Mod. (2012), 38, 363).*
- We have reported that surface energy can be considered as a useful parameter to rationalize the morphology of rock-salt crystals in presence of an impurity. On the basis of first principles DFT calculations of the surface energies before and after the adsorption of surface-capping agent (additive) on the NaCl surfaces, we have shown that the surface energy differences among the three important faces (100), (110) and (111) corroborates the change in character of salt crystals observed experimentally *(Cryst Eng Comm.(2013), 15, 2631).*
- We have shown using DFT calculations that

cyclic diamines show better interaction with AT and GC base pairs of DNA than the linear diamines *(J Phys Chem B. (2013), 117, 9840).*

- The noncovalent interactions can be exploited to achieve hyperbasicity of a base. A new class of superbase has been identified using paracyclophane-based carbenes that possess a proton affinity (PA) value of 1251.4 kJ/mol at the M06-2X/6-311+G**//B3LYP/6-31+G* level of theory *(J Phys Chem C. (2013), 117, 19325).*
- We have examined the reactivation mechanism of the tabun-conjugated AChE with various drugs using density functional theory (DFT) and post-Hartree-Fock methods. The electronic environments and structural features of neutral oximes (deazapralidoxime and 3-hydroxy-2-pyridinealdoxime) and charged monopyridinium oxime (2-PAM) and bispyridinium oxime (Ortho-7) are different, hence their efficacy varies towards the reactivation process of tabun-conjugated AChE *(PLoSOne, (2013), 8, e79591).*
- Role of solvation to predict the correct selectivity in electrophilic addition reaction. Facial distortions of π-faces are important to account for the selectivity. Molecular dynamics calculations reveal the geometric distortions in ground states. We have also presented here the effect of distortional asymmetry in the π-face of 5-Fluoro-2-methyleneadamantane in solvent, which leads to predict the correct observed stereoselectivity *(Comput Theo Chem (2013), 1026, 46).*
- The catalytic serine of AChE can be phosphonylated by the nerve agent soman, and subsequently can undergo an aging process. The consequence of irreversible inhibition of AChE due to the aging process is fatal for mammals. The DFT calculations shed light on some intricate features of aging process of soman inhibited AChE, which has been pondering in the literature. The DFT calculations (M05-2X/6-31G* level of theory) performed with the model systems revealed that the dealkylation of pinacolyl group and the methyl migration takes place simultaneously (*ChemBiol Interact. (2013), 204, 185*).
- Computational method was employed to probe the influence of different solvents for binding of lithium ion with aza-crown ligands. This study could be helpful to apply low polar solvents for the effective binding of lithium ion, which is of high techno-economic importance (*J Mol Graph Model. (2013), 46, 22*).
- The multiprotonation sites exploiting noncovalent interactions to achieve hyperbasicity of an uncharged organic base. A new class of carbene based organic superbase has been designed to attain the proton affinity (PA) value of 301.9 kcal/mol at M06-2X/6-311+G**//B3LYP/6-31+G* level of theory. These designed scaffold molecules can possess three independent protonation sites, which is not available in the literature to date *(J Phys Chem C. (2014), 118, 6680).*
- Silylene superbases were designed for the first time involving the intramolecular H^{+}….π interaction using density functional theory (DFT) calculations. The non-covalent interactions augment the proton affinity values by ~13 kcal mol−1 in the designed superbase compared to the acyclic silylene, [:Si(NMe2)2]. These divalent Si(II) compounds can act as powerful neutral organic superbases in gas and solvent phases *(Phys Chem. Chem Phys. (2014),16, 12567).*
- Organophosphorus nerve agents are highly toxic compounds which strongly inhibit acetylcholinesterase (AChE) in the blood and in the central nervous system (CNS). Tabun is one of the highly toxic organophosphorus (OP) compounds and is resistant to many oxime drugs formulated for the reactivation of AChE. We have shown that the newly designed drug candidate N-(pyridin-2-yl)hydroxylamine, at the MP2/6-31+G*//M05-2X/6-31G* level in the aqueous phase with the polarizable continuum solvation model (PCM), is more effective in reactivating the tabun-conjugated AChE than

typical oxime drugs *(Mol Bio Syst. (2014), 10, 2368).*

- We have given a one pot solution with Dimethyl(pyridin-2-yl)sulfonium based oxime to reverse the aging process of organophosphorus inhibited AChE and also reactivates the aged-AChE adduct *(ChemBiol Interact. (2014), 223, 58).*
- We have examined the mispairing of DNA bases with unnatural bases, computationally. 5-Halo uracils have been studied as mispairs in mutagenesis; however, the reports on their different forms are scarce in the literature. The stability of mispairs with keto form, enol form, and ionized forms of 5-halo-uracil has been computed with the M06-2X/6-31+G** level of theory. The enol form of 5-halo-uracil showed remarkable stability toward DNA mispair compared to the corresponding keto and ionized forms (*J Phys Chem A. (2014), 118, 9753).*
- The energy conversion efficiency of dye-sensitized solar cells derived from organic dye molecules has seen immense interest recently. In this work, we report a series of organic donor molecules with enhanced energy conversion efficiency using π-spacers and cyanoacrylic acid as an anchoring group. Density functional theory (DFT) and time-dependent DFT calculations of these molecules have been performed to examine their electronic structures and absorption spectra before and after binding to the semiconductor titanium dioxide surface (*J Phys Chem C. (2014), 118, 20763*)

प्रकरण 7
CHAPTER 7



समाज की सेवा में सीएसएमसीआरआई

CSMCRI in the Service of Society

भाग –1. प्रौद्योगिकी विकास

सीएसआईआर–सीएसएमसीआरआई ने उत्तराखंड की बाढ़ (जुलाई–2013) तथा उड़ीसा के चक्रवात (अक्टूबर 2013) आपदा के समय पीड़ितों को पेयजल उपलब्ध कराया

समाज की सेवा के लिए अपनी प्रतिबद्धता के क्रम में सीएसआईआर–सीएसएमसीआरआई ने उत्तराखंड की बाढ़ तथा उड़ीसा चक्रवात त्रासदी से पीड़ित लोगों के लिए सुरक्षित पेयजल उपलब्ध कराने हेतु तुरंत ही 12 सदस्यों की एक टीम भेजी। लगभग 3000 लीटर प्रति घण्टा की क्षमता वाला एक आरओ यूनिट ऋषिकेश में तथा अन्य दो होलो फाइबर (अल्ट्राफिल्ट्रेशन) यूनिट्स श्रीनगर (गढ़वाल) में स्थापित किये गये। ऋषिकेश पहुँची टीम ने पीड़ित समुदाय को लगातार 10 दिनों तक आरओ पेयजल उपलब्ध कराने की सेवा की। श्रीनगर में वीरचंद्र सिंघ, गढ़वाल सरकार, चिकित्सा विज्ञान तथा अनुसंधान संस्थान में 1000 लीटर प्रति घण्टा की उत्पादन क्षमता वाले अल्ट्राफिल्ट्रेशन प्लान्ट तथा कॉलेज परिसर में 10,000 लीटर प्रति घण्टा की क्षमता वाले प्लान्ट द्वारा अस्पताल के मरीज़ों तथा स्थानीय समुदाय को 10 दिनों से भी ज्यादा समय के लिए, संयंत्र स्थल से टैंकरो के माध्यम से पेयजल उपलब्ध कराने की सेवा प्रदान की गई।

सीमांत नमक उत्पादकों द्वारा उत्पादित नमक की गुणवत्ता में सुधार हेतु प्रशिक्षण

सीमांत नमक उत्पादकों को अति शुद्ध नमक उत्पादन तथा मूल्यवर्धित रसायनों के लिए बिटर्न के उपयोग के बारे में प्रशिक्षित किया गया। चुने गए सॉल्ट वर्क्स में नमक उत्पादन की सतत निगरानी तथा सौर नमक उत्पादन की नवीन पद्धति के कार्यान्वयन हेतु परियोजना कर्मियों की भर्ती करके राजुला में तैनात किया गया। स्थानीय नमक उत्पादकों द्वारा ब्राइन और नमक के नमूनों के विश्लेषण के लिए राजुला में केंद्रीकृत स्थान पर उपकरणों से पूर्ण एक 'गुणवत्ता नियंत्रण प्रयोगशाला' बनाई गई। अच्छी गुणवत्तायुक्त नमक उत्पादन की गतिविधियां गुजरात के पाटन जिले के सांथलपुर क्षेत्र में भी शुरु कर दी गई हैं और सांथलपुर के अगरियाओं को प्रशिक्षित करने के लिए विभिन्न प्रशिक्षण कार्यक्रम आयोजित किये गये।

संस्थान की पहुँच को नए क्षेत्रों तक विस्तृत करते हुए, गुजरात राज्य के कच्छ क्षेत्र के आदेसर गाँव के सीमांत अगरियाओं की आजीविका में सुधार लाने के लिए गैर सरकारी संगठन, एएचआरएम के साथ एक संयुक्त परियोजना का प्रस्ताव गुजरात सरकार, उद्योग आयुक्त को प्रस्तुत किया गया।

उड़ीसा राज्य में नमक उत्पादन–सक्षम क्षेत्रों का सर्वेक्षण

उड़ीसा राज्य में उद्योग विभाग, उड़ीसा सरकार के आदेशानुसार राज्य में छोटे पैमाने पर नमक उत्पादन कार्य तथा सौर नमक उत्पादन बढ़ाने हेतु अतिरिक्त सक्षम क्षेत्रों के सर्वेक्षण का कार्य शुरु किया गया। उपरोक्त कार्यक्रम के अंतर्गत सभी संभावित नमक उत्पादक क्षेत्रों का सर्वेक्षण कर पाया गया कि राज्य में नमक उत्पादन हेतु लगभग 75% से अधिक अतिरिक्त भूमि उपलब्ध है। तत्संबंधी अंतिम रिपोर्ट उड़ीसा राज्य सरकार को प्रस्तुत की गई।

तामिलनाडु में मरकानम में एक मॉडल सॉल्ट फार्म की स्थापना

देशभर में बुनियादी स्तर पर अति शुद्ध सौर नमक प्रौद्योगिकियों का प्रसार करने के हमारे प्रयास को जारी रखते हुए हमने नमक विभाग भारत सरकार से तामिलनाडु राज्य के वेल्लापुरम जिले के मरकानम में मॉडल सॉल्ट फार्म को स्थापित करने का कार्यभार लिया। मॉडल सॉल्ट फार्म संपूर्ण रुप से स्थापित किया गया और 2012-13 में नमक की सुनहरी स्क्रैपिंग की गई।

राजस्थान के डीडवाना क्षेत्र में खाद्य ग्रेड के सौर नमक की गुणवत्ता में सुधार

राजस्थान के डीडवाना क्षेत्र में खाद्य ग्रेड के सौर नमक की गुणवत्ता में सुधार का एक प्रस्ताव विज्ञान एवं प्रौद्योगिकी विभाग, भारत सरकार द्वारा अनुमोदित किया गया है। गैर सरकारी संगठन–एसवीएस इस कार्य के लिए सहयोग दे रहा है और डीडवाना क्षेत्र के नमक उत्पादकों को संगठित कर रहा है।

ZnCr LDHs तथा उनके बहुलक यौगिकों से जलीय फ्लोराइड का निष्कासन

फ्लोराइड़ मुक्त पेयजल उपलब्ध कराने हेतु सीएसआईआर–सीएसएमसीआरआई ने ZnCr LDHs युक्त संश्लेषित नाइट्रेट के साथ Zn/Cr का बैच रिएक्टर में अध्ययन किया जिसने $ZnCr_3$-NO_3-LDH के लिए 31mgF/g की महत्तम मात्रा हटाने की क्षमता दर्शायी।

पेयजल में आर्सेनिक का स्तर, विश्व स्वास्थ्य संगठन द्वारा निर्धारित सीमा तक लाने के लिए, आयन चयनात्मक रेज़िन और मेम्ब्रेन आधारित प्रणाली का विकास

300 लीटर आर्सेनिक विशिष्ट रेज़िन विशेष रुप से तैयार किया गया और प्रयोगशाला में रेज़िन की प्रत्येक बैच आर्सेनिकयुक्त जल में से आर्सेनिक हटाने के लिए बैचमार्क की गई। यांत्रिक उपकरण और जल प्रवाही पम्प के उपयोग द्वारा आर्सेनिक से दूषित जल की पूर्वोपचार तकनीक में सुधार किया गया। जल से आर्सेनिक तथा मैलापन कम करने के लिए दोनों तकनीकें प्रभावी हैं लेकिन दूसरी तकनीक किफ़ायती है। पांच सामुदायिक स्तर के आर्सेनिक विहीनीकरण यूनिट्स की डिज़ाइन तैयार करके उन्हें आर्सेनिक प्रभावी क्षेत्रों में स्थापित किया गया।

आर्सेनिक प्रदूषित जल के पूर्वोपचार के दौरान उत्पन्न कचरे को मिट्टी के साथ मिला कर ईंट तैयार करने हेतु भट्ठी में पकाया गया। पश्चिम बंगाल के आर्सेनिक प्रभावित क्षेत्रों में पहले से स्थापित 65 घरेलू तथा पांच सामुदायिक स्तर के आर्सेनिक विहीनीकरण इकाइयों का नियंत्रण एवं अनुरक्षण किया गया। प्रत्येक घरेलू तथा सामुदायिक स्तर के इकाइयों ने क्रमशः 25 और 250 लीटर प्रति घण्टा आर्सेनिक मुक्त जल का उत्पादन किया। पहले तैयार की गई आर्सेनिक परीक्षण किट जल में 10 ppb स्तर तक आर्सेनिक का पता लगाने के लिए पुनः अनुकूल की गई जिसने परिवेशी तापमान पर उत्तम कार्य किया है। परीक्षण किट्स तैयार करके लाभार्थियों को वितरित की गई।

टार्टैरिक एसिड का उपयोग कर चयनात्मक पोटाश अवक्षेपण के माध्यम से पोटाश रसायन और उर्वरक उत्पादन का तकनीकी प्रक्रम

पोटाश धारक फीड स्टॉक समुद्री बिटर्न से सीधे पोटाश की पुनर्प्राप्ति हेतु एक प्रक्रम विकसित किया गया। इस प्रक्रम में पोटैशियम को चयनित रुप से अवक्षेपित करने के बाद इच्छित पोटैशियम लवण में परिवर्तित किया जाता है। यह प्रक्रम, बायोमास राख/चार में से पोटाश की पुनर्प्राप्ति के साथ पोटैशियम क्लोराइड (MOP) को बहुपोषकयुक्त पोटाश उर्वरक में परिवर्तित करने के लिए भी प्रभावी रुप से कार्य करता है।

जेट्रोफा बायोडीज़ल का उत्पादन

सीएसआईआर–सीएसएमसीआरआई ने गुजरात वन विभाग के साथ सासन–गीर में सभी वातानुकूलित पर्यटक वाहनों को जेट्रोफा बायोडीज़ल से चलाने की पहल में सहयोग किया है जिसके अन्तर्गत 12100 लीटर बायोडीज़ल की आपूर्ति की गई है। अनुसंधान डिजाइन तथा मानक संगठन (RDSO) ने सीएसआईआर–सीएसएमसीआरआई के जेट्रोफा बायोडीज़ल को डीज़ल लोकोमोटिव (IR-WR) में बी–10 क्षेत्र परीक्षण के लिए अनुमोदन दिया है। हमने 10kWe पैमाने पर जेट्रोफा फल आवरण के गैसीकरण के माध्यम से कैप्टिव बिजली उत्पादन की अवधारणा को साबित करने हेतु अध्ययन किया।

छोटे समुदाय स्तर के ड्रायर

एक नया अप्रत्यक्ष प्रकार का सौर ड्रायर डिज़ाइन तैयार किया गया और उसका परीक्षण पापड, आलू वेफर्स, अंगूर, प्याज, लहसुन, अदरक, लालमिर्च, मेथी पत्ती, मशरुम आदि जैसे खाद्य पदार्थो को सुखाने के लिए किया गया। ड्रायर की क्षमता प्रतिदिन 5-20 किग्रा. कच्ची सामग्री सुखाने की है, हालांकि यह सुखाये जाने वाले खाद्य के प्रकार पर आधारित है। गुजरात में धूप के मौसम के दौरान (800-900 वॉट/m^2) 60-80^0 C पर इसे नियंत्रित किया जा सकता है। इस ड्रायर से विभिन्न खाद्य उत्पादों को खुले में सौर ताप में सुखाने में लगने वाले समय से आधे समय में सुखाया जा सकता है। इस प्रकार के सौर ड्रायर केसर, खूमानी, मशरुम आदि जैसे विशिष्ट खाद्य उत्पादों को बिगड़ने की समस्या को कम करके सुखाने में अत्यंत अनुकूल है और सूखे उत्पादों के रंग और स्वाद को बनाए रखने के लिए मदद करता है। इस तरह का एक ड्रायर पश्चिम बंगाल में सुंदरबन के सागरद्वीप में स्थापित किया गया है।

उड़ीसा में चक्रवात के कारण क्षतिग्रस्त जेट्रोफा उद्यान का पुनर्स्थापन

12 अक्तूबर 2013 में उड़ीसा में हुए महाचक्रवात के बाद, बेरहामपुर (उड़ीसा) में 5 हेक्टर की भूमि में स्थित जेट्रोफा उद्यान में अत्यंत क्षति हुई थी। यथासमय एक सप्ताह की अवधि के भीतर संशोधक उपाय किये गये जिससे अपरिवर्तनीय क्षति नियंत्रण में सहायता मिली।

सेलीकोर्निया की सघनता वर्धन

आर्थिक रुप से महत्वपूर्ण, लवणोद्भिद सेलीकोर्निया का सरतानपर, विक्टर पोर्ट, निंगाला, जाफराबाद तथा गुजरात के दीव तट पर से बडी मात्रा में विनाश हो गया है। परिणाम स्वरुप सेलीकोर्निया की संख्या के घनत्व में तेजी से कमी आयी है। सीएसआईआर–सीएसएमसीआरआई द्वारा गुजरात के समुद्रतट दीव, निंगाला, सरतानपर तथा विक्टर पोर्ट जैसे स्थलों पर सेलीकोर्निया की सघनता को पुनः बढ़ाने हेतु प्रयास किये गये, इससे इनकी संख्या में वृद्धि हुई है।

सीएसआईआर– सीएसएमसीआरआई में आरक्षण नीति का क्रियान्वयन

मंत्रालय/विभाग/संगठन में 01.01.2012, 01.01.2013 तथा 01.01.2014 को आरक्षण लागू होने की तारीख को प्राप्त प्रगति को निम्न प्रपत्र में अलग से सूचित करते हुए, स्तर–वार कर्मचारियों की संख्या।

01.01.2012 को

पद का श्रेणी/स्तर	पदों की कुल संख्या	अनुसूचित जातियों की संख्या [प्रतिशत के साथ]	अनुसूचित जनजातियों की संख्या [प्रतिशत के साथ]	अन्य पिछड़ी जातियों की संख्या [प्रतिशत के साथ]
वैज्ञानिक ग्रेड IV (पे बैन्ड 3 और 4 में)	93	07 07.52 %	03 03.22 %	07 07.52 %
तकनीकी ग्रेड III (पे बैन्ड 2, 3 और 4 में	34	09 26.47 %	01 02.94 %	04 11.76 %
तकनीकी ग्रेड II (पे बैन्ड 1 और 2 में)	61	09 14.75 %	05 08.19 %	04 06.55 %
तकनीकी ग्रेड I (पे बैन्ड 1 में)	15	03 20.00 %	00 00.00 %	00 00.00 %
प्रशासनिक				
समूह–ए (पे बैन्ड 3 और 4 में)	07	00 00.00 %	00 00.00 %	01 14.28 %
समूह–बी (पे बैन्ड 2 में)	25	03 12.00 %	02 08.00 %	02 08.00 %
समूह–सी (पे बैन्ड 1में)	17	02 11.76 %	02 11.76 %	01 05.88 %
सफाईवाला (पे बैन्ड 1में)	03	03 100.00 %	00 00.00 %	00 00.00 %

01.01.2013 को

पद का श्रेणी/स्तर	पदों की कुल संख्या	अनुसूचित जातियों की संख्या [प्रतिशत के साथ]	अनुसूचित जनजातियों की संख्या [प्रतिशत के साथ]	अन्य पिछड़ी जातियों की संख्या [प्रतिशत के साथ]
वैज्ञानिक ग्रेड IV (पे बैन्ड 3 और 4 में)	90	06 06.66 %	03 03.33 %	07 07.77 %
तकनीकी ग्रेड III (पे बैन्ड 2, 3 और 4 में	35	09 25.71 %	01 02.85 %	04 11.42 %
तकनीकी ग्रेड II (पे बैन्ड 1 और 2 में)	56	09 16.07 %	05 08.92 %	04 07.14 %
तकनीकी ग्रेड I (पे बैन्ड 1 में)	15	03 20.00 %	00 00.00 %	00 00.00 %
प्रशासनिक				
समूह–ए (पे बैन्ड 3 और 4 में)	06	00 00.00 %	00 00.00 %	00 00.00 %
समूह–बी (पे बैन्ड 2 में)	25	03 12.00 %	02 08.00 %	02 08.00 %
समूह–सी (पे बैन्ड 1में)	16	02 12.50 %	02 12.50 %	01 06.25 %
सफाईवाला (पे बैन्ड 1में)	03	03 100 %	00 00.00 %	00 00.00 %

01.01.2014 को

पद का श्रेणी/स्तर	पदों की कुल संख्या	अनुसूचित जातियों की संख्या [प्रतिशत के साथ]	अनुसूचित जनजातियों की संख्या [प्रतिशत के साथ]	अन्य पिछड़ी जातियों की संख्या [प्रतिशत के साथ]
वैज्ञानिक ग्रेड IV (पे बैन्ड 3 और 4 में)	88	08 9.09 %	04 4.54 %	07 7.95 %
तकनीकी ग्रेड III (पे बैन्ड 2, 3 और 4 में	40	09 22.50 %	01 2.50 %	06 15.00 %
तकनीकी ग्रेड II (पे बैन्ड 1 और 2 में)	59	08 13.55 %	06 10.16 %	07 11.86 %
तकनीकी ग्रेड I (पे बैन्ड 1 में)	14	03 21.42 %	00 00.00 %	00 00.00 %
प्रशासनिक				
समूह–ए (पे बैन्ड 3 और 4 में)	07	00 00.00 %	00 00.00 %	00 00.00 %
समूह–बी (पे बैन्ड 2 में)	24	02 8.33 %	04 16.66 %	04 16.66 %
समूह–सी (पे बैन्ड 1में)	16	02 12.50 %	01 6.25 %	02 12.50 %
सफाईवाला (पे बैन्ड 1में)	03	03 100 %	00 00.00 %	00 00.00 %

2012, 2013 एवं 2014 के दौरान हुई भर्तियों का वर्षवार विवरण

2012

क्रम संख्या	समूह / वर्ग	कुल नियुक्तियां	अनुसूचित जाति नियुक्तियों की संख्या	अनुसूचित जनजाति नियुक्तियों की संख्या	अन्य पिछड़ी जाति नियुक्तियों की संख्या
1	IV	04	00	00	00
2	III	03	00	00	00
3	II	00	00	00	00
4	I	00	00	00	00
प्रशासनिक					
5	A	00	00	00	00
6	B	00	00	00	00
7	C	00	00	00	00

2013

क्रम संख्या	समूह / वर्ग	कुल नियुक्तियां	अनुसूचित जाति नियुक्तियों की संख्या	अनुसूचित जनजाति नियुक्तियों की संख्या	अन्य पिछड़ी जाति नियुक्तियों की संख्या
1	IV	04	01	01	01
2	III	06	00	00	02
3	II	06	00	01	02
4	I	00	00	00	00
प्रशासनिक					
5	A	00	00	00	00
6	B	00	00	00	00
7	C	02	00	00	01

2014

क्रम संख्या	समूह / वर्ग	कुल नियुक्तियां	अनुसूचित जाति नियुक्तियों की संख्या	अनुसूचित जनजाति नियुक्तियों की संख्या	अन्य पिछड़ी जाति नियुक्तियों की संख्या
1	IV	00	00	00	00
2	III	03	00	02	00
3	II	02	00	00	01
4	I	00	00	00	00
प्रशासनिक					
5	A	00	00	00	00
6	B	00	00	00	00
7	C	00	00	00	00

Part-1. Technology Development

CSIR-CSMCRI responded to the Uttarakhand Flood (July 2013) and Odsiha cyclone (October 2013) Tragedies

In commitment to serve the society, CSIR-CSMCRI had rushed in a team of 12 members to the challenging task as soon as the dimensions of the tragedy unfolded for providing safe drinking water solutions for the victims of Uttarakhand flood and Odisha cyclone. One RO mobile unit of about 3000 litre/hour capacity at Hrishikesh and another two Hollow fiber ultrafiltration units at Srinagar (Garhwal) were set up. The team at Hrishikesh extensively served the community by providing RO water tankers for 10 days. The other two ultrafiltration plants at Veer Chandra Singh Garhwali Govt. Medical Science & Research Institute Srinagar of 1000 litre/hour capacity and another plant at College campus of 10,000 litre/hour capacities served the hospital patients and other local community via tankers and from the plant sites for more than 10 days.

Training on improving quality of salt produced by the marginal salt producers

Marginal salt manufacturers were trained for production of high purity salt and utilization of bittern for value added chemicals. Project personnel were recruited and posted at Rajula for the implementation of the innovative methodologies of solar salt production and continuous monitoring of salt production in the adopted salt works. A fully equipped QC lab for analysis of samples of brines & salts by local salt manufacturers has been constructed at a centralized place in Rajula. The activities of good quality salt production have been further extended to Santhalpur region, Dist. Patan of Gujarat and various training programs have been conducted to educate the agarias of Santhalpur. Expanding our spectrum to new areas, a joint project proposal with NGO AHRM on improving the livelihood of the marginal agarias of Adesar region, Kutch Dist. of Gujarat was submitted to the Industries Commissionerate, Govt. of Gujarat.

Survey of potential areas of salt production in the state of Odisha

The survey of the small scale salt works and additional potential areas for increasing solar salt production in the state of Odisha was undertaken at the behest of the Industries Dept. Govt. of Odisha. All the salt producing areas were visited under the above program and more than 75% of additional land available for salt production has been surveyed. A final report was submitted to Odisha state government.

Establishing a model salt farm at Marakanam in Tamil Nadu

In continuation to our effort to disseminate high purity solar salt technologies to grass root level at across the country we undertook assignment from Salt Department, Govt. of India regarding establishment of a Model Salt Farm at Marakanam of Vellupuram District in Tamil Nadu. The model salt farm has been fully established and "golden scrapping of salt" has been carried out in 2012-2013.



Further operations are ongoing in said model salt farm. The Model Salt Farm is established in 10 acres area and is operating on sub soil brine. The land for the model salt farm was provided by Adi Dravida Co- Operative Salt producers & sales society. BIS grade II salt could be produced in the model salt farm.

Improving the quality of solar salt to edible grade in Didwana region of Rajasthan

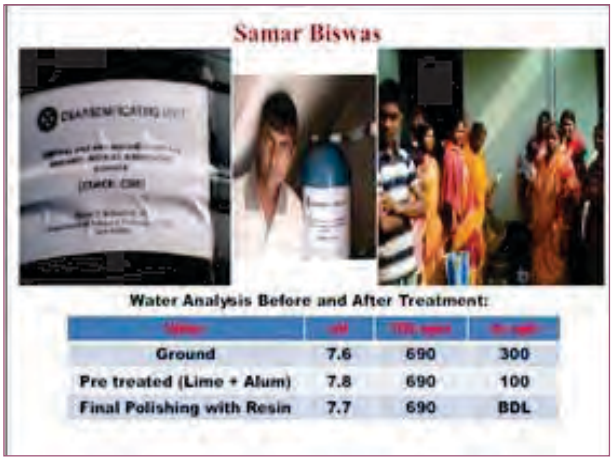
A proposal on improving the quality of solar salt to edible grade in Didwana region of Rajasthan has been approved by Department of Science and Technology, govt. of India. The NGO named SVS is collaborating in the work and mobilizing the salt producers in Didwana region.

Aqueous fluoride removal using ZnCr LDHs and their polymeric composites

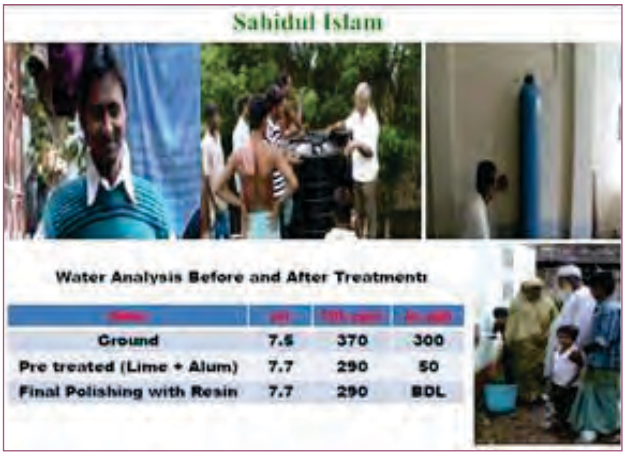
To make availability of the fluoride-free drinking water, CSIR-CSMCRI has synthesized nitrate containing ZnCr LDHs with Zn/Cr in a batch reactor which showed a maximum uptake capacity of 31mgF/g for $ZnCr_3$-NO_3-LDH.

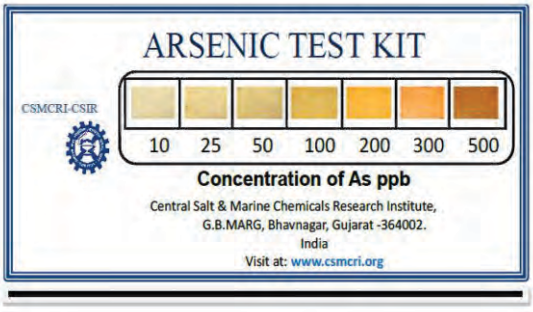
Ion-selective resins and membranes based systems/processes to bring the level of arsenic to WHO limits in drinking water

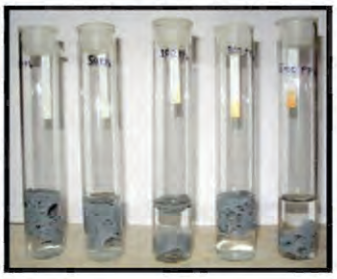
300 litres of arsenic specific resin was specifically prepared. Each batch of the resin was benchmarked for the removal of arsenic from arsenic spiked water in the laboratory. The pre-treatment technique of arsenic contaminated water was improved by using a mechanical device and water circulating pump. Both the techniques are quite effective for the reduction of arsenic and turbidity but the latter one is cost effective. Five community scale dearsenificating units were designed, fabricated and installed in arsenic affected areas.



The sludge generated during the pre-treatment of arsenic contaminated water was mixed with clay and baked in a kiln to prepare bricks from it. 65 domestic and 5 community scale dearsenificating units installed earlier in arsenic affected areas of West Bengal were monitored and maintained. Each domestic and community scale units produces 25 and 250 LPH arsenic free water respectively. Arsenic test kit prepared earlier was further fine-tuned to detect arsenic in water upto 10 ppb level and it works well at ambient temperature. The test kits prepared were distributed among the beneficiaries.







Process know-how for production of potassic chemicals and fertilisers through selective K-precipitation using tartaric acid

A process has been developed for recovery of potash directly from sea bittern and other K-bearing feed stocks. In this process, potassium is selectively precipitated and subsequently converted to desired potassium salts. This process also works efficiently for recovery of potash from biomass ash/char as well as for conversion of potassium chloride in to multi-nutrient K-fertilisers.

Production of Jatropha biodiesel

CSIR-CSMCRI has collaborated with Gujarat Forest Department in their initiative to run all AC tourist vehicles in Sasan-Gir with the neat Jatropha biodiesel. 12100 liter of Jatropha biodiesel has been supplied. Research Designs & Standards Organization (RDSO) approved CSIR-CSMCRI Jatropha Biodiesel for B10 field trials in Diesel Locomotives (IR-WR). We have conducted proof-of-concept studies for captive power generation through gasification of Jatropha fruit shells at 10kWe scale.

Small community scale solar dryer

A new indirect type of solar dryer was designed ,fabricated and tested for drying of food products like papad, potato wafers, banana wafers, grapes, onion, garlic, ginger, red chilies, methi leaves, mushrooms etc. The capacity of the dryer is about 5 -20 of kg of raw material per day, however it depends on the nature of the food to be dried. The temperature of drying could be controlled at 60- 80°C during sunny weather condition (800–900 watt/ m^2) in Gujarat. The drying of various food products could be achieved with about half the time duration taken for open sun drying.



This type of solar dryer is highly suited for drying of specialty food products like saffron, apricot, mushroom etc. to eliminate spoilage problems and impart controlled drying conditions which help to retain the colour and flavour of the dried products. Such a dryer is installed in Sagar Islands of Sunderbans, West Bengal.

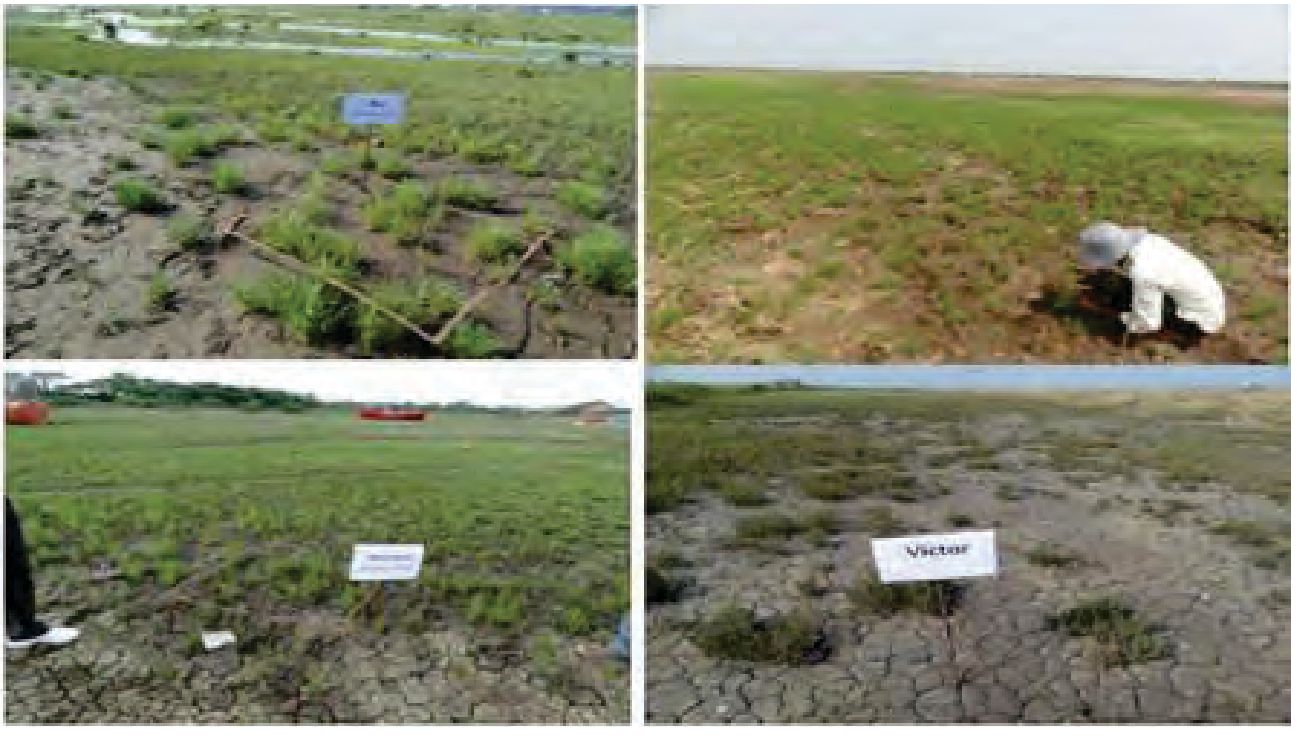
Rehabilitation of damage to Jatropha plantation at Odisha due to cyclone

Jatropha plantation at Berhampur (Odisha) in 5 ha land received a huge damage just after a very big cyclone hit the Odisha state on October 12, 2013. Timely corrective measures were, taken immediately within a week period (15th -21st October, 2013) that helped the irreversible damage control.



Densification of *Salicornia*

An economically important halophyte *Salicornia* has been largely eradicated from different sites *viz.* Sartanpar, Victor port, Ningala, Zafrabad and Diu of Gujarat coast. This results in reduction of population density of *Salicornia*. Therefore, an effort was made by CSIR-CSMCRI to restore the *Salicornia* vegetation by densification at some sites of Gujarat coast such as Diu, Ningala, Sartanpar, and Victor port. This leads to increase in population density of *Salicornia*.



Luxurious germination of *Salicornia* at different desified sites A) Diu; B) Ningala; C) Sartanpur and D) Victor

Implementation of Reservation Policy at CSIR-CSMCRI

Level-wise staff strength as on the date when reservation were enforced in the Ministry/ Department/ Organization as on 01.01.2012, 01.01.2013 and 01.01.2014 indicating the progress achieved in the following proforma mentioned below

As on 01.01.2012

Category/Level of Posts	Total No. of posts	Number of SCs (with percentage)	Number of STs (with percentage)	Number of OBCs (with percentage
Scientists Gr IV (in pay band 3 & 4)	93	07 07.52 %	03 03.22 %	07 07.52 %
Technical Gr III (in pay band 2, 3 & 4)	34	09 26.47 %	01 02.94 %	04 11.76 %
Technical Gr II (in pay band 1& 2)	61	09 14.75 %	05 08.19 %	04 06.55 %
Technical Gr I (in pay band 1)	15	03 20.00 %	00 00.00 %	00 00.00 %
Administration				
Group-A (in pay band 3 & 4)	07	00 00.00 %	00 00.00 %	01 14.28 %
Group-B (in pay band 2)	25	03 12.00 %	02 08.00 %	02 08.00 %
Group-C (in pay band 1)	17	02 11.76 %	02 11.76 %	01 05.88 %
Safaiwala (in pay band 1)	03	03 100.00 %	00 00.00 %	00 00.00 %

As on 01.01.2013

Category/Level of Posts	Total No. of posts	Number of SCs (with percentage)	Number of STs (with percentage)	Number of OBCs (with percentage
Scientists Gr IV (in pay band 3 & 4)	90	06 06.66 %	03 03.33 %	07 07.77 %
Technical Gr III (in pay band 2, 3 & 4)	35	09 25.71 %	01 02.85 %	04 11.42 %
Technical Gr II (in pay band 1& 2)	56	09 16.07 %	05 08.92 %	04 07.14 %
Technical Gr I (in pay band 1)	15	03 20.00 %	00 00.00 %	00 00.00 %
Administration				
Group-A (in pay band 3 & 4)	06	00 00.00 %	00 00.00 %	00 00.00 %
Group-B (in pay band 2)	25	03 12.00 %	02 08.00 %	02 08.00 %
Group-C (in pay band 1)	16	02 12.50 %	02 12.50 %	01 06.25 %
Safaiwala (in pay band 1)	03	03 100 %	00 00.00 %	00 00.00 %

As on 01.01.2014

Category/Level of Posts	Total No. of posts	Number of SCs (with percentage)	Number of STs (with percentage)	Number of OBCs (with percentage
Scientists Gr IV (in pay band 3 & 4)	88	08 9.09 %	04 4.54 %	07 7.95 %
Technical Gr III (in pay band 2, 3 & 4)	40	09 22.50 %	01 2.50 %	06 15.00 %
Technical Gr II (in pay band 1& 2)	59	08 13.55 %	06 10.16 %	07 11.86 %
Technical Gr I (in pay band 1)	14	03 21.42 %	00 00.00 %	00 00.00 %
Administration				
Group-A (in pay band 3 & 4)	07	00 00.00 %	00 00.00 %	00 00.00 %
Group-B (in pay band 2)	24	02 8.33 %	04 16.66 %	04 16.66 %
Group-C (in pay band 1)	16	02 12.50 %	01 6.25 %	02 12.50 %
Safaiwala (in pay band 1)	03	03 100 %	00 00.00 %	00 00.00 %

Year-wise statements showing the recruitments made during 2012, 2013, 2014

2012

Sr. No.	Group/Class	Total appointments made	No. of SCs appointed	No. of STs appointed	No. of OBCs appointed
1	IV	04	00	00	00
2	III	03	00	00	00
3	II	00	00	00	00
4	I	00	00	00	00
Administration					
5	A	00	00	00	00
6	B	00	00	00	00
7	C	00	00	00	00

2013

Sr. No.	Group/Class	Total appointments made	No. of SCs appointed	No. of STs appointed	No. of OBCs appointed
1	IV	04	01	01	01
2	III	06	00	00	02
3	II	06	00	01	02
4	I	00	00	00	00
Administration					
5	A	00	00	00	00
6	B	00	00	00	00
7	C	02	00	00	01

2014

Sr. No.	Group/Class	Total appointments made	No. of SCs appointed	No. of STs appointed	No. of OBCs appointed
1	IV	00	00	00	00
2	III	03	00	02	00
3	II	02	00	00	01
4	I	00	00	00	00
Administration					
5	A	00	00	00	00
6	B	00	00	00	00
7	C	00	00	00	00

भाग–2 हिन्दी विभाग

राजभाषा संबंधी संवैधानिक और कानूनी उपबंधो का अनुपालन सुनिश्चित करने और संघ के सरकारी कामकाज में हिन्दी के प्रयोग को बढ़ावा देने के लिए केन्द्रीय नमक व समुद्री रसायन अनुसंधान संस्थान में हिन्दी विभाग कार्यरत है। विभाग द्वारा राजभाषा नीति के अनुपालन के साथ–साथ संस्थान की वैज्ञानिक गतिविधियों को हिन्दी भाषा के माध्यम से जनमानस तक पहुँचाने के सक्रिय प्रयास किये जा रहे हैं। वर्ष 2012-14 के दौरान विभाग द्वारा किये गये प्रयास निम्नानुसार हैं।

राजभाषा प्रचार–प्रसार

- गृहमंत्रालय, राजभाषा विभाग, हिन्दी द्वारा कार्यान्वयन संबंधी वर्ष 2012-13 तथा 2013-14 के लिए प्राप्त वार्षिक कार्यक्रम सभी विभागाध्यक्षों को प्रेषित किये गये।
- वार्षिक रिपोर्ट 2012-13 तथा 2013-14 तैयार की गई।
- 14 सितम्बर, हिन्दी दिवस के अवसर पर वर्ष 2012 में दिनांक 07/09/2012 से 14/09/2012 तक तथा वर्ष 2013 में दिनांक 09/09/2013 से 16/09/2013 के दौरान हिन्दी सप्ताह मनाया गया। कक्षा 1 से 12 तक हिन्दी में सर्वाधिक अंक प्राप्त करनेवाले कर्मचारियों के बच्चों को, तथा वर्ष के दौरान पांच हजार से अधिक हिन्दी शब्दों का प्रयोग करनेवाले कर्मचारियों को नगद पुरस्कार दिया गया। हिन्दी सप्ताह के दौरान विभिन्न प्रतियोगिताओं जैसे कम्प्युटर प्रश्नोतरी, वैज्ञानिक शोधपत्र पर आधारित हिन्दी पोस्टर्स प्रतियोगिता, कविता पाठ, तस्वीर क्या बोलती है?, सारांश लेखन (प्रशासनिक एवं कार्यशाला के कर्मचारियों के लिए), निबंध लेखन, कम्प्युटर पर हिन्दी टाइपिंग (यूनिकोड में), तथा प्रश्नोत्तरी का आयोजन किया गया। प्रतिदिन इन्ट्रानेट द्वारा ऑनलाइन प्रश्नोतरी का भी आयोजन किया गया, जिसमें कर्मचारियों ने उत्साहपूर्वक भाग लिया।
- वर्ष 2012 के हिन्दी सप्ताह समापन समारोह के अतिथि विशेष के रूप में प्रो. ए. कुमार, महाराजा कृष्णकुमारसिंहजी भावनगर विश्वविद्यालय को आमंत्रित किया गया। जिनके द्वारा विभिन्न प्रतियोगिताओं के विजेताओं को पुरस्कृत किया गया। वर्ष 2013 में अतिथि विशेष के रुप में महाराजा कृष्णकुमारसिंहजी भावनगर, हिन्दी विभाग के अध्यक्ष, प्रो. एच एल वाघेला को आमंत्रित किया गया था।
- संस्थान की वैज्ञानिक गतिविधियों को राजभाषा हिन्दी के माध्यम से आम जन तक पहुँचाने के प्रयासरुप 20 रेडियो वार्तालाप की श्रृंखला तैयार की गई जिसके अंतर्गत संस्थान की विविध गतिविधियों संबंधी वार्तालाप हिन्दी तथा क्षेत्रीय भाषा गुजराती में तैयार करके आकाशवाणी, राजकोट से प्रसारित किया गया।
- राजभाषा विभाग, गृह मंत्रालय के निदेशानुसार संस्थान में किये जा रहे कार्यो के बारे में "केन्द्रीय नमक व समुद्री रसायन अनुसंधान संस्थान में राजभाषा कार्यान्वयन" बुकलेट तैयार की गई।
- वर्ष 2011 "ईयर ऑफ केमिस्ट्री" के उपलक्ष्य में डॉ. डी डी ओझा तथा श्रीमती दिना भट्ट के सहलेखन में 'उपयोगी रसायन और जीवन' पुस्तक लिखी गई, जो सीएसआईआर की प्रयोगशालाओं/संस्थानों, गुजरात राज्य के केन्द्रीय विद्यालयों, विश्वविद्यालयों एवं भावनगर के अन्य विद्यालयों में विज्ञान प्रचार प्रसार हेतु निःशुल्क वितरित की गई।

हिन्दी प्रशिक्षण

- 31 मार्च 2013 तक का संस्थान के कर्मचारियों का हिन्दी ज्ञान संबंधी रोस्टर अद्यतन किया गया।
- गृहमंत्रालय के आदेशानुसार प्रवीणता प्राप्त कर्मचारी/अधिकारियों को इन वर्षों के लिये व्यक्तिगत आदेश जारी किये गये।
- समुद्री शैवाल फील्ड स्टेशन मन्डपम (तमिलनाडु) में नये भर्ती हुए वैज्ञानिक का हिन्दी प्रशिक्षण के लिये राजभाषा विभाग के लीला सॉफ्टवेयर में भावनगर से ऑनलाइन रजिस्ट्रेशन करवाया गया।

हिन्दी कार्यशाला

- हिन्दी विभाग द्वारा संस्थान के कर्मचारियों/अधिकारियों को हिन्दी में कार्य करने के लिए प्रोत्साहित करने हेतु तिमाही की कार्यशालाओं का आयोजन किया गया। जिसके अंतर्गत टेबल वर्कशॉप, यूनिकोड स्थापना एवं निदर्शन तथा उपयोग विषय पर कार्यशाला, वैज्ञानिकों एवं तकनीशियनों के लिये कार्यशाला आयोजित की गयी।
- दिनांक 26.10.2012 को आयोजित "उपयोगी रसायन और जीवन" पुस्तक के विमोचन समारोह में राजभाषा विभाग, गृह मंत्रालय, पश्चिम क्षेत्र (कार्यान्वयन) के उपनिदेशक श्री विनोद कुमार शर्मा को विशेष अतिथि के रुप में आमंत्रित किया गया। पुस्तक विमोचन समारोह से पहले एक कार्यशाला का आयोजन किया गया जिसके अंतर्गत "प्रशासन एवं विज्ञान में सरल हिन्दी का प्रयोग" विषय पर श्री विनोद कुमार शर्मा ने सरल भाषा में मार्गदर्शन दिया।
- विभाग द्वारा अक्टूबर–दिसंबर, 2013 तिमाही की एक दिवसीय कार्यशाला का आयोजन, संस्थान में पी.एच.डी कर रहे शोधार्थियों के लिए "संस्थान के पी.एच.डी शोधार्थियों द्वारा राजभाषा में शोध पत्र प्रस्तुतीकरण" विषय पर किया गया। जिसके अंतर्गत शोधार्थियों ने अपने शोध–कार्य संबंधित वैज्ञानिक प्रस्तुति हिन्दी में की। इस कार्यशाला में डॉ. डी डी ओझा को विशेष अतिथि तथा समीक्षक के रुप में आमंत्रित किया गया था।
- हिन्दी विभाग द्वारा संस्थान के कर्मचारियों के लिए जनवरी–मार्च, 2014 तिमाही के दौरान दिनांक 26.03.2014 को हिन्दी साफ्टवेयर के प्रभावी प्रयोग विषय पर एक कार्यशाला का आयोजन संस्थान के सभागृह में किया गया।

तकनीकी अनुवाद

- संस्थान के द्विवार्षिक प्रतिवेदन 2010-12 का हिन्दी अनुवाद किया गया।
- आकाशवाणी राजकोट द्वारा प्रसारित किये जाने वाले रेडियो वार्तालाप का हिन्दी तथा क्षेत्रीय भाषा गुजराती में अनुवाद किया गया।
- सिविल विभाग के निविदा नियम व शर्ते संबंधी दस्तावेजों का हिन्दी अनुवाद तथा टंकण किया गया।
- आवश्यकतानुसार रबड़ की मोहरों का हिन्दी अनुवाद तथा टंकण किया गया।
- आवश्यकतानुसार टेन्डर, नोटिस, एमओयु फार्म, विभिन्न विभागों के संशोधित/परिवर्तित फार्मों का अनुवाद तथा टंकण कार्य किया गया।
- सभी विभागों के फार्मों को यूनिकोड में परिवर्तित करके हाइपर लिंक देकर सीडी तैयार की गई।
- आर्सेनिक विहीनीकरण प्रक्रिया की बुकलेट का हिन्दी अनुवाद और टाइपिंग की गई।
- सॉल्ट पम्फलेट का हिन्दी अनुवाद और टाइपिंग की गई।

हिन्दी पत्राचार

- हिन्दी में आये समस्त पत्रों के उत्तर हिन्दी में तथा अन्य भाषाओं के पत्रों के उत्तर हिन्दी में अथवा द्विभाषा में भेजे गये।
- वर्ष के दौरान आयोजित हिन्दी कार्यशाला की रिपोर्ट तथा राजभाषा कार्यान्वयन समिति की बैठक की मिनिट्स सीएसआईआर की सभी प्रयोगशालाओं एवं नगर राजभाषा कार्यान्वयन समिति के सदस्यों को भेजी गई।

हिन्दी बैठक

- 2012-2014 के दौरान प्रत्येक तिमाही में राजभाषा कार्यान्वयन समिति की आठ बैठकें निदेशक महोदय की अध्यक्षता में संपन्न की गईं। दिनांक 26.10.2012 की बैठक में श्री विनोद कुमार शर्मा, उपनिदेशक, राजभाषा विभाग (पश्चिम क्षेत्र), गृहमंत्रालय को विशेष रुप से आमंत्रित किया गया था। चार बार नगर राजभाषा कार्यान्वयन समिति द्वारा आयोजित अर्द्धवार्षिक बैठकों में संस्थान का प्रतिनिधित्व किया गया।

निरीक्षण

- दिनांक 06.06.2012 को राजभाषा विभाग (पश्चिम क्षेत्र), गृहमंत्रालय, मुंबई की अनुसंधान अधिकारी, श्रीमती साधना त्रिपाठी द्वारा संस्थान की राजभाषा कार्यान्वयन प्रगति का निरीक्षण किया गया।
- राजभाषा कार्यान्वयन समिति द्वारा प्रतिमास संस्थान के एक–एक विभाग का राजभाषा कार्यान्वयन संबंधी आंतरिक निरीक्षण किया गया।

प्रोत्साहन

- संस्थान में हिन्दी के प्रगामी प्रयोगों हेतु कर्मचारियों को हिन्दी में कार्य करने के लिए प्रोत्साहित करने हेतु विभिन्न पुरस्कारों से पुरस्कृत किया गया जिसमें प्रतिवर्ष प्रत्येक तिमाही में सबसे ज्यादा पत्र लिखने वाले तीन कर्मचारियों को पुरस्कार, हिन्दी विषय में सर्वाधिक अंक प्राप्त करने वाले कर्मचारियों के बच्चों को पुरस्कार आदि शामिल हैं।

विशेष कार्य

- दिनांक 13.04.2013 को संसदीय समिति की दूसरी उपसमिति द्वारा संस्थान का राजभाषा संबंधी प्रगति का निरीक्षण अहमदाबाद में किया गया। तत्संबंधी विस्तृत रिपोर्ट तैयार करने संबंधी सभी कार्य किए गए। इस संदर्भ में हिन्दी में किए जा रहे कार्यों संबंधी बुकलेट्स तैयार की गई जो निम्न हैं : 1. संस्थान में राजभाषा कार्यान्वयन, 2. निविदा आलेख पुस्तिका, राजभाषा हिन्दी में वैज्ञानिक एवं सुरक्षा संबंधी पोस्टर्स, 3. सिविल कार्यों के लिए अनुबंध की शर्तें, 4. संस्थान द्वारा प्राप्त यू.एस. पेटेंट के द्विभाषी सारांश, 5. वैज्ञानिक तथा तकनीकी अधिकारियों के आकाशवाणी वार्तालाप।

भाग–3 ग्रंथालय तथा सूचना प्रणाली

इस क्षेत्र में सीएसआईआर–सीएसएमसीआरआई के ग्रंथालय को एक उत्तम ग्रंथालय माना जाता है जिसमें संस्थान में किये जा रहे अनुसंधान और विकास कार्यों के क्षेत्र से संबंधित पुस्तकों, पत्र–पत्रिकाओं, संदर्भ साहित्य आदि का समृद्ध संग्रह है। अनुसंधान तथा विकास से जुड़े संस्थान के कर्मचारियों की जानकारी की पूर्ति करने के अलावा ग्रंथालय अन्य विश्वविद्यालय के शोधछात्रों, उद्योगों के अनुसंधान एवं विकास से जुड़े कर्मचारियों, सरकारी अधिकारियों को भी सुविधा प्रदान करता है। ग्रंथालय में उपलब्ध संग्रह, सुविधा तथा सेवाएं निम्नानुसार है।

क्रमांक	विवरण	**31.3.2012** तक उपलब्ध	**2012-13** के दौरान वृद्धि	**2013-14** के दौरान वृद्धि	**31.3.2014** तक के संग्रह
1	पुस्तकें (अंग्रेजी)	12096	40	14	12150
	पुस्तकें (हिन्दी)	476	11	66	553
2	पिछले अंक	27446	-	-	27446
3	अनुवाद	427	-	-	427
4	फोटो कॉपी	2149	-	-	2149
5	पेटेन्ट्स	340	-	-	340
6	मानक	761	-	-	761
7	माइक्रो कार्ड्स	67	-	-	67
8	माइक्रो फिल्म	1326	-	-	1326
9	नक्शे / चार्ट	265	-	-	265
10	रीप्रिन्ट्स	2698	-	-	2698
	कुल	**48051**			**48182**

जरनल / डेटाबेस / ई–जरनलों की सदस्यता

अंतर्राष्ट्रीय जरनल 55 (2012-13)
राष्ट्रीय जरनल 72 (2012-13)
ग्रंथसूची डेटाबेस 04 (साई–फाइन्डर, ए.एस.टी.एम. डी.एल, थॉमसन इनोवेशन, वेब ऑफ साइन्स)

इनके अलावा ग्रंथालय में नेशनल नॉलेज रीसोर्स कोन्सोर्टीयम सीएसआईआर द्वारा मेसर्स एल्सवीयर, स्प्रिंगर, ए.सी.एस, आर.एस.सी, वायले ब्लेकवेल, ऑक्सफोर्ड यूनिवर्सिटी प्रेस पब्लिशर के जरनलों की ऑनलाइन ऐक्सेस की सुविधा उपलब्ध है। ग्रंथालय में अंतर्राष्ट्रीय सारांश तथा अनुक्रमण सेवाओं जैसे रासायनिक सारांश, जैविक सारांश, वर्तमान सामग्री / एफ.टी.पी / 2005, रसायन शास्त्र, रासायनिक प्रौद्योगिकी, जीव विज्ञान तथा सामान्य विज्ञान के जरनल के पिछले संस्करणों का विशेष संग्रह है।

सूचना सेवाएं

अनुसंधान एवं विकास कार्यों से जुड़े कर्मचारियों को वर्तमान तथा अद्यतन सूचना सरल तथा त्वरित रुप से उपलब्ध कराने हेतु ग्रंथालय अपने उपयोगकर्ताओं के लिए विभिन्न सूचना सेवाएं प्रदान करता है। इन सेवाओं के माध्यम से वैज्ञानिकों तथा तकनीकी कर्मचारियों को उनकी रुचि–क्षेत्र की वर्तमान प्रवृत्तियों के बारे में अवगत रखा जाता है। ये सेवाएं निम्नलिखित रुप में प्रदान की जाती हैं।

1. अंतर–पुस्तकालय ऋण सेवाएं
2. पाठकों के प्रश्न
3. दस्तावेज वितरण सेवा
4. डेटाबेस के माध्यम से ग्रंथसूची खोजना
5. संदर्भ सेवा
6. साहित्य खोज सुविधा

बाहरी क्षेत्र जैसे कॉर्पोरेट एवं विश्वविद्यालयों के सदस्यों को भी ग्रंथालय में दस्तावेज परामर्श के लिए अनुमति प्रदान की जाती है। ये सेवायें ग्रंथालय के अधिकतम उपयोग के उद्देश्य को पूरित करती हैं।

वर्कशॉप / प्रशिक्षण

ग्रंथालय ने 'वेब ऑफ साइन्स साइटेशन डेटाबेस' पर प्रशिक्षण तथा ग्रंथालय द्वारा खरीदे गये विभिन्न ई–संसाधनों के लिये अभिमुखीकरण कार्यक्रमों का आयोजन किया है। लगभग 100 उपयोगकर्ताओं ने इस कार्यक्रम में भाग लिया और इलेक्ट्रॉनिक संसाधनों के उपयोग के प्रशिक्षण से लाभान्वित हुए।





संस्थागत संग्रह

ग्रंथालय ने संस्थान के वैज्ञानिकों और छात्रों द्वारा जमा किये गये शोध–पत्र, शोध–प्रबंध तथा शोध–निबंधों को डी–स्पेस मुक्त स्रोत सॉफ्टवेयर के उपयोग द्वारा एक संस्थागत संग्रह तैयार किया है।

Part-3. Library & Information System

The CSMCRI library is considered to be premier one in this region having rich collections of books, periodicals, reference materials etc in the areas of R & D being carried out in the institute. Besides catering to the information needs of R&D staff of the institute, the library also extends facilities to the visiting research scholars, University staff, R & D staff of the industries, government officials and others. A brief account of library collection, facilities, services are as under:

Sr. No.	Particulars	Available as on 31.3.2012	Addition during 2012-13	Addition during 2013-14	Collection as on 31.3.2014
1	Books (English)	12096	40	14	12150
	Books (Hindi)	476	11	66	553
2	Back Vols.	27446	-	-	27446
3	Translation	427	-	-	427
4	Photocopy	2149	-	-	2149
5	Patents	340	-	-	340
6	Standards	761	-	-	761
7	Micro-cards	67	-	-	67
8	Microfilms	1326	-	-	1326
9	Maps/Charts	265	-	-	265
10	Reprints	2698	-	-	2698
	Total	**48051**			**48182**

Journals/Databases/E-journals subscription

International Journals 55 (2012-13)
National Journals 72 (2012-13)
Bibliographic Databases 04 (Sci-Finder, ASTM DL, Thomson Innovation, Web of Science)

Apart from the above library has received the access of online journals through CSIR-National Knowledge Resource Consortium from M/S Elsevier, Springer, ACS, RSC, Wiley Blackwell, Oxford University Press publishers. The library is having specialized collection of international abstracting and indexing services viz. Chemical Abstracts, Biological Abstracts, Current Contents/FTP/2005, back volumes of journals in chemistry, chemical technology, biological sciences and general sciences.

Information services

For easy and quick access to current and latest information by the R & D staff, library renders various information services to its users. Through these services, scientific and technical staff is kept well informed about the current trends in the field of their interest. The services rendered are as follows:

1.Inter-library loan services.
2.Reader's queries.
3.Document delivery service.
4.Bibliographic search through databases.
5.Reference service
6.Literature search facility to outsider.

The external members from corporate sectors, universities are also granted permission to consult the documents in the library. This fulfills the aim of maximum utilization of library documents.

Workshop/Trainings

The library has organized trainings on Web of Science citation database and conducts library orientation for various e-resources subscribed by the library. About 100 users participated in the programme got benefited by the training for use of electronic resources effectively.

Institutional repository

Library has set up an institutional repository using D-Space open source software for research articles, thesis and dissertations submitted by the scientists and students of the institute.

ANNEXURE

Research Output and Other Activities

1. Research Papers Published
2. Books / Chapters in Books
3. Patents - Granted / Filed
4. Papers / Lectures Presented in Seminars / Symposia
5. Inter Agency Linkages
6. Human Resource Development
7. Awards and Recognitions
8. Deputation abroad: CSMCRI Scientists & Research Scholars
9. Visitors from abroad to CSMCRI
10. Distinguished Visitors & Lectures
11. Invited Talks / Lectures Delivered By CSMCRI Scientists
12. Dateline CSMCRI
13. Seminars / Workshops / Events / Meetings Organized
14. Appointments
15. Retirement/Voluntary/Transfer/Termination/Resignation
16. Resoureces - Staff and Budgetary Details
17. Research Council
18. Management Council

1. Research Papers Published

2012 –2013

1. A binuclear chloride bridged Copper (II) complex with a modified ligand structure and different coordination environment and mononuclear Cobalt (II) complexes with a Pyridylpyrazole ligand: Synthesis, structure and cytotoxic activity. Kumar, SB; Zala, M; Solanki, A; Rangrez, M; Parikh, P; Suresh, E. *Polyhedron*.**2012.** 36. 1: 15 - 20.
2. A cascade reaction actuated by Nucleophilic Heterocyclic Carbene catalyzed intramolecular addition of Enals via Homoenolate to Alpha, beta-unsaturated Esters: Efficient synthesis of Coumarin derivatives. Sinu, CR; Padmaja, DVM; Ranjini UP; Seetha Lakshmi KC; Suresh, E; Nair, V. *Org Lett*. **2013**. 15: 68 - 71.
3. A CN- specific turn-on phosphorescent probe with probable application for enzymatic assay and as an imaging reagent. Reddy, UG; Das, P; Saha, S; Baidya, M; Ghosh, SK; Das, A. *Chem Commun*. **2013**. 49: 255 - 257.
4. Adsorption of pH-responsive amphiphilic copolymer micelles and gel on membrane surface as an approach for antifouling coating. Muppalla, R; Rana, H H; Devi, S; J, Suresh K. *Appl Surf Sci*. **2013.** 268: 355–367.
5. A computational study toward understanding the separation of ions of Potassium chloride microcrystal in water. Sen, A; Ganguly, B. *Theor Chem Acc*. **2012.** 131: 1296-1308.
6. A dechlorination pathway for synthesis of horn shaped carbon nanotubes and its adsorption properties for CO_2, CH4, CO and N-2. Sawant, SY; Somani, RS; Bajaj, HC; Sharma, SS. *J Hazard Mater*. **2012.** 227: 317- 326.
7. A facile four component protocol for the synthesis of dihydropyridine derivatives. Nair, V; Jose, A; Seetha Lakshmi, KC; Rajan, R; Suresh, E. *Org Biomol Chem*. **2012.** 10. 38: 7747-7752.
8. A highly selective and dual responsive test paper sensor of Hg2+/Cr3+ for naked eye detection in neutral water. Das, P; Ghosh, A; Bhatt, H; Das, A. *RSC Advances*. **2012.** 2. 9: 3714 -3721.
9. A new class of solvatochromic material: Geometrically unsaturated Ni (II) complexes. Selvakumar, PM; Nadella, S; Froehlich, R; Albrecht, M; Subramanian, P S. *Dyes Pigments*. **2012.** 95: 563 - 571.
10. A rapid and green synthetic approach for hierarchically assembled porous ZnO nanoflakes with enhanced catalytic activity. Sinhamahapatra, A; Giri, AK; Pal, P; Pahari, SK; Bajaj, HC; Panda, AB. *J Mater Chem*. **2012.** 22: 17227 - 17235.
11. A taco complex derived from a bis-crown ether capable of executing molecular logic operation through reversible complexation. Mandal, AK; Das, P; Mahato, P; Acharya,S; Das, A. *J Org Chem*. **2012.** 77: 6789 - 6800.
12. Adsorption of an anionic dye from aqueous medium by organoclays: equilibrium modeling, kinetic and thermodynamic exploration. Bhatt, AS; Sakaria, PL; Vasudevan, M; Pawar, R; Sudheesh, N; Bajaj, HC; Mody, HM. *RSC Adv*. **2012.** 2: 8663 - 8671.
13. Adsorption selectivity of CO_2 over N-2 by cation exchanged zeolite L: Experimental and simulation studies. Dangi, GP, Munusamy, K; Somani, RS; Bajaj, HC. *Indian J Chem A*. **2012.** 51: 1238 - 1251.
14. Agarose processing in protic and mixed protic-aprotic ionic liquids: Dissolution, regeneration and high conductivity, high strength ionogels. Trivedi, TJ; Srivastava, DN; Rogers, RD; Kumar, A. *Green Chem*. **2012.** 14: 2831 - 2839.

15. Agro-technology of *Jatropha curcas* for diverse environmental conditions in India. Singh, B; Singh, K; Rao, GR; Chikara, J; Kumar, D; Mishra, DK; Saikia, SP; Pathre, UV; Raghuvanshi, N; Rahi, TS; Tuli, R. **2013.** *Biomass Bioenerg.* 48: 191 – 202.

16. Alcohol-induced change of "reverse osmosis" polyamide membrane surface. Agrawal, VK; Singh, PS. *J Appl Polym Sci*.**2012.** 124: E290 - E299.

17. Amidoxime copolymer beads containing Cu/Cu_2O microparticles as a biocidal material for water disinfection. Gangadharan, D; Dixit, D; Popat, KM; Singh, AP. *J Appl Polym Sci*. **2013.** 127: 3491 - 3499.

18. An interrupted PET coupled TBET process for the design of a specific receptor for Hg2+ and its intracellular detection in MCF7 cells. Saha, S; Mahato, P; Baidya, M; Ghosh, SK; Das, A. *Chem Commun*. **2012**. 48: 9293 - 9295.

19. Ansa-Ferrocene-Incorporated Calixpyrroles and Calixphyrins: Syntheses and Spectral/Structural Characterization. Ramakrishnan, S; Anju, KS; Thomas, AP; Sreedevi, K CG; Salini, P.; Holaday, MGD; Suresh, E; Srinivasan, A. *Organometallics*. **2012**. 31: 4166 – 4173.

20. Application of targeted metagenomics to explore abundance and diversity of CO_2-fixing bacterial community using cbbL gene from the rhizosphere of *Arachis hypogaea*. Yousuf, B; Keshri, Ji; Mishra, A; Jha, B. *Gene*. **2012**. 506: 18 - 24.

21. Aqueous-Biamphiphilic ionic liquid systems: Self-Assembly and synthesis of Gold nanocrystals/microplates. Srinivasa Rao, K; Trivedi, TJ; Kumar, A. *J. Phys. Chem. B*. **2012.** 116: 14363 – 14374.

22. Aqueous biphasic hydrogenation of benzene catalyzed by ruthenium complex of trisulfonated tris(biphenyl)phosphine. Dabbawala, AA; Bajaj, HC; Bricout, H; Monflier, E. *Catal Sci Technol.* **2012.** 2: 2273 – 2278.

23. Assessing the reactivation efficacy of hydroxylamine anion towards VX-inhibited AChE: a computational study. Khan, MAS; Ganguly, B. *J Mol Model*. **2012.** 18: 1801 - 1808.

24. Assessment of changes in DNA methylation by methylation-sensitive amplification polymorphism in *Jatropha curcas* L. subjected to salinity stress. Mastan, SG; Rathore, M S; Bhatt, VD; Yadav, P; Chikara, J. *Gene*. **2012.** 508: 125 - 129.

25. Asymmetric hydrolytic kinetic resolution with recyclable macrocyclic CoIII-salen complexes: A practical strategy in the preparation of (R)-Mexiletine and (S)-Propranolol. Sadhukhan, Arghya; Khan, Noor-ul H.; Roy, T; Kureshy, RI; Abdi, SHR; Bajaj, HC. *Chem- Eur J*. **2012.** 18: 5256 - 5260.

26. Bacterial extracellular polymeric substances and their effect on settlement of zoospore of *Ulva fasciata*. Singh, RP; Shukla, MK; Mishra, A; Reddy, CRK; Jha, B. *Colloid Surface B*. **2013.** 103: 223 – 230.

27. Bioethanol from Macroalgal Biomass: Utilization of Marine Yeast for Production of the Same. Khambhaty, Y; Upadhyay, D; Kriplani, Y; Joshi, N. *BioEnerg Res*. 2013. 6: 188 - 195.

28. C-2-Symmetric recyclable organocatalyst for enantioselective strecker reaction for the synthesis of alpha-amino acid and chiral diamine- an intermediate for APN inhibitor. Saravanan, S; Sadhukhan, A; Khan, NH; Kureshy, RI; Abdi, SHR. *J Org Chem*. **2012.** 77: 4375 - 4384.

29. Calixarenes: Versatile molecules as molecular sensors for ion recognition study. Patra, S; Maity, D; Gunupuru, R; Agnihotri, P; Paul, P. *J Chem Sci*. **2012**. 124: 1287 – 1299.

30. Calix receptor edifice; Scrupulous turn off fluorescent sensor for Fe(III), Co(II) and Cu(II). Bhatt, KD; Gupte, HS; Makwana, BA.; Maity, D; Jain VK. *J Fluoresc*. **2012.** 22: 1493 - 1500.

31. Calix[4]arene based fluorescent chemosensor bearing coumarin as fluorogenic unit: Synthesis, characterization, ion-binding property and molecular modeling. Patra, S; Rabindranath L; Chakraborty, A; Gunupuru, R; Maity, D; Ganguly, B; Paul, P. *Polyhedron.* 2013. 50: 592 - 601.

32. Can surface energy be a parameter to define morphological change of rock-salt crystals with additives? A first principles study. Khan, MAS; Ganguly, B. *Cryst Eng Comm*. **2013.** 15: 2631 – 2639.

33. Carbon dioxide - A potential raw material for the production of fuel, fuel additives and bio-derived chemicals. Sankaranarayanan, S; Srinivasan, K. *Indian J Chem A.* **2012.** 51: 1252 – 1262.

34. Carboxymethyl Tamarind-g-poly(acrylamide)/Silica: A high performance hybrid nanocomposite for adsorption of Methylene blue dye. Pal, S; Ghorai, S; Das, C; Samrat, S; Ghosh, A; Panda, AB. *Ind Eng Chem Res*. **2012**. 51: 15546 – 15556.

35. Clean synthesis of crystalline p-nitrobenzyl bromide from p-nitrotoluene with zero organic discharge. Dinda, M Agrawal, MK.; Gandhi, MR.; Upadhyay, SC.; Adimurthy, S; Chakraborty, S; Ghosh, PK. *RSC Adv*. **2012.** 2: 6645 - 6649.

36. Cloning and transcript analysis of type 2 metallothionein gene (SbMT-2) from extreme halophyte *Salicornia brachiata* and its heterologous expression in *E. coli*. Chaturvedi, A K; Mishra, A; Tiwari, V; Jha, B. *Gene*. **2012.** 499: 280 - 287.

37. CO_2 and N-2 adsorption in alkali metal ion exchanged X-Faujasite: Grand canonical monte carlo simulation and equilibrium adsorption studies. Pillai, RS; Peter, SA; Jasra, RV. *Micropor Mesopor Mat*. **2012.** 162: 143 -151.

38. Comparative molecular analysis of chemolithoautotrophic bacterial diversity and community structure from coastal saline soils, Gujarat, India. Yousuf, B; Sanadhya, P; Keshri, J; Jha, B. *Bmc Microbiol*. **2012.** 12. Article Number: 150.

39. Comparative study of the hydrolysis of different oils by lipase-immobilized membranes. Gupta, S; Ingole, P; Singh, K; Bhattacharya, A. *J Appl Polym Sci.* **2012.** 124. 1: E17 - E26.

40. Controlled growth of polyaniline fractals on HOPG through potentiodynamic electropolymerization. Bhattacharjya, D; Mukhopadhyay, I. *Langmuir*. **2012.** 28: 5893 - 5899.

41. Copper(0)-catalyzed aerobic oxidative synthesis of imines from amines under solvent-free conditions. Patil, RD.; Adimurthy, S. *RSC Adv*. **2012.** 2: 5119 - 5122.

42. Co(II)/Zn(II) Coordination Polymers with Angular Dicarboxylate and Flexible N-Donor Struts: Structural and Photoluminescence Studies; Bisht, KK; Suresh, E. *Cryts Growth Des.* **2013.** 13: 664 - 670.

43. Deposition and optoelectronic properties of ITO (In2O3:Sn) thin films by Jet nebulizer spray (JNS) pyrolysis technique. Sethupathi, N; Thirunavukkarasu, P; Vidhya, VS; Thangamuthu, R; Kiruthika, GVM; Perumal, K; Bajaj, HC; Jayachandran, M. *J Mater Sci-Mater El.* **2012.** 23: 1087 - 1093.

44. Designing of nitrile hydratase from alkaline protease using quanidine hydrochloride and cobalt metal ion. Kannan, K; Jasra, RV. *Catal Today*. **2012**. 198: 353 – 358.

45. Detection of epigenetic variations in the protoplast-derived germlings of *Ulva reticulata* using methylation sensitive amplification polymorphism (MSAP). Gupta, V; Bijo, AJ; Kumar, M; Reddy, CRK; Jha, B. *Mar Biotechnol.* **2012.** 14: 692 - 700.

46. Detection of ionic liquid stable cellulase produced by the marine bacterium *Pseudoalteromonas sp*. isolated from brown alga *Sargassum polycystum* C. Agardh. Trivedi, N; Gupta, V; Reddy, CRK; Jha, B. *Bioresource Technol.* **2013.** 132: 313 – 319.

47. Dimeric Copper(II) bis-chelate paddle wheel complex and its bipyridine/phenanthroline products. Mosae Selvakumar, P; Nadella, S; Sahoo, J; Suresh, E; Subramanian, PS. *J. Coord Chem*. **2013**. 66: 287 - 299.

48. Dye immobilized mesoporous silica thin films as optical pH sensor. Chauhan, SS; Jasra, R V; Sharma, AL. *Int J Nanosci*. **2012.** 11: 120001-1-120001-5.

49. DNA binding, antioxidant activity, and DNA damage protection of Chiral macrocyclic Mn(III) Salen Complexes. Pandya, N; Khan, NH.; Prathap, KJ; Kureshy, RI; Abdi, SHR; Mishra, S; Bajaj, HC. *Chirality*. **2012.** 24: 1063 –1073.

50. Efficacy of carbenes for CO_2 chemical fixation and activation by their superbasicity/alcohol: A DFT study. Lo, R; Ganguly, B. *New J Chem*. **2012**. 36: 2549 -2554.

51. Effects of metal alkoxides on electro-assisted water dissociation across bipolar membranes. Rajesh, AM; Chakrabarty, T; Prakash, S; Shahi, VK. *Electrochim Acta*. **2012.** 66: 325 - 331.

52. Efficient removal of Brilliant Blue G (BBG) from aqueous solutions by marine *Aspergillus wentii*: Kinetics, equilibrium and process design. Khambhaty, Y; Mody, K; Basha, S. *Ecol Eng*. **2012.** 41: 74 - 83.

53. Estimation of lipid hydroperoxide levels in tropical marine macroalgae. Puja K; Singh, R P; Bijo, AJ; Reddy, CRK; Jha B. *J Phycol.* **2012**. 48: 1362 - 1373.

54. Energetics of ortho-7 (Oxime Drug) translocation through the active-site gorge of tabun conjugated acetylcholinesterase. Sinha, V; Ganguly, B; Bandyopadhyay, T. *Plos One*. **2012.** 7. Article Number: e40188.

55. End group cross-linked 2-(dimethylamino) ethylmethacrylate based anion exchange membrane for electrodialysis. Chakrabarty, T; Prakash, S; Shahi, VK. *J Membrane Sci*. **2013.** 428: 86 – 94.

56. Esterification of Caprylic acid with alcohol over nano-crystalline sulfated Zirconia. Saravanan, K; Tyagi, B; Bajaj, HC. *J Sol-Gel Sci Techn*. **2012.** 62: 13 - 17.

57. Exploring supramolecular interactions between inorganic tetrachlorometallate and organic pyridinium dication: Synthesis, characterization and structural investigations. Bisht, KK; Kathalikkattil, AC; Eringathodi, S. *J Mol Struct*. **2012.** 1013: 102 - 110.

58. Fabrication of catalytically active nanocrystalline samarium (Sm)-doped cerium oxide (CeO_2) thin films using electron beam evaporation. Kundu, S; Sutradhar, N; Thangamuthu, R; Subramanian, B; Panda, AB; Jayachandran, M. *J Nanopart Res*. **2012.** 14. Article Number: 1040.

59. Fatty acid profiling of tropical marine macroalgae: an analysis from chemotaxonomic and nutritional perspectives. Kumari, P; Bijo, AJ; Mantri, VA; Reddy, CRK; Jha, B. *Phytochem.* **2013.** 86: 44 – 56.

60. Formation and characterization of onion shaped carbon soot from plastic wastes. Sawant, SY; Somani, RS; Panda, AB; Bajaj, HC. *Mater. Lett.* **2013.** 94: 132 – 135.

61. Free-flowing, transparent gamma-alumina nanoparticles synthesized by a supersonic thermal plasma expansion process. Bora, B; Aomoa, N; Bordoloi, RK; Srivastava, DN; Bhuyan, H; Das, AK; Kakati, M. *Curr Appl Phys*. **2012.** 12: 880 - 884.

62. Functional modification of agarose: A facile synthesis of an agarose-saccharate derivative. Chhatbar, MU; Godiya, CB; Siddhanta, AK. *Carbohyd Polym*. **2012.** 88: 1118 - 1123.

63. Generation and trapping of a cage annulated vinylidenecarbene and approaches to its cycloalkyne isomer. Sahu, B; Gururaja, GN; Kumar, T; Chatterjee, A; Ganguly, B; Mobin, SM; Namboothiri, N. *J Org Chem*.**2012.** 77: 6998 - 7004.

64. Grand canonical Monte Carlo simulation and volumetric equilibrium studies for adsorption of Nitrogen, oxygen, and argon in Cadmium (II) exchanged Zeolite A. Pillai, RS; Sebastian, J; Jasra, RVir. *J Porous Mat*. **2012.** 19: 683 - 693.

65. H-beta-Zeolite-Catalysed hydroarylation of styrenes. Mohan, DC; Patil, RD.; Adimurthy, S. *Eur J Org Chem*. **2012.** 2012. 18: 3520 - 3525.

66. Highly selective rapid synthesis of flavanone over porous Cs-MgO nanoflakes. Pal, P; Pahari, SK; Sinhamahapatra, A; Giri, AK; Bajaj, HC; Panda, AB. *RSC Adv.* **2013.** 3: 2802 - 2811.

67. Hydrogen sorption in transition metal exchanged zeolite Y: volumetric measurements and simulation study. Raj, MC; Prasanth, KP; Dangi, GP; Bajaj, HC. *J Porous Mat.* **2012.** 19: 657 - 666.

68. Immobilized dimeric chiral Mn(III) salen complex on short channel ordered mesoporous silica as an effective catalyst for the epoxidation of non-functionalized alkenes. Roy, T; Kureshy, Ra I.; Khan, NH; Abdi, SHR; Sadhukhan, A; Bajaj, HC. *Tetrahedron*. **2012.** 68: 6314 - 6322.

69. Improved salinity tolerance of *Arachis hypogaea* (L.) by the interaction of halotolerant plant-growth-promoting Rhizobacteria. Shukla, PS; Agarwal, PK; Jha, B. *J Plant Growth Regul*. **2012**. 31: 195 - 206.

70. Influence of film thickness on the structure and properties of PDMS membrane. Jadav, GL; Aswal, VK; Bhatt, H; Chaudhary, JC; Singh, PS. *J Membrane Sci*. **2012.** 415: 624 - 634.

71. In silico studies toward the recognition of fluoride ion by substituted borazines. Kesharwani, MK; Ganguly, B. *J Mol Graph Model*. **2012**. 38: 363 – 368.

72. Interfacial and film-formation behaviour of photoactive RuII-Bipyridyl-based metallosurfactants and a rare example of a monolayer-based logic-gate approach. Mahato, P; Saha, S; Choudhury, S; Das, A. *Chem Plus Chem*. **2012**. 77:1096 - 1105.

73. Investigation of polyelectrolyte for electrochemical detection of uric acid in presence of ascorbic acid. Prakash, S; Chakrabarty, Tina; Rajesh, AM; Shahi, VK. *Measurement*. **2012.** 45: 500 - 506.

74. Investigation of solid supported dendrimers for water disinfection. Gangadharan, D; Dhandhala, N; Dixit, D; Thakur, RS; Popat, KM; Anand, PS. *J Appl Polym Sci*. **2012.** 124: 1384 – 1391.

75. Ionic liquid-assisted preparation of ZnO nanostructures. Singh, T; Trivedi, TJ; Kumar, A. *Nanomat Energy*. **2012**. 1: 207 - 215.

76. Ionic liquids induced structural changes of bovine serum albumin in aqueous media: A detailed physicochemical and spectroscopic study. Singh, T; Bharmoria, P; Morikawa, M; Kimizuka, N; Kumar, A. *J Phys Chem B*. **2012.** 116: 11924 - 11935.

77. Is dual morphology of rock-salt crystals possible with a single additive? The answer is yes, with barbituric Acid. Sen, A; Ganguly, B. *Angew Chem Int Edit.* **2012.** 51: 45: 11279 - 11283.

78. $KHSO_4$-catalyzed synthesis of 1,1 '-oxybis(2-bromoethane-1,1-diyl)dibenzenes and 1-(1-(benzyloxy)-2-bromoethyl)benzenes under solvent-free conditions. Joshi, G; Suresh, E; Subbarayappa, A. *Synthetic Commun.* **2013**. 43: 587 - 599.

79. Lanthanide(III) complexes of Bis-semicarbazone and Bis-imine-Substituted phenanthroline ligands: Solid-State structures, photophysical properties, and anion sensing. Nadella, S; Selvakumar, PM; Suresh, E; Subramanian, PS; Albrecht, M; Giese, M; Frohlich, R. *Chem-A Euro J*. **2012**. 18: 16784 – 16792.

80. Layered inorganic nanocomposites: A promising carrier for 5-fluorouracil (5-FU). Kevadiya, BD.; Patel, TA.; Jhala, DD.; Thumbar, RP.; Brahmbhatt, H; Pandya, MP; Rajkumar, S; Jena, PK; Joshi, GV.; Gadhia, PK; Tripathi, CB; Bajaj, HC. *Eur J Pharm Biopharm.* **2012.** 81: 91 - 101.

81. Luminescent metalloreceptors with pendant macrocyclic ionophores with NS_2O_3 donor sites: Synthesis, characterization and ion-binding property. Boricha, VP; Patra, S; Parihar, S; Chouhan, YS; Paul, P. *Polyhedron*. **2012.** 43: 104 - 113.

82. Mesoporous borated Zirconia: A solid Acid-Base bifunctional catalyst. Sinhamahapatra, A; Pal, P; Tarafdar, A; Bajaj, HC; Panda, AB. *Chemcatchem*. **2013**. 5: 331 – 338.

83. Microwave assisted isomerization of alkenyl aromatics over solid base catalysts: An understanding through theoretical study. Jinesh, CM; Sen, A; Ganguly, B; Kannan, S. *RSC Adv.* **2012.** 2: 6871 - 6878.

84. Microbial population index and community structure in saline-alkaline soil using gene targeted metagenomics. Keshri, J; Mishra, A; Jha, B. *Microbiol Res.* **2013.** 168: 165 – 173.

85. Mixed ligand Copper(II) complexes of N,N-Bis(benzimidazol-2-ylmethyl)amine (BBA) with diimine Co-Ligands: Efficient chemical nuclease and protease activities and cytotoxicity. Loganathan, R; Ramakrishnan, S; Suresh, E; Riyasdeen, A; Akbarsha, M A; Palaniandavar, M. *Inorg Chem*. **2012.** 51: 5512 - 5532.

86. Mixed metal nanoparticles loaded catalytic polymer membrane for solvent free selective oxidation of benzyl alcohol to benzaldehyde in a reactor. Prakash, S; Charan, C; Singh, A K; Shahi, VK. *Appl Catal B: Environ*. 2013. 132 – 133: 62 – 69.

87. Modified asymmetric strecker reaction of aldehyde with secondary amine: A protocol for the synthesis of S-Clopidogrel (An antiplatelet agent). Sadhukhan, A; Saravanan, S; Khan, NH; Kureshy, RI; Abdi, SHR.; Bajaj, HC. *J Org Chem*. **2012.** 77: 7076 – 7080.

88. Molecular characterization of intra-population variability of *Jatropha curcas* L. using DNA based molecular markers. Mastan, SG; Sudheer, Pamidimarri DVN; Rahman, H; Ghosh, A; Rathore, MS; Prakash, RCh; Chikara, J. *Mol Biol Rep*. **2012.** 39: 4383 - 4390.

89. Montmorillonite/poly-(epsilon-caprolactone) composites as versatile layered material: Reservoirs for anticancer drug and controlled release property. Kevadiya, BD; Thumbar, RP.; Rajput, MM; Rajkumar, S; Brahmbhatt H; Joshi, GV; Dangi, GP; Mody, HM; Gadhia, PK; Bajaj, HC. *Eur J Pharm Sci*. **2012.** 47: 265 - 272.

90. Nanosized sulfated Zinc Ferrite as catalyst for the synthesis of Nopol and other fine chemicals. Jadhav, SV; Jinka, KM; Bajaj, HC. *Catal Today*. **2012**. 198: 98 - 1 05.

91. NaOH-Catalyzed imine synthesis: Aerobic oxidative coupling of alcohols and amines. Donthiri, RR; Patil, RD.; Adimurthy, S. *Eur J Org Chem*. **2012.** 2012: 4457 - 4460.

92. New chemodosimetric reagents as ratiometric probes for cysteine and homocysteine and possible detection in living cells and in blood plasma. Das, P; Mandal, AKumar; Chandar, NB; Baidya, M; Bhatt, HB.; Ganguly, Bt; Ghosh, SK; Das, A. *Chem Eur J*. **2012**. 18: 15382 – 15393.

93. Newly designed resorcinolate binding for Ru(II)- and Re(I)- Polypyridyl complexes on Oleic Acid capped TiO_2 in nonaqueous solvent: Prolonged charge separation and substantial

thermalized (MLCT)-M-3 injection. Banerjee, T; Kaniyankandy, Sh; Das, A; Ghosh, HN. *J Phys Chem C*. **2013.** 117: 3084 – 3092.

94. Non-ionic surfactant mediated preparation of kappa-carrageenan/calcium carbonate biocomposite. Kumar, S; Prasad, K; Siddhanta, AK. *Indian J Chem A*. **2012.** 51: 1085 - 1089.

95. Novel biodegradable nanocomposite based on XG-g-PAM/SiO_2: Application of an efficient adsorbent for Pb2+ ions from aqueous solution. Ghorai, S; Sinhamahpatra, A; Sarkar, A; Panda, ABaran; Pal, S. *Bioresource Technol*. **2012**. 119: 181 - 190.

96. Oligosaccharide mass profiling of nutritionally important Salicornia brachiata, an extreme halophyte. Mishra, A; Joshi, M; Jha, B. *Carbohyd Poly*. **2013.** 92: 1942 - 1945.

97. One-pot synthesis of fluorescent polysaccharides: Adenine grafted agarose and carrageenan. Oza, Mihir D; Prasad, K Siddhanta, AK. *Carbohyd Res*. **2012.** 357: 23 - 31.

98. Operando DRIFT spectroscopy on unprecedented influence of Cu2+ over NiAl LDHs for isomerization of eugenol. Jinesh, CM; Badari, CA; Lonyi, F; Kannan, S. *Catal Commun*. **2012.** 28: 100 – 104.

99. Optical analysis of a photovoltaic V-trough system installed in Western India. Maiti, S; Sarmah, N; Bapat, P; Mallick, TK. *Appl. Optics*. **2012**. 51: 8606 – 8614.

100. Optical resolution of racemic lysine monohydrochloride by novel enantioselective thin film composite membrane. Ingole, PG; Bajaj, HC; Singh, K. *Desalination*. **2012**. 305: 54 – 63.

101. Origins of reversing diastereoselectivity of alpha,beta-dichloro-gamma-butenolides and gamma-butyrolactams in direct vinylogous aldol addition: A computational study. Khan, MAS; Zhang, J; Das SK; Gangli, B. *RSC Adv*. **2012.** 2: 8460 – 8466.

102. Oxidative esterification of benzaldehyde and deactivated aromatic aldehydes with n-bromosuccinimide-pyridine. Agrawal, MK; Adimurthy,S; Ghosh, PK. *Synthetic Commun*. **2012.** 42: 2931 - 2936.

103. Palladium catalyzed reaction of ortho-functionalized aryl iodides with bicyclic hydrazines: facile route toward heteroannulated cyclopentenes and azabicycles. John, J; Rajan, R; Chand, SS; Prakash, P; Joseph, N; Suresh, E; Radhakrishnan, KV. *Tetrahedron*. **2013**. 69: 152 - 159.

104. Peroxidase-like activity and amperometric sensing of hydrogen peroxide by Fe2O3 and Prussian Blue-modified Fe_2O_3 nanoparticles. Dutta, AK; Maji, SK; Srivastava, DN.; Mondal, A; Biswas, P; Paul, P; Adhikary, B. *J Mol Catal A-Chem*. **2012.** 360: 71 - 77.

105. Peroxidase-like behavior, amperometric biosensing of hydrogen peroxide and photocatalytic activity by Cadmium Sulfide nanoparticles. Maji, SK; Dutta, AK; Srivastava, DN.; Paul, P; Mondal, A; Adhikary, B. *J Mol Catal A-Chem*. **2012.** 358: 1 - 9.

106. Phenol red dye functionalized nanostructured silica films as optical filters and pH sensors. Chauhan, SS; Jasra, RV.; Sharma, AL. *Ind Eng Chem Res*. **2012.** 51: 10381 - 10389.

107. Photosensitization of nanoparticulate TiO_2 using a Re(I)-polypyridyl complex: Studies on interfacial electron transfer in the ultrafast time domain. Kar, Pt; Banerjee, T; Verma, S; Sen, A; Das, A; Ganguli, B; Ghosh, HN. *Phys Chem Chem Phys*. **2012.** 14: 8192 - 8198.

108. Physicochemical characterization of biosurfactant and its potential to remove oil from soil and cotton cloth. Jain, RM; Mody, K; Mishra, A; Jha, B. *Carbohyd Polym*. **2012.** 89: 1110 1116.

109. Polymer thin films embedded with metal nanoparticles for electrochemical biosensors applications. Prakash, S; Chakrabarty, T; Singh, AK; Shahi, VK. *Biosens Bioelectron*. **2013.** 41: 43 - 53.

110. Porous Cesium impregnated MgO (Cs-MgO) nanoflakes with excellent catalytic activity for highly selective rapid synthesis of flavanone. Pal, P; Pahari, SK; Sinhamahapatra, A; Bajaj, HC; Panda, AB. *RSC Adv.* **2013.** 3: 2802 – 2811.

111. Porous ZnO microtubes with excellent cholesterol sensing and catalytic properties. Giri, AK; Sinhamahapatra, A; Prakash, S; Chaudhari, J; Shahi, VK; Panda, AB. *J Mater Chem A*. **2013.** 1: 814 - 822.

112. Preparation, characterization and application of beta-cyclodextrin-glutaraldehyde crosslinked membrane for the enantiomeric separation of amino acids. Singh, K; Ingole, P G; Bajaj, HC; Gupta, H. *Desalination*. **2012**. 298: 13 – 21.

113. Preparation and characterization of graphene and Ni-decorated graphene using flower petals as the precursor material. Ray, AK; Sahu, RK; Rajinikanth, V; Bapan, H; Ghosh, M; Paul, P. *Carbon*. **2012.** 50: 4123 - 4129.

114. Preparation and performance evaluation of enantioselective polymer composite materials. Ingole, PG; Bajaj, HC; Singh, K. *RSC Adv.* **2013**. 3: 3667 – 3676.

115. Preparation of polysulfone-polyamide thin film composite hollow fiber nanofiltration membranes and their performance in the treatment of aqueous dye solutions. Maurya, SK; Parashuram, K; Singh, PS; Ray, P; Reddy, AVR. *Desalination*. **2012.** 304: 11 - 19.

116. Probing the simulant behavior of PNPDPP toward parathion and paraoxon: A computational study. Khan, MAS; Bandyopadhyay, T; Ganguly, B. *J Mol Graph Model*. **2012.** 34: 10 - 17.

117. Properties and applications of Poly(dimethylsiloxane) containing Poly(meth)acrylate-based thermoplastic elastomer/clay nanocomposites. Muppalla, R; Jewrajka, SK. *Ind Eng Chem Res*. **2012**. 51: 15942 – 15952.

118. Proteome profiling of seed storage proteins reveals the nutritional potential of *Salicornia brachiata* Roxb., an extreme halophyte. Jha, B; Singh, NPal; Mishra, A. *J Agr Food Chem.* **2012.** 60: 4320 - 4326.

119. Purification and characterization of exo-β-agarase from an endophytic marine bacterium and its catalytic potential in bioconversion of red algal cell wall polysaccharides into galactans. Gupta, V; Trivedi, N; Kumar, M; Reddy, CRK; Jha, B. *Biomass Bioenerg.* **2013**. 49: 290 - 298.

120. Purification and characterization of haloalkaline thermoactive, solvent stable and SDS-induced protease from *Bacillus sp.*: A potential additive for laundry detergents. Jain, D; Pancha, I; Mishra, SK; Shrivastava, A; Mishra, S. *Bioresource Technol*. **2012.** 115: 228 - 236.

121. Quorum sensing inhibition by *Asparagopsis taxiformis*, a marine macro alga: Separation of the compound that interrupts bacterial communication. Jha, B; Kavita, K; Westphal, J; Hartmann, A; Schmitt-Kopplin, P. *Marine Drugs*. **2013.** 11: 253 - 265.

122. Rare example of TICT based optical responses for the specific recognition of Cr3+ by a 2,2 ':6 ',2 "-Terpyridine derivative and demonstration of multiple logic operations. Mahato, P; Saha, S; Das, A. *J Phys Chem C*. **2012.** 116: 17448 - 17457.

123. Rational design of a new class of polycyclic organic bases bearing two superbasic sites and their applications in the CO_2 capture and activation process. Lo, R; Singh, A; Kesharwani, MK; Ganguly, B. *Chem Commun*. **2012.** 48: 5865 -5867.

124. Recognition of Hg2+ Ion through restricted imine isomerization: Crystallographic evidence and imaging in live cells. Mandal, AK; Suresh, M; Das, P; Suresh, E; Baidya, M; Ghosh, SK; Das, A. *Org Lett*. **2012.** 14: 2980 - 2983.

125. Recyclable Cu(II)-macrocyclic salen complexes catalyzed nitroaldol reaction of aldehydes: A practical strategy in the preparation of (R)-phenylephrine. Kureshy, RI; Dangi, B; Das, A; Khan, NH; Abdi, SHR; Bajaj, HC. *Appl Catal A-Gen*. **2012.** 439: 74 - 79.

126. Rejuvenation of discarded RO membrane for new applications. Raval, HD.; Chauhan, VR.; Raval, AH; Mishra, S. *Desalin Water Treat.* **2012**. 48: 349 - 359.

127. Rhodium complex encapsulated functionalized hexagonal mesoporous silica for heterogeneous hydroaminomethylation. Sudheesh, N; Shukla, RS. *Applied Catal. A Gen.* **2013.** 453: 159 - 166.

128. Room temperature Baeyer-Villiger oxidation using molecular oxygen over mesoporous Zirconium phosphate. Sinhamahapatra, A; Sinha, A; Pahari, SK; Sutradhar, N; Bajaj, HC; Panda, AB. *Catal Sci Technol.* **2012.** 2: 2375 – 2382.

129. Seaweed sap as an alternative liquid fertilizer for yield and quality improvement of wheat. Shah, MT; Zodape, ST; Chaudhary, DR; Eswaran, K; Chikara, J. *J Plant Nutr*. **2013.** 36: 192 - 200.

130. Self-assembled nanofiltration membrane containing antimicrobial organo silica prepared by sol–gel process. Singh, AK; Thakur, AK; Shahi, VK. *Desalination.* 2013. 309: 275 – 283.

131. Self-assembly of modified Rhodamine-6G with tri-block copolymer: unusual vesicle formation, pH sensing and dye release properties. Praveen, L; Saha, S; Jewrajka, SK; Das, A. *J Mater Chem B*. **2013**. 1: 1150 - 1155.

132. Self-assembled silica nanocrystal-based anti-biofouling nanofilter membranes. Singh, AK; Pandey, RP; Jasti, A; Shahi, VK. *RSC Adv*. **2013.** 3: 458 - 467.

133. Sequential energy and electron transfer in polynuclear complex sensitized TiO_2 nanoparticles. Verma, S; Kar, P; Banerjee, T; Das, A; Ghosh, HN. *J Phys Chem Lett*. **2012.** 3: 1543 - 1548.

134. Silver nanoparticles built-in chitosan modified glassy carbon electrode for anodic stripping analysis of As(III) and its removal from water. Prakash, S; Chakrabarty, T; Singh, AK; Shahi, VK. *Electrochim Acta*. **2012.** 72: 157 - 164.

135. Single pot synthesis of pyridine-N-oxide based polymeric complexes of cadmium and manganese: Crystal structure and luminescence property. Mondal, S; Guha, A; Suresh, E; Jana, AD; Banerjee, A. *J Mol Stru*. 1029: 169 – 174.

136. Single-source precursor approach for the preparation of CdS nanoparticles and their photocatalytic and intrinsic peroxidase like activity. Maji, SK; Dutta, AK; Dutta, S; Srivastava, DN; Paul, P; Mondal, A; Adhikary, B. *Appl Catal B-Environ.* **2012.** 126: 265 - 274.

137. Sorption of Carbon Dioxide, Methane, Nitrogen and Carbon Monoxide on MIL-101(Cr): Volumetric measurements and dynamic adsorption studies. Munusamy, K; Sethia, G; Patil, DV; Phani BSR; Somani, RS; Bajaj, HC. *Chem Eng J*. **2012.** 195: 359 - 368.

138. Spontaneous resolution of a Mixed-Ligand Nickel(II) coordination polymer with achiral precursors. Bisht, KK; Suresh, E. *Inorg Chem.* **2012.** 51: 9577 - 9579.

139. Stable and hydroxide ion conductive membranes for fuel cell applications: Chloromethyaltion and amination of poly(ether ether ketone). Jasti, A; Prakash, S; Shahi, VK. *J Membrane Sci*. **2013.** 428: 470 – 479.

140. Structure modulation, argentophilic interactions and photoluminescence properties of silver(I) coordination polymers with isomeric N-donor ligands. Bisht, KK; Kathalikkattil, AC; Suresh, E. *RSC Adv*. **2012.** 2: 8421 - 8428.

141. Structure-performance-fouling studies of polysulfone microfiltration hollow fibre membranes. Singh, PS; Parashuram, K; Maurya, S; Ray, P; Reddy, AVR. *B Mater Sci.* **2012.** 35: 817 - 822.

142. Studies on the effects of salt and surfactant in wet phase separation of polysulfone. Sharma, S; Dhandhala, N; Bhattacharya, A. *J Macromol Sci A.* **2012**. 49: 918 – 925.

143. Sulfated Zirconia: An efficient solid acid catalyst for esterification of myristic acid with short chain alcohols. Saravanan, K; Tyagi, B; Bajaj, HC. *Catal Sci Technol*. **2012**. 2: 2512 – 2520.

144. Synchrotron SAXS to probe cross-linked network of polyamide 'reverse osmosis' and 'nanofiltration' membranes. Singh, PS; Ray, P; Xie, Z; Hoang, M. *J Membrane Sci*. **2012.** 421: 51 - 59.

145. Synthesis, spectrochemical characterisation and catalytic activity of transition metal complexes derived from Schiff base modified Chitosan. Antony, R; David, ST; Saravanan, K; Karuppasamy, K; Balakumar, S. *Spectrochimica Acta A*. **2013**. 103: 423 - 430.

146. Synthesis of Imidazo [1, 2-a] pyridines: "Water-Mediated" Hydroamination and Silver-Catalyzed Aminooxygenation. Mohan, DC; Rao, SN; Adimurthy, S. *J Org Chem.* **2013**. 78: 1266 – 1272.

147. Synthesis of FeS and FeSe nanoparticles from a single source precursor: A study of their photocatalytic activity, peroxidase-like behavior, and electrochemical sensing of H_2O_2. Dutta, AK; Maji, SK; Srivastava, DN.; Mondal, A; Biswas. P; Paul, P; Adhikary, B. *Acs Appl Mater Inter*. **2012.** 4: 1919 - 1927.

148. Synthesis, crystal structures and competitive binding property of a family of functionalized calix[4]arene ionophores. Ramakrishna, V; Patra, S; Suresh, E; Bhatt, AK; Bhatt, PA; Hussain, A; Paul, P. *Inorg Chem Commun*. **2012.** 22: 85 - 89.

149. Synthesis and characterization of a novel polymeric hydrogel based on hydroxypropyl methyl cellulose grafted with polyacrylamide. Das, R; Panda, AB; Pal, S. *Cellulose*. **2012**. 19: 933 – 945.

150. Tailoring the molecular weight cut off values of polyacrylonitrile based hollow fibre ultrafiltration membranes with improved fouling resistance by chemical modification. Parashuram, K; Maurya, SK; Rana, HH; Singh, PS; Ray, P; Reddy, AVR. *J. Membrane. Sci.* **2013.** 425 – 426: 251 – 261.

151. Temperature invariance of NaCl solubility in water: inferences from salt-water cluster behavior of NaCl, KCl, and NH_4Cl. Bharmoria, P; Gupta, H; Mohandas, VP; Ghosh, PK.; Kumar, A. *J Phys Chem B*. **2012.** 116: 11712 - 11719.

152. Template free synthesis of mesoporous hectorites: Efficient host for pH responsive drug delivery. Pawar, RR; Kevadiya, BD; Brahmbhatt, H; Bajaj, HC. *Int J Pharmaceut.* **2013**. 446: 145 – 152.

153. The first bromide ion directed double helicate and its role in catalysis. Selvakumar, PM.; Jebaraj, PY; Sahoo, J; Suresh, E; Jaya PK; Kureshy, RI; Subramanian, PS. *RSC Advances*. **2012**. 2: 7689 – 7692.

154. The roots of the halophyte *Salicornia brachiata* are a source of new halotolerant diazotrophic bacteria with plant growth-promoting potential. Jha, B; Gontia, I; Hartmann, A. *Plant Soil*. **2012.** 356: 265 - 277.

155. The *SbSOS1* gene from the extreme halophyte *Salicornia brachiata* enhances Na^+ loading in xylem and confers salt tolerance in transgenic tobacco. Yadav, NS; Shukla, PS; Jha, A; Agarwal, PK; Jha, B. *BMC Plant Biol.* **2012.** 12: 188 – 205.

156. The sbasr-1 gene cloned from an extreme halophyte *Salicornia brachiata* enhances salt tolerance in transgenic tobacco. Jha, B; Lal, S; Tiwari, V; Yadav, SK; Agarwal, PK. *Mar Biotechnol*. **2012.** 14: 782 - 792.

157. Thidiazuron (TDZ) induced plant regeneration from cotyledonary petiole explants of elite genotypes of *Jatropha curcas*: A candidate biodiesel plant. Kumar, N; Reddy, MP. *Ind Crop Prod*. **2012.** 39: 62 - 68.

158. Titanium complexes of chiral amino alcohol derived Schiff bases as efficient catalysts in asymmetric oxidation of prochiral sulfides with hydrogen peroxide as an oxidant. Bera, PK; Ghosh, D; Abdi, SHR; Khan, NH; Kureshy, RI; Bajaj, HC. *J Mol Catal A-Chem*. **2012.** 361: 36 - 44.

159. Transesterification of edible, non-edible and used cooking oils for biodiesel production using calcined layered double hydroxides as reusable base catalysts. Sankaranarayanan, S; Antonyraj, CA; Kannan, S. *Bioresource Technol*. **2012.** 109: 57 – 62.

160. Visible-light-driven synthesis of 2-substituted benzothiazoles using CdS nanosphere as heterogenous recyclable catalyst. Das, S; Samanta, S; Maji, SK; Samanta, PK; Dutta, AK; Srivastava, DN; Adhikary, B; Biswas, P. *Tetrahedron Lett*. **2013.** 54: 1090 - 1096.

161. Zirconium tri-ethylene tetra-amine ligand-chelator complex based cross-linked membrane for selective recovery of Cu2+ by electrodialysis. Chakrabarty, T; Shah, B; Srivastava, N; Shahi, VK; Chudasama, U. *J Membrane Sci*. **2013.** 428: 462 – 469.

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1. (3-glycidoxypropyl) Trimethoxy Silane induced switchable zwitterionic membrane with high protein capture and separation properties. Chakrabarty, T; Shahi, VK. *J Membrane* Sci. **2013**. 444: 77 – 86.

2. A facile one-pot synthesis of a fluorescent agarose-*O*-naphthylacetyl adduct with slow release properties. Kondaveeti, S; Chejara, DR; Siddhanta, AK. *Carbohyd Polym*. **2013**. 98: 589 – 595.

3. A first principles investigation of aging processes in soman conjugated AChE. Chandar, NB; Ganguly, B. *Chem Biol Interact*. **2013**. 204: 185 – 190.

4. A new receptor with a FRET based fluorescence response for selective recognition of Fumaric and Maleic acids in aqueous medium. Reddy, UG; Lo, R; Roy, S; Banerjee, T; Ganguly, B; Das, A. *Chem Commun*. **2013**. 49: 9818 – 9820.

5. A novel amperometric biosensor for hydrogen peroxide and Glucose based on Cuprous sulfide nanoplates. Maji, SK; Dutta, AK; Bhadu, GR; Paul, P; Mondal, A; Adhikary, B. *J Mat Chem B*. **2013**.1: 4127 – 4134.

6. Aliphatic-aromatic sulphonated polyimide and acid functionalized polysilsesquioxane composite membranes for fuel cell applications. Pandey, RP; Shahi, VK. *J Mat Chem A*. **2013.** 1: 14375 – 14383.

7. An efficient method for Agrobacterium-Mediated genetic transformation and plant regeneration in Cumin (*Cuminum cyminum* L.). Pandey, S; Mishra, A; Patel, MK; Jha, B. *Appl Biochem Biotech*. **2013.**171: 1 – 9.

8. An alternative hydrolytic synthesis route for uniform metal Selenide nanoparticles. Pahari, SK; Pal, P; Saha, A; Mahanty, S; Panda, AB. *RSCADV*. **2013.** 3: 16322 – 16325.

9. An exclusive approach to 3,4-disubstituted Cyclopentenes and Alkylidene Cyclopentenes via

the Palladium catalyzed ring opening of Azabicyclic Olefins with Aryl halides. Joseph, N; Rajan, R; John, J; Devika. NV; Chand, SS; Suresh, E; Pihko, PM; Radhakrishnan, KV.*RSC Adv.* **2013.** 3: 7751 – 7757.

10. An improved protocol for electrodialytic desalination yielding mineral-balanced potable water. Thakur, AK; Srivastava, N; Chakrabarty, T; Rebary, B; Patidar, R; Sanghavi, RJ; Shahi, VK; Ghosh, PK. *Desalination.* **2014.** 335: 96 – 01.

11. Aqueous fluoride removal using ZnCr layered double hydroxides and their polymeric composites: Batch and column studies. Koilraj, P; Kannan, S. *Chem Eng J.* **2013.** 234: 406 - 415.

12. Asymmetric Aminolytic Kinetic resolution of Racemic Epoxides using recyclable Chiral Polymeric Co(III)-Salen Complexes: A protocol for total utilization of Racemic Epoxide in the synthesis of (*R*)-Naftopidil and (*S*)-Propranolol. Kumar, M; Kureshy, RI; Shah, AK; Das, A; Khan, NH; Abdi, SHR; Bajaj, HC. *J. Org. Chem.* **2013.**78: 9076 – 9084.

13. Asymmetric cyanoethoxy carbonylation reaction of aldehydes catalyzed by a TiIV macrocyclic complex: An efficient synthetic protocol for -Blocker and 1-Adrenergic receptor agonists. Sadhukhan, A; Choudhary, MK; Khan, NH; Kureshy, RI; Abdi, SH R; Bajaj, HC. *ChemCat Chem.* **2013.** 5: 1441 - 1448.

14. Asymmetric cycloaddition of CO_2 and an Epoxide using recyclable bifunctional polymeric Co(III) Salen complexes under mild conditions. Roy, T; Kureshy, RI; Khan, NH; Abdi, SHR; Bajaj, HC. *Catal Sci Technol.* **2013.**3: 2661 – 2667.

15. Asymmetric Friedel-Crafts addition of indoles to N-sulfonyl Aldimines catalyzed by Cu(II) Chiral Amino Alcohol based Schiff base complexes. Kumari, P; Bera, PK; Khan, NH; Kureshy RI; Abdi, SHR. Bajaj, HC. *Catal Sci Technol.* **2014**. 4: 563 – 568.

16. Azaindole-1,2,3-triazole conjugate as selective fluorometric sensor for dihydrogenphosphate. Ghosh, K; Kar, D; Joardar, S; Sahu, D; Ganguly, B. *RSC Adv.* **2013.** 3: 16144 – 16151.

17. Bacterial community structure in a semi-arid haloalkaline soil using culture independent method. Keshri, J; Mody, K; Jha, B. *Geomicrobiol J.* **2013.** 30: 517 – 529.

18. Beta-Cyclodextrin-mediated highly efficient [2+3] cycloaddition reactions for the synthesis of 5-substituted 1H-tetrazoles. Patil, DR; Wagh, YB; Ingole, PG; Singh, Kripal; Dalal, DS. *New J Chem.* **2013.** 37: 3261 – 3266.

19. Biamphiphilic ionic liquid induced folding alterations in the structure of bovine serum albumin in aqueous medium. Bharmoria, P; Rao, KS; Trivedi, TJ; Kumar A. *J Phys Chem B.* **2014.** 118: 115 – 124.

20. Binary co-crystals of the active pharmaceutical ingredient 1,4-bis(4-pyridyl)-2,3-diaza-1,3-butadiene and camphoric acid. Bisht, KK; Patel, P; Rachuri, Y; Suresh, E. *Acta Crystallogr B.* **2014.** 70: 63 – 71.

21. Bioaccumulation of nutrient elements from fly ash-amended soil in *Jatropha curcas* L.: A biofuel crop. Chaudhary, DR; Ghosh, A. *Environ Monit Assess*. **2013.** 185: 6705 – 6712.

22. Biodegradation of low-density polyethylene by marine bacteria from pelagic waters, Arabian Sea, India. Harshvardhan, K; Jha B. *Mar Pollut Bull*. **2013**. 77: 100 – 106.

23. Bioengineering for salinity tolerance in plants: State of the art. Agarwal, PK; Shukla, PS; Gupta, K; Jha, B. *Mol Biotechnol.* **2013.** 54:102 -123.

24. Bis-functionalization of 1,3-Dienes through 1,4-conjugate addition of Amphiphilic Bis-pi-Allyl and related Palladium intermediates. Baiju, TV; Vijayan, A; Joseph, N; Preethalayam, Pr; Radhakrishnan, KV; Suresh, E; Yamamoto, Y. *Synlett*. **2014**. 25: 359 – 364.

25. Bromide-Bromate couple of varying ratios for bromination, vicinal functionalization and oxidation in a clean manner. Adimurthy, S; Ranu, BC; Ramachandraiah, G; Ganguly, B; Ghosh, PK. *Curr Org Syn.* **2013.**10: 864 - 884.

26. Can surface energy be a parameter to define morphological change of rock-salt crystals with additives? A first principles study. Khan, MAS; Ganguly, B. *CrystEng Comm.* 2013. 15: 2631 - 2639.

27. Calix[4]arene functionalized gold nanoparticles: Application in colorimetric and electrochemical sensing of cobalt ion in organic and aqueous medium. Maity, D; Gupta, R; Gunupuru, R; Srivastava, DN; Paul, P. *Sensor Actuat B-Chem.* **2014.** 191: 757 – 764.

28. Catalytic methods for Imine syntheses. Patil, RD; Adimurthy, S. *Asian J. Org. Chem.* **2013.**2: 726 – 744.

29. Catalysis of enantioselective Strecker reaction in the synthesis of D-Homophenylalanine using recyclable, Chiral, Macrocyclic Mn^{III}–Salen complexes. Saravanan, S; Khan, NH; Bera, Prasanta K; Kureshy, RI; Abdi, SHR; Kumari, P; Bajaj, HC. *ChemCat Chem.* **2013.**5: 1374 – 1385.

30. Central metabolic processes of marine macrophytic algae revealed from NMR based metabolome analysis. Gupta, V; Thakur, RS; Reddy, CRK; Jha, B. *RSC Adv.* **2013**.3: 7037-7047.

31. CeO_2 nanowires with high aspect ratio and excellent catalytic activity for selective oxidation of Styrene by molecular Oxygen. Pal, P; Pahari, SK; Sinhamahapatra, A; Jayachandran, M; Manohar Kiruthika, GV; Bajaj, HC; Panda, AB. *RSC Adv.* **2013**.3: 10837 –10847.

32. Characterisation and anti-biofilm activity of extracellular polymeric substances from *Oceanobacillus iheyensis*. Kavita, K; Singh, VK; Mishra, A; Jha, B. *Carbohyd Polym.* **2014.**101: 29 – 35.

33. Chiral Cu(II)-amino alcohol based complexes for asymmetric Aza-Henry reaction of N-Ts imines. Choudhary, MK; Das, A; Kureshy, RI; Kumar, M; Khan, NH; Abdi SHR; Bajaj, HC. *Catal Sci Technol.* **2014**. 4: 548 – 555.

34. Chiral recyclable Cu(II)-catalysts in Nitroaldol reaction of Aldehydes with various Nitroalkanes and its application in the synthesis of a valuable drug (R)-isoproterenol. Das, A; Kureshy, RI; Prathap, KJ; Choudhary, MK; Ganga Rao, VS; Khan, NH; Abdi, SHR; Bajaj, HC. *Appl Catal A-Gen.* **2013.** 459: 97 – 105.

35. Choline Chloride-thiourea, a deep eutectic solvent for the production of chitin nanofibers. Mukesh, C;Mondal, D;Sharma, M; Prasad, K. *Carbohyd Polym.* **2014.** 103: 466 - 471.

36. Cis-9-octadecenoic acid from the rhizospheric bacterium *Stenotrophomonas maltophilia* BJ01 shows quorum quenching and anti-biofilm activities. Singh, VK; Kavita, K; Prabhakaran, R; Jha, B. *Biofouling.* **2013.** 29: 855 – 867.

37. Complexation of Chitosan with surfactant like ionic liquids: Molecular interactions and preparation of Chitosan nanoparticles. Bharmoria, P; Singh, T; Kumar, A. *J Colloid Interf Sci.* **2013.**407: 361 – 369.

38. Conformational preference of Glycinamide in solution: An answer derived from combined experimental and computational studies. Ganguly, B; Kesharwani, MK; Basarić, N; Suresh, E; Biswas, AK; Minarić-Majerski, K. *J Mol Graph Modell.* **2013.** 46: 52 - 58.

39. Controlled-release performance of Chitosan-polyuronic acid adducts. Chhatbar, MU; Godiya, CB; Meena, R; Siddhanta, AK. *Indian J Chem A.* **2013**. 52: 1269 – 1274.

40. Copper (I) Iodide – catalyzed aerobic oxidative synthesis of Imidazo[1,2-α]pyridines from 2-Aminopyridines and Methyl Ketones. Chandra Mohan, D; Ramachandra RD; Nageswara RS; Adimurthy, S. *Adv Synth Catal.* **2013.** 355: 2217 - 2221.

41. Copper(II) complexes with 2NO and 3N donor ligands: Synthesis, structures and chemical nuclease and anticancer activities. Rajarajeswari, C; Loganathan, R; Palaniandavar, M; Suresh, E; Riyasdeen, A; Akbarsha, MA. *Dalton T.* **2013**.42: 8347 - 8363.

42. Cross-Linked Zirconium Tri-Ethylenetetramine membrane in aqueous media for selective separation of Cu^{2+}. Shah, B; Chakrabarty, T; Shahi, VK; Chudasama U. *Sep Sci Technol.* **2013.** SI. 48: 2382 – 2390.

43. Cycloaddition profile of pentafulvenes with 3-oxidopyrylium betaine: Experimental and theoretical investigations. Kuthanapillil, JM; Nijamudheen, A; Joseph, N; Prakash, P; Suresh, E; Datta, A. Radhakrishnan, KV. *Tetrahedron.* **2013.** 69: 9751 – 9760.

44. Designing a thiol specific fluorescent probe for possible use as a reagent for intracellular detection and estimation in blood serum: Kinetic analysis to probe the role of intramolecular hydrogen bonding. Das, P; Mandal, AK; Reddy, UG; Baidya, M; Ghosh, SK; Das, A. *Org Biomol Chem.* **2013.**11: 6604 – 6614.

45. Developing transgenic *Jatropha* using the SbNHX1 gene from an extreme halophyte for cultivation in saline wasteland. Jha, B; Mishra, A; Jha, A; Joshi, M. **2013.** *Plos One.* 8 Art. Num.: e71136.

46. Dextrin cross linked with poly (HEMA): A novel hydrogel for colon specific delivery of ornidazole. Das, D; Das, R; Ghosh, P; Dhara, S; Panda, AB; Pal, S. *RSC Adv.* **2013.**3: 25340 - 25350.

47. Dissolution of alpha-chitin in deep eutectic solvents. Sharma, M; Mukesh, C; Mondal, D; Prasad, K. *RSC Adv.* **2013.**3: 18149 – 18155.

48. Effective management of passive layers using composite cathodes in solid state magnesium batteries. Perween, M; Gupta, R; Rebary, B; Kulshreshtha, V; Srivastava, DN. *Phys Chem Chem Phys.* **2013.**15: 17758 – 17762.

49. Effect of Nitrate salts on solubility behavior of Calcium Sulfate Dihydrate (Gypsum) in the aqueous Sodium Chloride system and physicochemical solution properties at 308.15 K. Trivedi, TJ; Shukla, J; Kumar, A. *J Chem. Eng. Data.* **2014**. 59: 832 – 838.

50. Effect of seaweed saps on growth and yield improvement of green gram. Pramanick, B; Brahmachari, K; Ghosh, A. *African J Agric Res.* **2014.** 8: 1180 – 1186.

51. Effect of unconventional Carbon sources on biosurfactant production and its application in bioremediation. Jain, RM.; Mody, K; Joshi, N; Mishra, A; Jha, B. *Int J Biol Macromol.* **2013**. 62: 52 - 58.

52. Electrocatalytic activity of silver nanoparticles modified glassy carbon electrode as amperometric sensor for hydrogen peroxide. Maji, SK; Dutta, Amit K; Srivastava, DN.; Paul, P; Mondal, A; Adhikary, B; Adhikary, U. *J Nanosci Nanotechno.* **2013.** 13: 4969 – 4974.

53. Enhanced photocatalytic activity of bismuth-doped TiO_2 nanotubes under direct sunlight irradiation for degradation of Rhodamine B dye. Natarajan, TS; Natarajan, K; Bajaj HC; Tayade, R J. *J Nanopart Res.* **2013.**15 Art Num: 1669.

54. Enhanced photocatalytic degradation of aqueous Nitrobenzene using graphitic Carbon–TiO_2 composites. Jo, W; Won, Y; Hwang, I; Tayade, RJ. *Ind Eng Chem Res*. **2014**.53: 3455 – 3461.

55. Estimation of speed of sound in binary mixtures of Cyclohexane with Benzene, Benzaldehyde or Cyclohexylamine, and, Cyclohexylamine with Benzene in the temperature range (293.15-323.15) K employing empirical and theoretical models. Oswal, SB; Malek, NI; Ijardar, SP. *Indian J Chem A.* **2013.** 52: 492 – 497.

56. Estimation of bromide and sulphate in high purity solar salt and common table salt employing ion chromatographic technique. Rebary, B; Raichura M; Upadhyay SC; Paul, P. *J Indian Chem Soc*. **2013**. 90: 2063 – 2069.

57. Evaluation of genetic homogeneity in tissue culture regenerates of *Jatropha curcas* L. using flow cytometer and DNA-based Molecular Markers. By: Rathore, MS; Yadav, P; Mastan, SG; Prakash CR; Singh, A; Agarwal, PK. *Appl Biochem Biotechnol.* **2014.** 172: 298 -310.

58. Evaluation of Montmorillonite/Poly (L-Lactide) microcomposite spheres as ambidextrous reservoirs for controlled release of Capecitabine (Xeloda) and assessment of cell cytotoxic and oxidative stress markers. Kevadiya, BD; Chettiar,S; Rajkumar, S; Bajaj, HC; Brahmbhat, H; Chaudhary, J; Thumbar, RP; Jhala, D; Rao, MV. *Compos Sci Technol.* **2014.** 90: 193 – 201.

59. Excess molar properties for binary systems of CnMIM-BF4 ionic liquids with alkylamines in the temperature range (298.15-318.15) K. Experimental results and theoretical model calculations. Malek, NI; Ijardar, SP; Oswal, SL. *J Chem Eng Data.* **2014.** 59: 540 – 553.

60. Extracellular polymeric substances from two biofilm forming *Vibrio* species: Characterization and applications. Kavita, K; Mishra, A; Jha, B. *Carbohyd Polym.* **2013.** 94: 882 – 888.

61. Facile preparation of Agarose-chitosan hybrid materials and nanocomposite ionogels using an ionic liquid via dissolution, regeneration and sol-gel transition. Trivedi, TJ; Rao, Srinivasa K; Kumar, A. *Green Chem*. **2014**. 16: 320 – 330.

62. Facile synthesis of a new fluorogenic metal scavenging interpolymeric diamide based on cellulose and alginic acids. Sanandiya, ND; Siddhanta, AK. *Carbohyd Res.* **2013.** 381: 93 –100.

63. Fatty acids as biomarkers of microalgae. Sahu, A; Pancha, I; Jain, D; Paliwal, C; Ghosh, T; Patidar, S; Bhattacharya, S; Mishra, S. *Phytochem.* **2013.** 89: 53 – 58.

64. Fe(OH)(3) nano solid material: An efficient catalyst for regioselective ring opening of aryloxy epoxide with amines under solvent free condition. Shah, AK.; Prathap, KJ; Kumar, M; Abdi, SHR; Kureshy, RI; Khan, NH; Bajaj, HC. *Appl Catal A-Gen*. **2014**. 469: 442 – 450.

65. First demonstration of two-step FRET in a synthetic supramolecular assembly. Suresh, M; Mandal, AK; Suresh, E; Das, A. *Chem Sci.* **2013**. 4: 2380 -2386.

66. First principles studies toward the design of silylene superbases: A density functional theory study. Biswas, AKalam; Lo, R; Ganguly, B. *J Phys Chem A*. **2013.** 117: 3109 – 3117.

67. Fructose dehydration to 5-hydroxymethylfurfural: Remarkable solvent influence on recyclability of Amberlyst-15 catalyst and regeneration studies. Sampath, G; Kannan, S. **2013.** *Catal Commun.* 37: 41 – 44.

68. Fuel intermediates, agricultural nutrients and pure water from *Kappaphycus alvarezii* seaweed. Mondal, D; Sharma, M; Maiti, P; Prasad, K; Meena, R; Siddhanta, A K; Bhatt, P; Ijardar, S; Mohandas, VP; Ghosh, A; Eswaran, K; Shah, BG; Ghosh, PK. *RSC Adv.* **2013.** 3: 17989 – 17997.

69. Functional modification of agarose: A facile synthesis of a fluorescent Agarose-tryptophan based hydrogel. Kondaveeti, S; Prasad, K; Siddhanta, AK. *Carbohyd Polym.* **2013.**97: 165 – 171.

70. Functionalized chitosan based nano-filter membranes for pH-controlled separation of Amino acids. Chakrabarty, T; Thakur, AK; Shahi, VK. *Sep Purif Technol.* **2013.** 108: 57- 64.

71. Functionalized silica-chitosan hybrid membrane for dehydration of ethanol/water azeotrope: Effect of cross-linking on structure and performance. Pandey, RP; Shahi, VK. *J Membrane Sci.* **2013.** 444: 116 – 126.

72. Green synthesis of biocidal silver-activated charcoal nanocomposite for disinfecting water. Arputha K, Sherly V; Dakshinamurthy, A; Subramanian, PS; Selvakumar, PM. *J Exp Nanosci*. **2013.** 43: 1 – 13.

73. Guar gum and guar gum-oligomeric poly(vinyl alcohol) blends as novel flocculants for kaolinated waste water. Nasim, T; Panda, AB; Bandyopadhyay, A. *Int J Biol Macromol*. **2013.** 58: 140 -147.

74. H-β-Zeolite catalyzed synthesis of β-Bromostyrenes from Styrene bromohydrins. Venkatanarayana, P; Ramachandra RD; Chandra MD; Adimurthy, S. *Tetrahedron Lett*. **2014.** 55: 1793 - 1795.

75. Heterologous expression of an uncharacterized universal stress protein gene (SbUSP) from the extreme halophyte, *Salicornia brachiata*, which confers salt and osmotic tolerance to *E. coli*. Udawat, P; Mishra, A; Jha, B. *Gene.* **2014.** 536 : 163 – 170.

76. Hierarchically order porous lotus shaped nano-structured MnO_2 through $MnCO_3$: Chelate mediated growth and shape dependent improved catalytic activity. Pal, P; Pahari, SK; Giri, AK; Pal, S; Bajaj, HC.; Panda, AB. *J Mat Chem A*. **2013.** 1: 10251 – 10258.

77. Highly stable acid-base complex membrane for Ethanol dehydration by pervaporation separation. Thakur, AK; Gahlot, S; Kulshrestha, V; Shahi, VK. *RSC Adv*. **2013.** 3: 22014 – 22022.

78. Improved solubility of DNA in recyclable and reusable bio-based deep eutectic solvents with long-term structural and chemical stability. Mondal, D; Sharma, MC; Gupta, V; Prasad, K. *Chem Commun.* **2013.** 49: 9606 – 9608.

79. Inclusion complex of Isatoic anhydride with beta-cyclodextrin and supramolecular one-pot synthesis of 2, 3-dihydroquinazolin-4(1H)-ones in aqueous media. Patil, DR; Ingole, PG; Singh, K; Dalal, DS. *J Incl Phenom Macro.* **2013.** 76: 327 – 332.

80. Inductive responses of some organic metabolites for osmotic homeostasis in peanut (*Arachis hypogaea* L.) seedlings during salt stress. Parida, AK; Jha, B. *Acta Physiol Plant.* **2013.** 35: 2821 – 2832.

81. In silico studies toward the recognition of fluoride ion by novel bicyclic diborane receptors and tuning through remote substituent effects. Kesharwani, MK; Sahu, D; Desai, K; Ganguly, B. *Theor Chem Acc.* **2013.** 132, Art Num: 1358.

82. In silico studies to probe the catalytic role of cucurbit[n]uril on [4+2] cycloaddition reaction between cyclopentadiene and Methyl acrylate. Sahu, D; Ganguly, B. *Tetrahedron Lett.* **2013**. 54: 5246 – 5249.

83. In silico studies toward understanding the interactions of DNA base pairs with Protonated Linear/Cyclic Diamines. Sen, A; Sahu, D; Ganguly, B. *J Phys Chem B.* **2013**. 117: 9840 – 9850.

84. Influence of molecular shape on the design and synthesis of supramolecular assemblies. Delori, A; Suresh, E; Pedireddi, VR. *CrystEng Comm*. **2013**. 15: 4811 - 4815.

85. Interactional behaviour of surface active ionic liquids with gelling biopolymer agarose in aqueous medium. Bharmoria, P; Kumar, A. *RSC Adv.* **2013.** 3: 19600 – 19608.

86. Interfacial charge recombination of Os(II)-polypyridyl-resorcinol complex on oleic acid capped TiO_2 surface: What determines the dynamics. Banerjee, T; Das, A; Ghosh, HN. *New J. Chem.* **2013**.37: 3100 – 3108.

87. Is Non-covalent interactions sufficient for Paracyclophane based Carbenes to achieve the dual properties: Hyperbasicity and multiple dihydrogen storage materials? A first principles study. Lo, R; Ganguly, B. *J Phys Chem C.* **2013**. 117: 19325 – 19333.

88. Is the Isodesmic reaction approach a better model for accurate calculation of pK_a of organic superbases? A computational study. Biswas, AK: Lo, R; Ganguly, B. *Synlett.* **2013**. 24: 2519 – 2524.

89. L-Proline: An efficient catalyst for transamidation of Carboxamides with Amines. Rao, SN; Mohan, DC; Adimurthy, S. *Org Lett.* **2013.**15: 1496 – 1499.

90. Macrocyclic Mn (III) salen complexes as recyclable catalyst for oxidative kinetic resolution of secondary alcohols. Bera, PK; Maity, NC; Abdi, SHR; Khan, NH; Kureshy, RI.; Bajaj, Hari C. *Appl Catal A- Gen.***2013.** 467: 542 – 551.

91. Mesoporous Niobium Oxide spheres as a highly effective and reusable catalyst for the Transamidation of primary Amides with Amines. Ghosh, SC; Cheng, CL; Hua, CZ; Joyce, SY; Ngiam, AMS; Chen, A**.** *Adv Synth Catal***. 2014.**: 475 - 484.

92. Mg/La mixed oxide as catalyst for the synthesis of Dimethyl carbonate from cyclic Carbonates and Methanol. Murugan, C; Baja, HC. *Indian J Chem A.* **2013.** 52: 459 – 466.

93. Mild Rhodium (I) catalyzed ring opening of cyclopropane appended spirotricyclic Olefins through C-H activation of arylboronic acids. Prakash, P; Jijy, E; Shimi, M; Aparna, PS; Suresh, E; Radhakrishnan, KV. *RSC Adv*. **2013.** 3: 19933 – 19936.

94. Microwave-assisted rapid valorization of Glycerol towards acetals and ketals. Pawar, RR; Jadhav, SV; Bajaj, HC. *Chem Eng J.* **2014.** 235: 61 – 66.

95. Microwave-assisted synthesis of kC/Xylan/PVP-based blend hydrogel materials: physicochemical and rheological studies. Meena, R; Lehnen, R; Saake, B. *Cellulose*. **2014.** 21: 553 – 568.

96. Mixed ligand Nickel (II) complexes as catalysts for alkane hydroxylation using m-chloroperbenzoic acid as oxidant. Sankaralingam, M; Vadivelu, P; Suresh, E; Palaniandavar, M. *Inorg Chim Acta.* **2013.** 407: 98 – 107.

97. Modification of Polysulfone with pendant Carboxylic acid functionality for ultrafiltration membrane applications. Sainath, AVS; Reddy, AVR. *Bull Mat Sci.* **2013.**36: 271 – 276.

98. Molecular interactions, Proton exchange, and Photoinduced processes prompted by an inclusion process and a [2] Pseudorotaxane formation. Mandal, AK; Suresh, M; Kesharwani, MK; Gangopadhyay, M; Agrawal, M; Boricha, VP; Ganguly, B; Das, A. *J. Org. Chem.* **2013.** 78: 9004 - 9012.

99. Multi-block poly(arylene ether)s containing pre-choloromethylated bisphenol: Anion conductive ionomers. Jasti, A; Shahi, VK. *J Mat Chem A.* **2013**. 1: 6134 – 6137.

100. Nanocrystalline Zeolite Tetraethylammonium-Beta membrane for prefential sorption and transport of CO_2over N_2. Singh PS; Selvam, T; Reu, S; Avhale, A; Lopez-Orozco, S; Schwieger, W. *Chem-Eng-Technol.* **2013.** 36: 1209 - 1216.

101. New chemodosimetric probe for the specific detection of Hg2+ in physiological condition and its utilisation for cell imaging studies. Saha, S; Agarwalla, H; Gupta, H; Baidya, M; Suresh, E; Ghosh, SK; Das, A. *Dalton T.* **2013.** 42 : 15097 – 15105.

102. New generation energy-efficient light source for photocatalysis: LEDs for environmental applications. Jo, WK; Tayade, RJ. *Ind Eng Chem Res*. **2014.** 53: 2073 – 2084.

103. New Ruthenium(II) arene complexes of anthracenyl-appended diazacycloalkanes: Effect of ligand intercalation and hydrophobicity on DNA and protein binding and cleavage and cytotoxicity. Ganeshpandian, M; Loganathan, R; Suresh, E; Riyasdeen A; Akbarsha, M A; Palaniandavar, M. *Dalton T.* **2014.** 43: 1203 – 1219.

104. Nickel nanoparticles as efficient catalyst for electron transfer reactions. Rathore, PS; Patidar, R; Rathore, S; Thakore, S. *Catal Lett.* **2014.** 144: 439 – 446.

105. Nitrate and phosphate regimes induced lipidomic and biochemical changes in the intertidal macroalga *Ulva lactuca* (Ulvophyceae, Chlorophyta). Kumari, P; Kumar, M; Reddy, CRK; Jha, B. *Plant Cell Physiol.* **2014**.55: 52 – 63.

106. Nitrogen stress triggered biochemical and morphological changes in the microalgae *Scenedesmus sp.* CCNM 1077. Pancha, I; Chokshi, K; George, B; Ghosh, T; Paliwal, C; Maurya, RK; Mishra, S. *Biores Technol*. **2014.**156: 146 – 154.

107. Novel approach for selective phosphate removal using colloidal LDHs and use of residue as fertilizer. Koilraj, P; Antonyraj, CA; Gupta, V; Reddy, CRK; Kannan, S**.** *Applied Clay Sci.* **2013.** 86: 111 - 118.

108. NHC-catalysed annulation of enals to ene-1,4-diones: stereoselective synthesis of 1,3-diaryl-4-acyl cyclopentenes. Paul, RRajan; Lakshmi, KCS; Suresh, E; Nair, V. *Tetrahedron Lett.* **2013.** 54: 2046 – 2049.

109. Occurrence and distribution of selected heavy metals and boron in groundwater of the Gulf of Khambhat region, Gujarat, India. Upadhyaya, D; Survaiya, MD; Basha, S; Mandal, SK; Thorat, RB; Haldar, S; Goel, S; Dave, H; Baxi, K; Trivedi, RH; Mody, K H. *Environ Sci Pollut Res.* **2014.**21: 3880 – 3890.

110. One-Pot fabrication of RGO–Ag3VO4 Nanocomposites by in situ photoreduction using different sacrificial agents: High selectivity toward catechol synthesis and photodegradation ability. Das, DP; Samal, A; Das, J; Dash, A; Gupta, H. *Photochem Photobiol.* **2014.** 90: 57 – 65.

111. One-Step Hydroxylation of Benzene to Phenol over layered double Hydroxides and their derived forms. Antonyraj, CA; Srinivasan, K. *Catal Sur Asia.* **2013.**17: 47 – 70.

112. Organic free low temperature direct synthesis of hierarchical protonated layered Titanates/Anatase TiO_2 hollow spheres and their task-specific applications. Sutradhar, N; Pahari, SK; Jayachandran, M; Stephan**,** AM; Nair**,** JR; Subramanian**,** B**;** Bajaj**,** HC; Mody, HM; Panda, AB. *J Mat Chem A*. **2013**. 1: 9122 – 9131.

113. Oxazoline-Based organocatalyst for Enantioselective Strecker Reactions: A protocol for the synthesis of Levamisole. Sadhukhan, A; Sahu, D; Ganguly, B; Khan, NUH; Kureshy, RI; Abdi, SHR; Suresh, E; Bajaj, HC. *Chem-Eur J.* **2013.**19: 14224 – 14232.

114. Oxidative rearrangement of Vinyl Bromides to -Bromoketones and direct synthesis of ,-Dibromoketones from Alkynes using HBr/H_2O_2 System. Venkatanarayana, P; Ramachandra RD; Patil, RD; Adimurthy, S. *J Energy Chem Eng.* **2013.** 1: 27 – 50.

115. Pathogenesis-related gene, Jcpr-10a from *Jatropha curcas* exhibit Rnase and antifungal activity. Agarwal, P; Bhatt, V; Singh, R; Das, M; Sopory, SK; Chikara, J. *Mol Biotechnol.* **2013.**54: 412 – 425.

116. Pathogenesis related-10 proteins are small, structurally similar but with diverse role in stress signaling. Agarwal, P; Agarwal, PK. *Mol Biol Rep.* **2014.**41: 599 – 611.

117. Phosphine-Mediated reaction of 3-Alkyl Allenoates and Diaryl 1,2-Diones: Efficient diastereoselective synthesis of fully substituted Cyclopentenones. Jose, A; Lakshmi, KC S; Suresh, E; Nair, V. *Org Lett.* **2013.**15: 1858 – 1861.

118. Physiological and biochemical responses reveal the drought tolerance efficacy of the halophyte *Salicornia brachiata*. Parida, AK; Jha B. *J Plant Growth Regul.* **2013**.32: 342 – 352.

119. Physicochemical and rheological properties of Agarose/xylans composite hydrogel materials. Meena, R; Ralph, L; Uwe, S; Bodo, S. *Polym Composite.* **2013.**34: 978 – 988.

120. Preparation of bifunctional poly(dimethylsiloxane) membrane by dual X-linking. Jadav, GL; Aswal, VK; Singh, PS. *J Mat Chem A.* **2013**.1: 4893 - 4903.

121. Preparation, characterization and performance evaluation of separation of alcohol using crosslinked membrane materials. Ingole, PG; Thakare, NR; Kim, K; Bajaj, HC; Singh, K; Lee, H. *New J Chem.* **2013.** 37: 4018 – 4024.

122. Preparation of tamarind gum based soft ion gels having thixotropic properties. Sharma, M; Mondal, D; Mukesh, C; Prasad, K**.** *Carbohyd Poly.* **2014.** 102: 467 - 471.

123. Preparation of thin film polymer composite membranes for optical resolution of racemic mixture of -Amino acids. Ingole, PG; Bajaj, HC; Srivastava, DN; Rebary, B; Singh, K. *Sep Sci Technol.* **2013**.48: 1777 – 1785.

124. Probing the influence of solvent effect on the Lithium ion binding affinity of 12-crown-O3N derivatives with unsaturated side arms: A computational study. Patidar, R; Paul, P; Ganguly, B. *J. Mol. Graph. Model.* **2013**.46: 22 – 28.

125. Probing the role of solvation in predicting the л-Facial selectivity of 5-Fluoro-2-methyleneadamantane with per-acid: A Case Study. Sen, A; Ganguly, B. *Comput Theor Chem.* **2013.** 1026: 46 – 54.

126. Probing the selective salt rejection behaviour of thin film composite membranes: A DFT study. Lo, R; Bhattacharya, A; Ganguly, B. *J Membrane Sci.* **2013**. 436: 90 – 96.

127. Purification and characterization of cellulase from a marine *Bacillus* sp H1666: A potential agent for single step saccharification of seaweed biomass. Kumar, H; Mishra, A; Jha, B. *J Mol Catal B-Enzym.* **2013.** 93: 51 – 56.

128. Quantification of selected endogenous Hydroxy-oxylipins from tropical marine macroalgae. Kumari, P; Reddy, R; Jha, B. *Marine Biotechnol*. **2014.**16: 74 - 87.

129. Radiation stability of several polymeric supports used for radionuclide transport from nuclear wastes using liquid membranes. Mohapatra, PK; Raut, DR; Ghosh, AK. *J Radioanal Nucl Ch.* **2013.**298: 807 – 811.

130. Rapid dissolution of DNA in a novel bio-based ionic liquid with long-term rapid dissolution of DNA in a novel bio-based ionic liquid with long-term structural and chemical stability: Successful recycling of the ionic liquid for reuse in the process. Mukesh, C; Mondal, D; Sharma, M; Prasad, K. *Chem Commun.* **2013**. 49: 6849 – 6851.

131. Rapid synthesis of Carbon nanoparticles with an optimized combination of specific surface area and crystallinity by a plasma-assisted single-step process. Aomoa, N; Bhuyan, H; Cabrera, AL; Favre, M; Diaz-Droguett, DE; Rojas, S; Ferrari, P; Srivastava, DN; Kakati, M. *J Phys D-Appl Phys.* **2013.** 46 (16) Art Num: 165501.

132. Rheological study of organoclays prepared from Indian bentonite - Effect of dispersing methods. Bhatt, J; Somani, RS; Mody, HM; Bajaj, HC. *Appl Clay Sci.* **2013**. 83 – 84: 106 – 114.

133. Rhodium exchanged ETS-10 and ETS-4: Efficient heterogeneous catalyst for hydroaminomethylation. Sudheesh N; Shukla, RS. *Applied Catal. A Gen.* **2014.** 473: 116 - 124.

134. Role of metal ion in specific recognition of pyrophosphate ion under physiological conditions and hydrolysis of the phosphoester linkage by alkaline phosphatase. Das, P; Chandar, NB; Chourey, S; Agarwalla, H; Ganguly, B; Das, A. *Inorg Chem.* **2013.** 52: 11034 – 11041.

135. Schoenite and potassium sulphate: Indigenous potassic fertilizer for rainfed groundnut (*Arachis hypogaea* L.). Rathore, SS; Chaudhary, DR; Vaisya, LK; Shekhawat, K; Bhatt, BP. *Indian J Trad Know.* **2014.**13: 222 - 226.

136. Self-assembly of model graft copolymers of Agarose and weak polyelectrolyte-based amphiphilic diblock copolymers: Controlled drug release and degradation. Muppalla, RK; Jewrajka, SK; Prasad, K. *J Biomed Mater Res A.* **2013.** 101A (6): 1637 – 1650.

137. Self-healing Guar gum and Guar gum-multiwalled Carbon nanotubes nanocomposite gels prepared in an ionic liquid. Sharma, M; Mondal, D; Mukesh, C; Prasad K. *Carbohyd Polym.* **2013**. 98: 1025 -1030.

138. Small molecule as a Chiral Organocatalyst for Asymmetric Strecker reaction. Saravanan, S; Khan, NH; Kureshy, RI; Abdi, SHR; Bajaj, HC. *ACS Catal.* **2013.**3: 2873 – 2880.

139. Sodium hydroxide catalyzed N-Alkylation of (Hetero) aromatic primary Amines and N-1,C-5-Dialkylation of 4-Phenyl-2-aminothiazoles with Benzyl alcohols. Donthiri, RR; Pappula, V; Mohan, D. Chandra; G, Hiren H; Adimurthy, S. *J Org Chem.* **2013.** 78: 6775 – 6781.

140. Solar photo-thermochemical reaction and supercritical CO_2 work up for a fully green process of preparation of pure p-nitrobenzyl bromide. Dinda M, Chakraborty S, Samanta S, Bhatt C, Maiti S, Roy S, Kadam Y, Ghosh PK. *Environ Sci Technol.* **2013**.47: 10535 – 10540.

141. Solar photo-thermochemical syntheses of 4-bromo-2,5-substituted oxazoles from N-arylethylamides. Dinda, M; Samanta, S; Suresh E; Ghosh, PK. *Rsc Adv.* **2014.** 4 (24): 12252 – 12256.

142. Solid state structural transformation of Tetraborate into Monoborate in the interlayer galleries of reconstructed ZnAl layered double Hydroxide. Koilraj, P; Thakur, RS; Kannan S. *J Phys Chem C.* **2013.** 117: 6578 – 6586.

143. Solid-state dechlorination pathway for the synthesis of few layered functionalized carbon nanosheets and their greenhouse gas adsorptivity over CO and N_2. Sawant, SY; Somani, RS; Sangita, S; Sharma, S; Bajaj, HC. *Carbon*. **2014.**68: 210 – 220.

144. Solvent responsive healing of Guar gum and Guar gum-multiwalled Carbon nanotube nanocomposite gels prepared in an ionic liquid. Sharma, M; Mondal, D; Mukesh, C; Prasad K. *RSC Adv.* **2013.** 3: 16509 – 16515.

145. Sonochemistry: A simple and efficient route for biodiesel production from neat and blended vegetable oils using LDH-derived base catalysts. Sankaranarayanan, S; Kannan, S. *Int J Adv Eng Sci Appl Math.* **2013.**5: 210 - 218.

146. Spontaneous resolution to absolute Chiral induction: Pseudo-Kagomé type Homochiral Zn(II)/Co(II) coordination polymers with achiral precursors. Bisht, KK; Suresh, E. *J. Am. Chem. Soc.* **2013**. 135: 15690 – 15693.

147. Structural and functional studies on ternary coordination polymers from 5-bromoisophthalate and imidazole based flexible linker. Bisht, KK; Rachuri, Y; Parmara, B; Suresh, E. *RSC ADV.* **2014**. 4: 7352 – 7360.

148. Superior grafting and state-of-the-art interfacial electron transfer rates for newly designed geminal dicarboxylate bound Ruthenium (II)– and Osmium(II)–Polypyridyl dyes on Tio_2 nanosurface. Banerjee, T; Biswas, AK; Upendar RG; Sahu, TS; Das, A; Ganguly, B; Ghosh, HN. *J. Phys. Chem. C.* **2014.**118: 3864 – 3877.

149. Study on identification of leather industry wastewater constituents and its photocatalytic treatment. Natarajan, TS; Natarajan, K; Bajaj, HC; Tayade, RJ. *Int J Environ Sci Te.* **2013.**10: 855 – 864.

150. Studies on the structure-property relationship of Sodium alginate based thixotropic hydrogels. Chejara, DR; Kondaveeti, S; Prasad, K; Siddhanta, AK. *RSC ADV.* **2013.** 3: 15744 – 15751.

151. Synthesis and characterization of Chiral recyclable dimeric Copper(II)-salen complexes and their catalytic application in asymmetric Nitroaldol (Henry) reaction. Das, Anjan; Kureshy, RI; Subramanian, PS; Khan NH; Abdi SHR; Bajaj, HC. *Catal Sci Technol.* **2014.** 4: 411 – 418.

152. Synthesis and self-assembly properties of well-defined four-arm star poly(epsilon-caprolactone)-b-poly(N-vinylpyrrolidone) amphiphilic block copolymers. Mishra, AK; Ramesh, K; Paira, TK; Srivastava, DN; Mandal, TK; Misra, N; Ray, B. *Polym Bull.* **2013.** 70: 3201 – 3220.

153. Synthesis of Chiral ligands with multiple stereogenic centers and their application in Titanium(IV)-catalyzed Enantioselective desymmetrization of *meso*-Epoxides. Kumar, M; Kureshy, RI; Ghosh, D; Khan, NH; Abdi, SHR; Bajaj, HC. *ChemCatChem.* **2013**. 5: 2336 – 2342.

154. Synthesis of conformationally restricted symmetric macrodiolides via carbonyl Ylides. Muthusamy, S; Sivaguru, M; Suresh, E. *Synthesis-Stuttgart.* **2013**.45: 2034 - 2042.

155. Synthesis of functionalized Indanes via Palladium-Catalyzed Carboannulation of Diazabicyclic Olefins with o-Iodostyrenes. Jijy, E; Prakash, P; Saranya, S; Suresh, E; Radhakrishnan, KV. *Synthesis-Stuttgart.* **2013**.45: 2583 – 2592.

156. Synthesis, characterization, and catalytic study of Polymeric metal complexes derived from divalent transition metal ions with 2,4-Dihydroxy Benzophenone and 2,4-Dihydroxy Acetophenone. Ingole, PG; Bajaj, HC; Singh, K. *J Appl Polym Sci.* **2013.** 128: 66 – 74.

157. Synthesis, steady-state, and femtosecond transient absorption studies of resorcinol bound Ruthenium(II)- and Osmium(II)-polypyridyl complexes on nano-TiO_2 surface in water. Banerjee, T; Kaniyankandy, S; Das, A; Ghosh, HN. *Inorg Chem.* **2013.** 52: 5366 – 5377.

158. Synthesis, spectroscopic and catalytic studies of Cu(II), Co(II) and Ni(II) complexes immobilized on Schiff base modified chitosan. Antony, R.; Manickam, S.; Theodore David; Saravanan, K; Karuppasamy, K; Balakumar, S. *J Mol Stru.* **2013.** 1050: 53 – 60.

159. Synthetically amenable amide derivatives of tosylated-amino acids as organocatalysts for enantioselective allylation of Aldehydes: Computational rationale for enantioselectivity. Ghosh, D; Sahu, D; Saravanan, S; Abdi, SHR; Ganguly, B; Khan, NH; Kureshy; RI; Bajaj, HC. *Org Biomol Chem.* **2013**.11: 3451 - 3460.

160. Tandem oxidative Amidation of Benzyl alcohols with Amine Hydrochloride salts catalysed by Iron Nitrate. Ghosh, SC; Ngiam, JSY; Seayad, AM; Dang TT; Johannes, C W; Chen, A. *Tetrahedron Lett.* **2013.** 54: 4922 - 4925.

161. The transcriptional regulatory mechanism of the Peroxisomal Ascorbate Peroxidase (pAPX) gene cloned from an extreme halophyte, *Salicornia brachiata*. Tiwari, V; Chaturvedi, AK; Mishra, A; Jha, B. *Plant Cell Physiol*. **2014.** (1): 201 – 217.

162. The ameliorating effect of Acadian marine plant extract against ionic liquids-induced oxidative stress and DNA damage in marine macroalga *Ulva lactuca.* Kumar, M; Reddy, CRK; Jha, B. *J Appl Phycol.* **2013.** 25: 369 – 378.

163. Ultrasound-assisted adsorption of reactive blue 21 dye on TiO_2 in the presence of some rare earths (La, Ce, Pr & Gd). Srivastava, P; Goyal, S; Tayade, RJ. *Can J Chem Eng.* **2014.** 92: 41 – 51.

164. Unconventional electrode material prepared from coir fiber through sputter coating of Gold: A study toward value addition of natural biopolymer. Dibyendu DM; Perween, M; Srivastava, DN; Ghosh, PK. *ACS Sustain Chem. Eng.* **2014**. 2: 348 - 352.

165. Use of 2,4,6-pyridinetricarboxylic acid chloride as a novel co-monomer for the preparation of thin film composite polyamide membrane with improved bacterial resistance. Jewrajka, SK; Reddy, AVR; Rana, Harpalsinh H; Mandal, S; Khullar, S; Haldar, S; Joshi, N; Ghosh, PK. *J Membrane Sci.* **2013.** 439: 87 – 95.

166. Utilization of plastic wastes for synthesis of Carbon microspheres and their use as a template for nanocrystalline Copper (II) oxide hollow spheres. Sawant, SY; Somani, RS; Panda, AB; Bajaj, HC. *ACS Sustain Chem Eng.* **2013.** 1: 1390 – 1397.

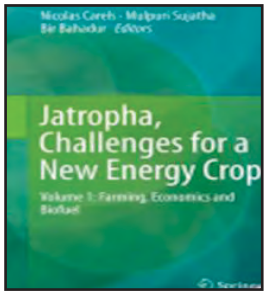
167. Vesicles and reverse vesicles of an ionic liquid in ionic liquids. Rao, KS; So, S; Kumar, A. *Chem Commun.* **2013.** 49: 8111 – 8113.

168. WD-XRF method for rapid analysis of macro and micronutrient uptake in maize grain upon foliar application of seaweed sap formulations. Patidar, R; Ghosh, A; Paul, P. *J Indian Chem Soc*. **2013**. 90: 2023 - 2028.

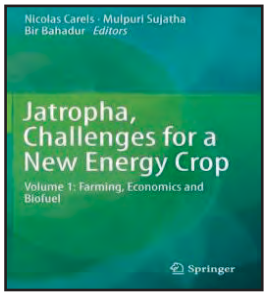
169. Water mediated deprotective intramolecular hydroamination of N-propargylaminopyridines: synthesis of imidazo [1, 2-alpha]pyridines. Mohan, DC; Sarang, NB; Adimurthy, S. *Tetrahedron Lett.* **2013.** 54: 6077 – 6080.

170. ZnAl layered double hydroxides as potential molybdate sorbents and valorize the exchanged sorbent for catalytic wet peroxide oxidation of Phenol. Koilraj, P; Srinivasan, Kannan. *Ind Eng Chem Res.* **2013.** SI 52 (22): 7373–7381.

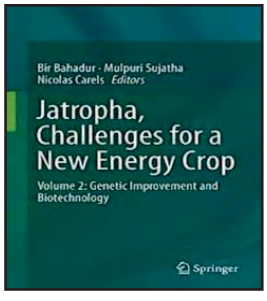
2. Books/ Chapters in Books



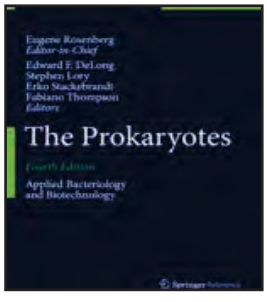
Value Addition of Jatropha Cake and its Utilization Cake and its Utilization as Manure in Jatropha and Other Crops
Springer Science Business Media, New York, 2012; 355-368
Name of the book: **Jatropha, Challenges for a New Energy Crop: Volume 1: Farming, Economics and Biofuel**
ISBN: **978-1-4614-4806-8-19**
Author (s): A Ghosh, J Chikara, D R Chaudhary



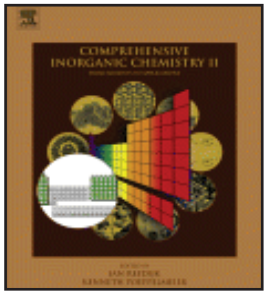
Micropropagation of *Jatropha curcas* for Large Scale of Quality Germplasm
Springer Science Business Media, New York, 2013; 503-511
Name of the book **Jatropha, Challenges for a New Energy Crop: Volume 1: Genetic Improvement and Biotechnology**
ISBN: **978-1-4614-4915-7-25**
Author(s): **A Singh, J Chikara**



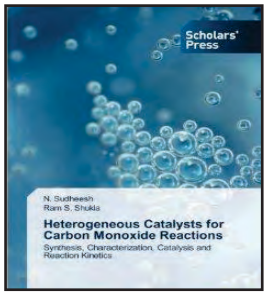
Genetic improvement in *Jatropha curcas* through Selection and Breeding
Springer Science Business Media, New York, 2013; 119-135
Name of the book: **Jatropha, Challenges for a New Energy Crop: Volume 2: Genetic improvement and Biotechnology**
ISBN: **978-1-4614-4915-7-8**
Author(s): **J Chikara, AR Prakash, S G Mastan, A Ghosh**



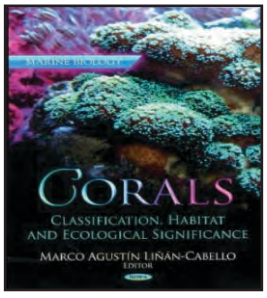
Microbial Exopolysaccharides
Springer Publishers, Heidelberg, Germany, 2013; 179–192
Name of the book: **The Prokaryotes**
ISBN: **978-3-642-31330-1**
Author(s): **A Mishra, B Jha**



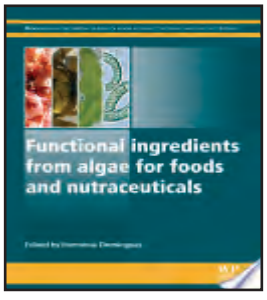
Asymmetric Cyanation Reaction, Volume 6: Homogeneous Catalytic Applications
Elsevier, Amsterdam, 2013; 413-456
Name of the book: **Comprehensive Inorganic Chemistry**
ISBN: **978-0-0809-7774-4**
Author(s): **N H Khan, R I Kureshy, S H R Abdi, H C Bajaj, A Sadhukhan**



Heterogeneous catalysts for carbon monoxide reactions: Synthesis, characterization, catalysis and reaction kinetics.
Scholars' Press, Germany, 2013
Name of the book: **Heterogeneous Catalysts for Carbon Monoxide Reactions**
ISBN: **978-3-6395-1905-1**
Author(s): **N Sudheesh, R S Shukla**



Community structure of coral-associated bacteria and their ecological significance
NOVA Science Publishers, USA, 2013; 75-90
Name of the book: **Corals: Classification, habitat and ecological significance**
ISBN: **978-1-62257-048-5**
Author(s): **S Haldar, K H Mody**



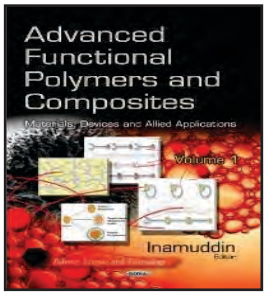
Algal lipids, fatty acids and sterols
Woodhead Publishing Ltd., Cambridge, UK, 2013; 87 - 134
Name of the book**: Functional ingredients from algae for foods and nutraceuticals**
ISBN:**978-0-85709-512**
Author (s): **K Puja, M Kumar, C R K Reddy, B Jha**



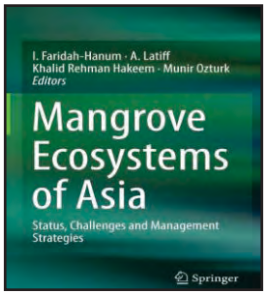
Salinity and desiccation induced oxidative stress acclimation in seaweeds
Elsevier, Amsterdam, 2014; 91-123.
Name of the book: **Sea Plants.** ***Adv. Bot. Res.*** **71**
ISBN: **978-0-12-408062-1**
Author(s): **M Kumar, K Puja, C R K Reddy, B Jha**



Seaweed Metabolomics: A new facet of functional genomics Elsevier, Amsterdam, 2014; 31-52
Name of the book: **Sea Plants.**
ISBN: **978-0-12-408062-1**
Author(s): **G Vishal, R S Thakur, R S Baghel, C R K Reddy, B Jha**



Ultraviolet Light-Emitting Diode (UV-LED) Source-Based Photocatalytic Reactors for Environmental Remediation
NOVA Science Publisher Inc. USA, 2014; 33-92
Name of the Book: **Advanced Functional Polymers and Composites**
ISBN: **978-1-62948-056-5**
Author(s): **T S Natarajan, K Natarajan, H C Bajaj, R J Tayade**



Impacts of Climate Change on Asian Mangrove Forests
Springer Science Business Media, New York, 2014; 233-256
Name of the book: **Mangrove Ecosystem of Asia Status, Challenges and Management Strategies**
ISBN: **978-1-4614-8581-0**
Author(s): **A K Parida, V Tiwari, B Jha**

3. Patents – Granted / Filed

2012-2013
Foreign Patent Granted (42 Patents for 26 Inventions)

Sr. No.	Title	Inventors	Patent No
1	Animal Powered Mechanical Device For Water Desalination	N Pathak, P.K. Ghosh, S.L. Daga, V.J. Shah, S.N. Patel	PH 1-2005-501203
2	Catalytic Epoxidation of Styrene With Molecular Oxygen Using Metal Ion Exchanged Zeolites	R. V. Jasra, J. Sebastian	DE 1966177 EP 1966177 CN ZI200580052409.7
3	Improved Process For The Recovery of Sulphate of Potash (SoP) From Sulphate Rich Bittern	P. Paul, P. K. Ghosh, K. J. Langalia, P.S. Subramanian, E. Suresh, Subrata Patra, PragatiAgnihotri	IL 190373 US 8182784 AU 2006200932
4	Enhancement of antitubercular activity of extracts of salicorniabrachiata	M. R. Rathod, B. D. Shethia, J. B. Pandya, P. K. Ghosh, P. J. Dodia, B.S. Srivastava, R. Srivastava, A. Srivastava, Vinita Chaturvedi	IL 178215 JP 5133683 CN ZI200580015459.8
5	Low Sodium Salt of Botanic Origin	P. K. Ghosh, K. H. Mody, M. P. Reddy, J. S. Patolia, K. Eswaran, B. Barot, A. Bhatt, M.R. Gandhi, Rajul Shah	CA 2562109
6	A method for the preparation of k-carrageenase	Y. N. Khambhaty, K. H. Mody, B. Jha	ID IDP0030969 PH 12008502142 CN ZI200680054085.5
7	A Novel Use of Herbal Extracts of Salicornia Species Active Against Tuberculosis And Process For The Preparation Thereof	M. R. Rathod, B. D. Shethia, J. B. Pandya, P. K. Ghosh, P. J. Dodia, B.S. Srivastava, R. Srivastava, A. Srivastava, Vinita Chaturvedi	ZA 2006/02576
8	An Eco-Friendly Process For Acylation of Alkylated Benzene Derivates	R. V. Jasra, B. Tyagi, Y. M. Badheka	KR 10-1154447
9	Process to separate nitrogen and argon from air by application of alkoxide to Zeolite at room temperature and pressure	R.V. Jasra, C.D. Chudasama, J Sebastian	DE 10314576

Sr. No.	Title	Inventors	Patent No
10	Process For The Preparation of Stable Iodate-Exchanged Synthetic Hydrotalcite With Zero Effluent Discharge	P.K. Ghosh, M.R. Gandhi, S.H. Mehta, G. Ramachandraiah, J.R. Chunawala, M.V. Sheth, G.S. Gohil	US 8241483 AP AP2624
11	Method For The Preparation of Refreshing Drink And Use Thereof	P.K. Ghosh, M.R. Rajyaguru, J.S. Patolia, K. Eswaran, P. Subbarao, M.T. Shah, S.T. Zodape, S.V. Joshi, A.V.R. Reddy, C.V. Devmurari, S. Bandyppadhyay, G. C. Sahoo	US 8252359
12	Process For The Preparation of Finely Divided Precipitated Silica	R.V. Jasra, H.M. Mody, R. S. Somani, H.C. Bajaj, D.B. Shukla, N.R. Vyas	US 8252261 AU 2008246949 CN ZI200880018780.5
13	An Improved Process For Preparation of Magnesium Oxide	P.K. Ghosh, H.L. Joshi, H.H. Deraiya, M.R. Gandhi, R.H. Dave, K.J. Langalia, V.P. Mohandas	JP 5095632 IL 192926
14	Novel Integrated Process For The Recovery of Sulphate of Potash (Sop) From Sulphate Rich Bittern	P. K. Ghosh, K. J. Langalia, M. R. Gandhi, R. H. Dave, H. L. Joshi	IL 176482
15	An Improved Process For Preparation of Magnesium Oxide	P.K. Ghosh, H.L. Joshi, H.H. Deraiya, M.R. Gandhi, R.H. Dave, K.J. Langalia, V.P. Mohandas	JP 5102780
16	Process For The Preparation Of Solar Salt Having High Purity And Whiteness	I. Mukhopadhyay, P. K. Ghosh, V. P. Mohandas, A. U. Hamidani, V. R. K. S. Susarla, R. J. Sanghavi	US 8282690 JP 5177956 CA 2617677
17	A Process For The Preparation Of Zeolite A From Kimberlite Tailings	R. V. Jasra, R. S. Somani, H. M. Mody, H. C. Bajaj, J. S. Chunawala, H. N. Ranpara, D. J. Barochiya, D. L. Ghelani, Suresh Chandra, M. K. Dhar, Keshav Rao, Kamlesh Kumar	CA 2592499
18	An Improved Process For The Cultivation of Algae	R.C. Reddy, O.P. Mairh, K. G. Rajakrishna, K. Eswaran, P.S. Subbarao, K.H. Mody, P.K. Ghosh	JP 5143330
19	Improved Process For Simultaneous Recovery of Industrial Grade Pottasium Chloride And Edible Salt Enriched With Kcl (Low Sodium Salt) From Bittern	R. N. Vohra, P. K. Ghosh, A. B. Kasundra, H. L. Joshi, Rohit Harshadr	BR PI0318668-7

Sr. No.	Title	Inventors	Patent No
20	Biodegradable Films Based On Semi Refined Kappa Carrageenan	P. K. Ghosh, A. K. Siddhanta, K. Prasad, R. Meena, A. Bhattacharya	AU 2004325362
21	A Manually Operated Continuous Flow Type Drinking Water Disinfector Using Concentrated Solar Radiation	Sodankur Rajan Thimmannabhat, P.K. Ghosh, S.N. Patel, J.N. Bharadia	ZA 2011/07043 NG NG/C/2011/570-001057
22	Photocatalytic Auto-Cleaning Process of Stains	P. K. Ghosh, R. V. Jasra, D. B. Shukla, A. K. Bhatt, R. J. Tayade	US 8343282 KR 10-1231894
23	Process For The Preparation Of Aldol Derivatives From Alkenes Using Catalyst	R.V. Jasra, V. K. Srivastava, R. S. Shukla, H. C. Bajaj, S. D. Bhatt	EP 1836148
24	A Method For Isolation, Purification And Identification of Extreme Alkaliphilic Bacteria Using Carrageenan As A Gelling Agent	G. Gnanasekaran, K. H. Mody, S. Datta, B. Jha	MY 148335
25	Preparation of non hazardous brominating reagents	Ramachandraiah G, Ghosh PK, Mehta As, Adimuthys, Jethva Ad, VaghelaSs	BR PI0215555-9
26	A process for the eco-friendly preparation of 3, 5-dibromo-4-hydroxybenzonitrile	Subbayarappa Adimurthy, GaddeRamachandraiah, Girdhar Joshi, Rajendra Patil, MaheshkumarRamniklal Gandhi, MallampatiSubbareddy, Pratyush Maiti	MX 305596

2012-2013
Indian Patent Granted

Sr. No.	Title	Inventors	Patent No
1	Catalytic Epoxidation of Styrene With Molecular Oxygen Using Metal Ion Exchanged Zeolites	R. V. Jasra, Jince Sebastian	251933
2	A Process For Recovery of Palladium As Palladium Spent Silica	A. B. Boricha, H. C. Bajaj, R. V. Jasra , Pradyut Ghosh, P. K. Ghosh	252378
3	A Process For Photocatalytically Cleaning Stains On A Surface	P. K. Ghosh, R. V. Jasra, D. B. Shukla, A. K. Bhatt, R. J. Tayade	252476

Sr. No.	Title	Inventors	Patent No
4	A Method For Preparation of X-Carrageenase	Y. N. Khambhaty, K. H. Mody, B. Jha	253554
5	A Process For Peparation of Sodium Silicate From Kimberlite Tailings	R.V. Jasra, H.C. Bajaj, R.S. Somani, H.M. Mody, J.R. Chunawala, D.L. Ghelani, H.N. Ranpara, D. J. Barochiya, Suresh Chandra, M.K. Dhar, C Kesava Rao, Kamlesh Kumar	253874
6	Organic-Inorganic Hybrid Chiral Sorbent And Process For The Preparation Thereof	S. H. R. Abdi, R. I. Kureshy, N. H. Khan, R. V. Jasra, V. J. Mayani, Santosh Agarwal	255441

2012-2013

Foreign Patents Filed (45 Patent applications for 17 Inventions)

Sr. No.	Title	Inventors	Patent No
1	Zn(ii) Based Colorimetric Sensors And Process For The Preparation Thereof	P. Mahato, A. Ghosh, S. K. Mishra, AnupamaShrivastava, S. Mishra, A. Das	US 13/636260 BR 1120120125893 CN 201180022839.X
2	A Process For Integrated Production Of Ethanol And Seaweed Sap From KappaphycusAlvarezil	K.H. Mody, P.K. Ghosh, B. Sana, G. Gnanasekaran, A.D. Shukla, K Eswaran, H.R. Brahmbhatt, B. G. Shah, S. Thampy, B. Jha	CN 201080050007.4 US 13/394745
3	Novel Process For The Preparation Of Polyhydroxyalkanoate And High Density Shell Briquette Integrated With Improved Process Of Production Of Methyl Ester From Whole Seed Capsule Of Jatropha Curcas	P.K. Ghosh, S.C. Mishra, M.R. Gandhi, S.C. Upadhyay, P. Paul, P.S. Anand, K.M Popat, A.V. Shrivastav, S.K. Mishra, NeelamOndhiya, R. D. Maru, Gangadharan Dyal, Harshad Brahmbhatt, Vinod Borisha, D. R. Chaudhary, Babulal Rebary, K. S. Zala	CN 201080050289.8
4	Process For Engine Worthy Fatty Acid Methyl Ester (Biodiesel) From Naturally Occurring And Cultured Microalgal Mat	S.C. Mishra, P.K. Ghosh, M.R. Gandhi, S. Bhattacharya, Subarna Maiti, S.C. Upadhyay, S.K. Mishra, A. V. Shrivastav, Imran Pancha, Chetan Paliwal, Tonmoy Ghosh, Rahul Maurya, Deepti Jain, Prabuddha Gupta, S. K. Patidar, Aditi Shah, Abhishek Sahu, Vekariya Vijay, Kirtan Dave, HetalBosamiya, Krushnadevsinh Zala	WO IN2012/000372

Sr. No.	Title	Inventors	Patent No
5	Preparation Of Inorganic Hydrogels With Alkali Halides	A. Singh, B. Ganguly	AU 2011225811 EP 11715741.2 US 13/583030 JP 2012-556608 CN 201180013651.9
6	Preparation Of Highly Efficient Heterogenous Catalyst For Asymmetric Nitroaldol Reaction	S. H. R. Abdi, R. I. Kureshy, N. H. Khan, H. C. Bajaj, V. J. Mayani, A.K. Shah	BR 1120120229850 US 13/634187 KR 10-2012-7026644
7	Production Of Potable Water From Highly Saline Sub-Soil Brine In Salt Works Using Exhaust Waste Heat Form Diesel Engine Employed Round The Clock During The Salt Manufacturing Season To Charge The Salt Pans With Susoil Brine	P.K. Ghosh, G.R. Desale, B. H. Khatri, R.N. Patel, S. N. Patel, M.R. Gajjar, N.G. Borle	LK 16901 IL 222445 US 13/641226 AP P/2012/006553 CN 201180030309.X
8	100-500 Um Size Spherical Sodium Chloride Having Improved Flow And Process Of Preparation From Brine Thereof	I. Mukhopadhyay, P. K. Ghosh, V. P. Mohandas	US 13/689468
9	An Improved Process For The Preparation Of 2-Phenyl Ethanol By Catalytic Hydrogenation Of Styrene Oxide	H. C. Bajaj, S. H. R. Abdi, R. I. Kureshy, N. H.Khan, A. A. Dabbawala, Tamal Roy	WO PCT/IN2012/ 000820
10	Cost-Effective Natural Salt Formulations For Seawater Substitution, Mineral Fortification And Processes Thereof	P. K. Ghosh, S.C. Upadhyay, S. C. Mishra, V. P. Mohandas, D. N. Srivastava, V. K. Shahi, R. J. Sanghavi, S. Thampy, B. S. Makwana, Imran Pancha, Ruma Pal, Ramkrishna Sen	WO PCT/IN2012/ 000857
11	A Process For The Production Of Oil Bearing Chlorella Sp. Utilizing By-Products Of Jatropha Methyl Ester Production From Whole Seeds	P.K. Ghosh, S.C. Mishra, M.R. Gandhi, S.C. Upadhyay, S.V. Mishra, Imran Pancha, A.V. Shrivastav, Deepti Jain, Bhumi Shethia, S. Maiti, K.S Zala	IL 224033 EP 11779230.9 GB 11779230.9 US 13/821055 DE 11779230.9 AU 2011306356 SG 201301888-2 CN 201180044942.4 CA 2811672 MY PI 2013700452 ID W-00 2013 01193 BR 11 2013006602-4 JP 2013-529771

Sr. No.	Title	Inventors	Patent No
12	A Method For The Preparation Of L-Enantiomers Selective Membrane For Optical Resolution Of Alpha-Amino Acids	K. Singh, H.C. Bajaj, P. G. Ingole	WO PCT/IN2013/ 000081
13	High Flux Hollow Fiber Ultrafiltration Membranes And Process For The Preparation Thereof	A. V. Reddy, P. Ray, P. S. Singh, KallemParashuram, S.K. Maurya, J. J. Trivedi	EP 11776523.0 JP 2013-528777
14	Double Fortified Salt Composition Containing Iron And Iodine And Process Of Preparation Thereof	J. R. Chunawala, P. K. Ghosh, M. R. Gandhi, S. H. Mehta, M. V. Sheth	WO PCT/IN2013/ 000124
15	Improved Household Solar Still With Easy Operation And Maintenance And Enhanced Output	S. Maiti, P. A. Patel, Chitangi Bhatt, J. N. Bharadia, M. R. Gajjar, P. S. Bapat, P. K. Ghosh	WO PCT/IN2013/ 000122 IL 234447
16	Preparation Of Ac@Mof Composite With Enhanced Methane Storage Capacity	H.C. Bajaj, R.S. Somani, Rallapalli Phani BS, Patil Dinesh, K.P. Prasanth, Raj Manoj C, R.S. Thakur, B. L. Newalkar, N. V. Chaudhary	CN 201280003121.0
17	Plant extract for treating anxiety disorders	Meena Rajnikant Rathod, Bhupendra Dhanvantrai Shethia, Jayant Batukrai Pandya, Prakash Jagjivanbhai Dodiya, GautamPalit, Manavi Chatterjee, Shibani Sen Gupta, Ashok Kumar Agarwal, Vinay Kumar Khanna	US 18/05/2012

2012-2013
Indian Patents Filed

Sr. No.	Title	Inventors	Application No
1	Process For Engine Worthy Fatty Acid Methyl Ester (Biodiesel) From Naturally Occurring And Cultured Microalgal Mat	S.Mishra, P. K. Ghosh, M. R. Gandhi, S. Bhattacharya, S. Maiti, S. C. Upadhyay, S. K. Mishra, A. V. Shrivastav, Imran Pancha, Chetan Paliwal, Tonmoy Ghosh, Maurya Rahul, Deepti Jain, Prabuddha Gupta, S. K. Patidar, Aditi Shah, Abhishek Sahu, Vijay Vekariya, Kirtan Dave, HetalBosamiya, Krushnadevsinh Zala	06564DELNP2012

Sr. No.	Title	Inventors	Patent No
2	Novel Double Fortified Salt Composition Containing Iron And Iodine And Process Of Preparation Thereof	J. R. Chunawala, P. K. Ghosh, M. R. Gandhi, S. H. Mehta, M. V. Sheth	02600DELNP2013
3	Process For Solar Driven Solvent Extraction Of Microalgal Lipids	P. K. Ghosh, S.Mishra, Subarna Maiti, Chetan Paliwal, S. K. Mishra, Tonmoy Ghosh, Pankaj Patel, J. N. Bharadia	0601DEL2012
4	Production Of High Purity Salt With Reduced Levels Of Impurities	P. K. Ghosh, S. C. Upadhyay, V. P. Mohandas, R. J. Sanghavi, B. Rebary	0597DEL2012
5	Process For Production Of Sulphate of Potash From Bittern Through Selective Extraction Of Pottasium	P. Maiti, P. K. Ghosh, M. R. Gandhi, Jignesh Solanki, H. R. Rahmbhatt	0606DEL2012
6	Novel Thin Film Composite Reverse Osmosis Membrane With Antifouling Properties And Method Of Preparation of The Same	P. K. Ghosh, S. K. Jewrajka, A. V. R. Reddy, Sanjay Mandal, SadhikaKhullar	1027DEL2012
7	Standalone Laboratory Scale Device For Conducting Solar-Driven Organic Reactions Promoted By Elevated Temperature, Light And Agitation And Process Thereof	P. K. Ghosh, Supratim Chakraborty, Milan Dinda, Subarna Maiti, Chitrangi Bhatt, JitendraNarsibhaiBharadia, Pankaj Arvindbhai Patel, P. S. Bapat	2117DEL2012
8	Process For Improved Seaweed Biomass Conversion For Fuel Intermediates And Fertilizer	P. K. Ghosh, Dibyendu Mondal, K. Prasad, A. K. Siddhanta	1789DEL2012
9	Preparation of Gaur Gum And Multiwalled Carbon Nanotubes Based Self Healable Ionic Gel Materials Having Ahdesive Properties	K. Prasad, Mukesh Sharma, Dibyendu Mondal, ChandrakantMukesh, Ramavatar Meena	2651DEL2012
10	A Novel Process For Preparation of Synthetic Hydrotalcite From Industrial Waste	M. R. Gandhi, J. R. Chunawala, S. H. Mehta	0603DEL2012
11	Integrated Process Of Production of Potassium Sulphate And Ammonium Sulphate From Kainite Mixed Salt	P. K. Ghosh, P. Maiti, M. R. Gandhi	0600DEL2012

Sr. No.	Title	Inventors	Patent No
12	Process For The Purification of Saline Reject Water Of Desalination Plant And Its Direct Use Thereafter As Salt Solution For Cooking Purpose	P. K. Ghosh, R. J. Sanghavi, A. V. R. Reddy, N. Pathak, Veenubhai Solanki	0593DEL2012
13	Development of A Cycle Process For The Production of High Purity Soda Ash With Reduced Fluoride Content From Mineral Trona	M. R. Gandhi, J. R. Chunawala, P. Maiti, K. M. Popat	1028DEL2012
14	Preparation of Seaweed Polysaccharide Based Hydrophobic Biocompatible Ropes	R. Meena, P. K. Ghosh, Dharmesh Chejara, K. Eswaran, A. K. Siddhanta, K. Prasad	3194DEL2012
15	Anion Exchange Membrane And Preparation Thereof	P.K. Ghosh, Saroj Sharma, Milan Dinda, SreekumaranThampy	3598DEL2012
16	Low Fouling Thin Film Composite Reverse Osmosis Membranes With Improved Chlorine Resistance And A Process For Preparation Thereof	A. V. R. Reddy, N. K. Saha, S. K. Jewrajka, J. J. Trivedi, P. Ray, N. Pathak, G. S. Trivedi, T. B. Gohil, R. S. Patil	600DEL2012
17	A Process For The Preparation Of Recyclable Chiral Catalysts For Asymmetric Nitroaldol Reaction For The Synthesis Of Pharmaceutically Important Compounds	R. I. Kureshy, N.H. Khan, S. H. R. Abdi, H. C. Bajaj, Tamal Roy, Anjan Das	0289DEL2013

2013-2014
Foreign Patent Granted (71 Patents for 23 Inventions)

Sr. No.	Title	Inventors	Patent No
1	An improved process for preparation of magnesium oxide	Ghosh Pushpito Kumar, Joshi Himanshi Labhshanker, Deraiya Hasina Hajibhai, Gandhi Maheshkumar Ramniklal, Dave Rohit Harshdrai, Langalia Kaushik Jethalal, Mohandas Vadakke Puthoor	IL 192952 CNZL 200680052178.4
2	A process for the preparation of amorphous silica from kimberlite tailings	Raksh Vir Jasra, Haresh Mahipatlal Mody, Hari Chand Bajaj, Rajesh Shantilal Somani, Jatin Shantilal Chunawala, Hema Nare	CA 2592518
3	A novel use of herbal extracts of salicornia species active against tuberculosis and process for the preparation thereof	Meena Rajnikanth Rathod, Bhupendra Dhanvantrai Shethia, Jayant Batukrai Pandya, Pushpito Kumar Ghosh, Prakash J Dodia, Br	CA 2541971
4	Herbal extracts of salicornia species, process of preparation thereof, use thereof against tuberculosis	Meena Rajnikanth Rathod, Bhupendra Dhanvantrai Shethia, Jayant Batukrai Pandya, Pushpito Kumar Ghosh, Prakash Jagjivanbhai D	CA 2577415 AP 002671
5	Iodized salt and a process for its preparation	Pushpito Kumar Ghosh, Satishbhai Hariray Mehta, Jatin Rameshchandra Chunawala, Mrunal Vinodray Sheth, Mahesh Ramniklal Gandhi	US 8440252
6	Catalytic epoxidation of styrene with molecular oxygen using metal ion exchanged zeolites	Raksh Vir Jasra, Jince Sebastian	JP 5289973 KR10-1299895
7	Improved process for the preparation of iodate-exchanged synthetic hydrotalcite as iodizing agent with zero effluent discharge	Pushpito Kumar Ghosh, Mahesh Ramaniklal Gandhi, Satish Hariray Mehta, Gadde Ramachandraiah, Jatin Rameshchandra Chunawala, Mrinal Vinodbhai Sheth, Girirajsinh Sabalsinh Gohil	CNZL 200880127465.6 AU 2008348619

Sr. No.	Title	Inventors	Patent No
8	Preparation of organic-inorganic hybrid chiral sorbent	Syed Hasan Razi Abdi, Rukhsana Ilyas Kureshy, Noor-Ul Hasan Khan, Raksh Vir Jasra, Vishal Jitendrabhai Mayani, Santosh A	AU 2007301436 JP 5312332 MX 316461 CNZL 200780044113.X
9	Nutritious, tasty and affordable drink from sap of kappaphycus alvarezii seaweed and its preparation thereof	Pushpito Kumar Ghosh, Maheshchandra Rameshchandra Rajyaguru, Jinalal Shambhubhai Patolia, Peddi Venkata Subbarao, Mukesh Tribhovanbhai Shah, Sudhakar Tukaram Zodape, Miss Sharda Vitthaldas Joshi, Alamuru Venkata Rami Reddy, Devmurari Chhaganlal Vithaldas, Sibdas Bandyopadhyay, Ganesh Chandra Sahoo	JP5312325 CN101500437B MY-149503-A
10	Process for production of glycine micronutrient-enriched nacl crystals with near spherical shape and improved flow characteristics	Parthasarathi Dastidar, Pushpito Kumar Ghosh, Amar Ballabh, Darskak Rameshbhai Trivedi, Amitava Pramanik, Velayudhan Nai	BR PI 0318682-2 B1
11	A process for recovery of common solt and marine chemicals from brine in integrated manner	Rajinder Nath Vohra, Pushpito Kumar Ghosh, Vadakke Puthoor Mohandas, Himanshu Labhshanker Joshi, Hasina Hajibhai Deraiya	JP 533640
12	Integrated process of production of potassium sulphate, magnesium hydroxide and ammonium sulfate from kainite mixed salt and ammonia	Pushpito Kumar Ghosh, Haresh Mahipatlal Mody, Jatin Rameshchandra Chunawala, Maheshkumar Ramniklal Gandhi, Hari Chand Bajaj, Pratyush Maiti, Himanshu Labhshanker Joshi, Hasina Hajibhai Deraiya, Upendra Padmakant Saraiya	FR2411330 DE2411330 IT2411330 NL2411330 ES2411330 GB2411330 MX 314491 JP 5509310 EP2411330
13	An improved process of preparation of common salt of high purity from brines in solar salt pans	Arvind Kumar, Pushpito Kumar Ghosh, Vadakke Puthoor Mohandas, Indrajit Mukhopadhyay, Jignesh Jasvantraj Shukla, Rahul Jasvantrai Sanghavi	AU 2008346089 IL 206877

Sr. No.	Title	Inventors	Patent No
14	Chiral heterogeneous catalyst for assymmetric nitroaldol reaction	Abdi; Sayed H. R., Kureshy; Rukhsana I., Khan; Noor-Ui H., Bajaj; Hari C., Mayani; Vishal J., Shah; Arpan K.	US 8557726
15	An improved process for the preparation of para-nitrobenzyl bromide	Manoj Kunjabihari Agrawal, Pushpito Kumar Ghosh, Maheshkumar Ramniklal Gandhi, Sumesh Chandra Upadhyay, Subbarayappa Adimurthy, Gadde Ramachandraiah, Paresh U Patoliya, Girdhar Joshi, Harshad Brahmbhatt, Rahul Jasvantrai Sanghavi	EP 2365960 FR 2365960 DE 2365960 GB 2365960
16	An improved process for preparation of fatty acid methyl ester (biodiesel) from jatropha curcas oil	Pushpito Kumar Ghosh, Subbarayappa Adimurthy, Mahesh Ramnikbhai Gandhi, Nilesh Kumar Kanjibhai Vaghela, Meena Rajnikant Rathod, Bhupendra Dhanvantrai Shethia, Jayant Batukrai Pandya, Rajendra Amrutlal Parmar, Prakash Jagjivanbhai Dodia, Mehul Ghanshyambhai Patel, Dahyabhai Revabhai Parmar, Sanat Natawarlal Patel	ID 34975 EP 1996680 AT 1996680 BE 1996680 DK 1996680 FR 1996680 DE 1996680 IT 1996680 NL 1996680 ES 1996680 GB 1996680
17	Novel process for the preparation of polyhydroxyalkanoate and high density shell briquette integrated with improved process of production of methyl ester from whole seed capsule of jatropha curcas	Ghosh Pushpito Kumar, Mishra Sandhya Chandrika Prasad, Gandhi Mahesh Ramniklal, Upadhyay Sumesh Chandra, Paul Parimal, Anand Pritpal Singh, Popat Kiritkumar Mangaldas, Shrivastav Anupama Vijaykumar, Mishra Sanjiv Kumar, Neelam Ondhiya, Maru Ramesh Dudabhai, Dyal Gangadharan, Brahmbhatt Harshad, Borisha Vinod, Doongar Ram Chaudhary, Babulal Rebary, Krushnadevsinh Sukhdevsinh Zala	EP 2475754 BE 2475754 FR 2475754 DE 2475754 NL 2475754 ES 2475754 GB 2475754
18	Plant extract for treating anxiety disorders	Meena Rajnikant Rathod, Bhupendra Dhanvantrai Shethia, Jayant Batukrai Pandya, Prakash Jagjivanbhai Dodiya, Gautam Palit, Manavi Chatterjee, Shibani Sen Gupta, Ashok Kumar Agarwal, Vinay Kumar Khanna	DE 2411030 EP 2411030 GB 2411030

Sr. No.	Title	Inventors	Patent No
19	Production of potable water from highly saline sub-soil brine in salt works using exhaust waste heat form diesel engine employed round the clock during the salt manufacturing season to charge the salt pans with susoil brine	Ghosh Pushpito Kumar, Desale Girish Rajanikant, Khatri Bhavin Hasmukhlal, Patel Rajeshkumar Naranbhai, Sanatkumar Natavarlal Patel, Gajjar Mahesh Ramjibhai, Borle Niitin Ganesh	LK 16901
20	A method for isolation, purification and identification of extreme alkaliphilic bacteria using carrageenan as a gelling agent	Gnanasekaran G, Kalpana Haresh Mody, Sumitra Datta, Bhavanath Jha	PH 1-2010-501544
21	100-500 um size spherical sodium chloride having improved flow and process of preparation from brine thereof	Indrajit Mukhopadhyay, Pushpito Kumar Ghosh, Vadakke Puthoor Mohandas	AU 2008346088 BG 2242722 FR 2242722 DE 2242722 IT 2242722 NL 2242722 RO 2242722 ES 2242722 GB 2242722 EP 2242722
22	Improved k-carrageenase production and a method of preparation thereof	Yasmin Najmuddin Khambhaty, Kalpana Haresh Mody, Bhavanath Jha	CN 10-1358770
23	A process for integrated production of ethanol and seaweed sap from kappaphycus alvarezil	Kalpana Haresh Mody, Pushpito Kumar Ghosh, Barindra Sana, G Gnanasekaran, Atindra Dinkerray Shukla, K Eswaran, Harshad Ramanbhai Brahmbhatt, Bharatiben Gunavantray Shah, Sreekumaran Thampy, Bhavanath Jha	CNZL 201080050007.4

2013-2014
Indian Patents Granted

Sr. No.	Title	Inventors	Patent No.
1	Method of removing phospholipids from rice bran oil membrane process	Kripal Singh, Virendra Kumar, Jayantilal Shah	260035

2013-2014

Foreign Patents Filed (68 Applications for 25 Inventions)

Sr. No.	Title	Inventors	Application No.
1	Process for production of sulphate of potash from bittern through selective extraction of pottasium	Pratyush Maiti, Pushpito Kumar Ghosh, Mahesh Ramniklal Gandhi, Jignesh Solanki, Harshad Raman Rahmbhatt	WO PCT/ IB2013/000582 CA 2,869,255 JO PA/286/2013 PH 1-2014-500709 EP 13722048.9 GB 13722048.9 DE 13722048.9
2	Process for solar driven solvent extraction of microalgal lipids	Ghosh Pushpito Kumar, Mishra Sandhya Chandrika Prasad, Maiti Subarna, Paliwal Chetan, Mishra Sanjiv Kumar, Ghosh Tonmoy, Patel Pankaj, Bharadia Jitendra Narsinh	WO PCT/ IN2013/000218
3	Production of high purity salt with reduced levels of impurities	Pushpito Kumar Ghosh, Sumesh Chandra Upadhyay, VadakkePuthoor Mohandas, Rahul Jasvantrai Sanghavi, BabulalRebary	WO PCT/ IN2013/000217
4	Novel thin film composite reverse osmosis membrane with antifouling properties and method of preparation of the same	Pushpito Kumar Ghosh, Suresh Kumar Jewrajka, AlamuruVenkata Rami Reddy, SoumyaHalder, Sanjay Mandal, SadhikaKhullar	WO PCT/ IN2013/000222
5	A process for the production of oil bearing chlorella sp. Utilizing by-products of jatropha methyl ester production from whole seeds	Ghosh Pushpito Kumar, Mishra Sandhya Chandrika Prasad, Gandhi Mahesh Ramniklal, Upadhyay Sumesh Chandra, Mishra Sanjiv Kumar, Pancha Imran, Shrivastav Anupama Vijaykumar, Jain Deepti, Shethia Bhumi, Maiti Subarna, Zala Krushnadevsinh Sukhdevsingh	KR 2013-7009991
6	High flux hollow fiber ultrafiltration membranes and process for the preparation thereof	AlamuruVenktarami Reddy, Paramita Ray, Puyam Sobhindro Singh, KallemParashuram, Sandipkumar Maurya, Jitendra Jaydevprasad Trivedi	US13/819692

Sr. No.	Title	Inventors	Application No.
7	Preparation of AC@MOF composite with enhanced methane storage capacity	Bajaj Hari Chand, Somani Rajesh Shantilal, RallapalliPhaniBs, Patil Dinesh, PrasanthKp, Raj Manoj C, Thakur Rajendra Singh, Newalkar Bharat L, Chaudhary Nv	JP 2014-501736 US 14/006729 EP 12718334.1 KR 2013-7028496
8	Standalone laboratory scale device for conducting solar-driven organic reactions promoted by elevated temperature, light and agitation and process thereof	Pushpito Kumar Ghosh, Supratim Chakraborty, Milan Dinda, Subarna Maiti, Chitrangi Bhatt, Jitendra Narsibhai Bharadia, Pankaj Arvindbhai Patel, Pratap Shashikant Bapat	WO PCT/ IB2013/055634 AU 2013288275
9	An improved process for the eco-friendly praparation of 3,5-dibromo-4-hydroxybenzonitrile (bromoxynil)	Subbayarappa Adimurthy, Gadde Ramachandraiah, Girdhar Joshi, Rajendra Patil, Maheshkumar Ramniklal Gandhi, Mallampati Subbareddy, Pratyush Maiti	US 13/981647
10	Novel process for the preparation of polyhydroxyalkanoate and high density shell briquette integrated with improved process of production of methyl ester from whole seed capsule of jatrophacurcas	Ghosh Pushpito Kumar, Mishra Sandhya Chandrika Prasad, Gandhi Mahesh Ramniklal, Upadhyay Sumesh Chandra, Paul Parimal, Anand Pritpal Singh, Popat KiritkumarMangaldas, ShrivastavAnupamaVijaykumar, Mishra Sanjiv Kumar, Neelam Ondhiya, Maru Ramesh Dudabhai, Dyal Gangadharan, Brahmbhatt Harshad, Borisha Vinod, Doongar Ram Chaudhary, Babulal Rebary, KrushnadevsinhSukhdevsinh Zala	US 13/981742
11	Integrated process of production of potassium sulphate, magnesium hydroxide and ammonium sulfate from kainite mixed salt and ammonia	Pushpito Kumar Ghosh, Haresh Mahipatlal Mody, Jatin Rameshchandra Chunawala, Maheshkumar Ramniklal Gandhi, Hari Chand Bajaj, Pratyush Maiti, HimanshuLabhshanker Joshi, Hasina Hajibhai Deraiya, Upendra Padmakant Saraiya	US 13/981957

Sr. No.	Title	Inventors	Application No.
12	Preparation of organic-inorganic hybrid chiral sorbent	Syed Hasan Razi Abdi, RukhsanaIlyas Kureshy, Noor-Ul Hasan Khan, RakshVirJasra, Vishal JitendrabhaiMayani, Santosh A	US 13/954402
13	Improved process for the preparation of fatty acid alkyl esters (Biodiesel) from triglyceride oils using eco-friendly solid base catalysts	Kannan Srinivasan, Sivashunmugam Sankaranarayanan, Churchil Angel Antonyraj	CA 2827063 JP 2013-553071 EP 12710563.3 MY PI2013701407 BR 112013020651-9 CN 201280008824.2 US 13/985443 KR 10-2013-7024184
14	Process for improved seaweed biomass conversion for fuel intermediates and fertilizer	Pushpito Kumar Ghosh, Dibyendu Mondal, Pratyush Maiti, Kamalesh Prasad, Subarna Maiti, Bharti Gunvantray Shah, Arup Kumar Siddhanta	WO PCT/ IN2013/000493
15	A process for preparation of synthetic hydrotalcite using industrial waste	Mahesh kumar Ramniklal Gandhi, JatinRameshchandra Chunawala, Satish Hariray Mehta	WO PCT/ IN2013/000536
16	Integrated process of production of potassium sulphate and ammonium sulphate from kainite mixed salt	Pushpito Kumar Ghosh, Pratyush Maiti, Maheshkumar Ramniklal Gandhi	WO PCT/ IB2013/058216
17	Method of recycling of by-products for the production of soda ash and ammonium sulphate	Pushpito Kumar Ghosh, Haresh Mahipatlal Mody, Rajesh Shantilal Somani, Pratyush Maiti, Maheshkumar Ramniklal Gandhi, Hari Chand Bajaj, Jatin Rameshchandra Chunawala, Sumesh Chandra Upadhyay	US 14/041856 AU 2013234427
18	An enviornment friendly cycle process for the production of high purity soda ash with reduced fluoride content from mineral trona	Maheshkumar Ramniklal Gandhi, Jatin Rameshchandra Chunawala, Pratyush Maiti, Kiritkumar Mangaldas Popat	AP/P/2013/007167

Sr. No.	Title	Inventors	Application No.
19	Biodegradable hydrophobic composite materials and process for the preparation thereof	Meena Ramavatar, Ghosh Pushpito Kumar, ChejaraDharmesh, Eswaran Karuppanan, Siddhanta Arup Kumar, Prasad Kamalesh, Chaudhary Jai Prakash	WO PCT/ IN2013/000617
20	A process for the preparation of recyclable chiral catalysts for asymmetric nitroaldol reaction for the synthesis of pharmaceutically important compounds	Kureshy RukhsanaIlyas, Khan Noor -Ul Hasan, Abdi Sayed Hasan Razi, Bajaj Hari Chand, Roy Tamal, Das Anjan	WO PCT/ IN2013/000670
21	An improved solar dryer with enhanced efficiency of drying	Pushpito Kumar Ghosh, Subarna Maiti, Pankaj Arvindbhai Patel, Jitendra Narsinhbhai Bharadia, Shobhit Singh Chauhan, Mahesh Laxmanbhai Sanghani, Pradip Vinubhai Parmar, Kruthika Eswaran, Paraskumar Vivekbabu Agravat	US 14/117956 OM/P/2013/00277 AE 1213/2013 CN 201180071899.0 AP/P/2013/007313
22	Process for engine worthy fatty acid methyl ester (biodiesel) from naturally occurring and cultured microalgal mat	Mishra Sandhya Chandrika Prasad, Ghosh Pushpito Kumar, Gandhi Mahesh Ramniklal, Bhattacharya Sourish, Maiti Subarna, Upadhyay Sumesh Chandra, Mishra Sanjiv Kumar, ShrivastavAnupamaVijayakumar, Pancha Imran, Paliwal Chetan, Ghosh Tonmoy, Maurya Rahul, Jain Deepti, Gupta Prabuddha, PatidarShailesh Kumar, Shah Aditi, Sahu Abhishek, Vekariya Vijay, Dave Kirtan, BosamiyaHetal, Zala Krushnadevsinh	US 14/119065 ZA 2013/08696 JP 2014-512005 IL 229556 OM P/2013/00282 MX A/2013/013883 EP 12737610.1 BR 112013030280-1 AU 2012260475 KR 10-2013-7034475 RU 2013157357 CN 201280025675.0 GB 12737610.1 DE 602012004145.5 IT 2737610.1 FR 12737610.1 FI 12737610.1 ES 12737610.1 CA 2836866

Sr. No.	Title	Inventors	Application No.
23	Anion exchange membrane and preparation thereof	Pushpito Kumar Ghosh, Saroj Sharma, Milan Dinda, Chiragkumar Rameshbhai Sharma, Uma Chatterjee, Vaibhav Kulshreshtha, Soumyadeb Ghosh, Babulal Surabhai Makwana, SreekumaranThampy, Girish Rajanikant Desale	WO PCT/ IN2013/000712
24	Low fouling thin film composite reverse osmosis membranes with improved chlorine resistance and a process for preparation thereof	AlamuruVenkata Rami Reddy, Saha Nirmal Kumar, Jewrajka Suresh Kumar, Jitendra Jaydevprasad Trivedi, Paramita Ray, Nagendra Pathak, Gaurang Shambuprasad Trivedi, Temubha Bhupatsinh Gohil, Rahul Shubhash Patil	WO PCT/ IN2013/000711
25	Cost-effective natural salt formulations for seawater substitution, mineral fortification and processes thereof	Pushpito Kumar Ghosh, Sumesh Chandra Upadhyay, Sandhya Chandrikaprasad Mishra, Vadakke Puthoor Mohandas, Divesh Narayan Srivastava, Vinod Kumar Shahi, Rahul Jasvantrai Sanghavi, SreekumaranThampy, Babulal Surabhai Makwana, Imran Pancha, Ruma Pal, Ramkrishna Sen	AU 2012360017 EG PCT/NA 351/2014 JP 2014-549639 IL 231690

2013-2014
Indian Patents Filed

Sr. No.	Title	Inventors	Application No
1	Process for solar driven solvent extraction of microalgal lipids	Ghosh Pushpito Kumar, Mishra Sandhya Chandrika Prasad, Maiti Subarna, Paliwal Chetan, Mishra Sanjiv Kumar, Ghosh Tonmoy, Patel Pankaj, Bharadia Jitendra Narsinh	05191DELNP2013
2	Kappaphycusalvarezii sap free of gibberellic acid (GA3) and its method of preparation	Pushpito Kumar Ghosh, Arup Ghosh, Dibyendu Mondal, Kamalesh Prasad, SudhakarTukaramji Zodape	1078DEL2013

Sr. No.	Title	Inventors	Application No.
3	Improved process to retain nutritious constituents in potable water obtained through desalination	Pushpito Kumar Ghosh, Vinod Kumar Shahi, Amit Kumar Thakur, Niharika Srivastava, Tina Chakrabarty	3599DEL2012
4	Novel ion exchange membrane and the process of preparation thereof	Uma Chatterjee, Suresh Kumar Jewrajka, SreekumaranThampy	2294DEL2013
5	Gold coated natural fibre as electrode and process for preparation thereof	Pushpito Kumar Ghosh, Divesh Narayan Srivastava, Dibyendu Mondal, Mosarrat Perween	2755DEL2013
6	A facile synthesis of seaweed polysaccharides based hydrophobic biocompatible crosslinked composite porous materials for energy-efficient separation	Ramavatar Meena, Naresh Dharmashibhai Sanandiya, Jai Prakash Chaudhary, Dibyendu Mondal	3079DEL2013
7	Polyester based thin film composite low pressure membrane and applications thereof	Pushpito Kumar Ghosh, Suresh Kumar Jewrajka, AnupamBera, Ravindra Maganbhai Gol	3247DEL2013
8	A device for efficient and cost-effective seaweed harvesting for large-scale commercial application	Pushpito Kumar Ghosh, Vaibhav Ajit Mantri, Jayanta Kumar Pothal, Veeraprakasam Veeragurunathan, Sangaiya Thiruppathi	3567DEL2013
9	A systemic approach to valorize seaweed biomass for a spectrum of bioproducts	Chennur Radhakrishna Reddy, Ravi Singh Baghel, Nitin Trivedi, Puja Kumari, Vishal Gupta, Kamlesh Prasad, Ramavatar Meena	3811DEL2013
10	New use of salt bitterns as draw solution in forward osmosis for energy efficient dewatering and process thereof	Pushpito Kumar Ghosh, Dibyendu Mondal, Sanna Kotrappanavar Nataraj, Alamuru Venkata Rami Reddy, Sumesh Chandra Upadhyay	0735DEL2014

4. Papers / Lectures Presented in Seminars / Symposia

2012 – 2014

Sr No	Title of the paper/poster	Name of the Seminar/ Conference	Place	Author(s)
1	Challenges before salt Industry	National Seminar on salt production April 26, 2012	New Delhi	Mohandas VP, Bhatt AM, and Kumar A.
2	The stepwise template decomposition in zeolite BEA membranes: synthesis, properties and their effect on their separation performance	12th International Conference on Inorganic Membranes July 09-13, 2012	Twente, Netherlands	Reuß S, Singh PS, Franz K, Mostafa MM, and Schwieger W.
3	CSIR – CSMCRI in the service of society.	Hindi Seminar August 21-24, 2012	Hyderabad	Mohandas VP.
4	Workshop on Societal Interventions: Empowering People – The CSIR800 Program	CSIR Foundation Day Celebrations September 26-27, 2012	CSIR, New Delhi	Bhatt AM.
5	Carbon source dependent production of biosurfactant by an alkaliphilic bacterium, *Klebsiella* sp. for its application in pollutant removal	International Conference on "Industrial Biotechnology" November 21-23, 2012	Punjabi University, Patiala, Panjab	Jain RM, Mody K, Joshi NK, Mishra A, and Jha B.
6	Unconventional carbon sources dependent biosurfactant production by an alkaliphilic bacterium, *Klebsillea* sp.	National Carbohydrate Conference (Carbo-XXVII) on prospects and perspectives of glycoscience and allied technologies December 13-15, 2012	CSIR-CFTRI Mysore	Jain RM, Mody K, Joshi NK, Mishra A, and Jha B.
7	Preparation Of Guar Gum Based Electro Conductive Composites	Carbo XXVII December 13-15, 2012	CSIR-CFTRI, Mysore	Chandrakant M, and Prasad K.
8	New Solvent System for dissolution of chitin	Carbo XXVII December 13-15, 2012	CSIR-CFTRI, Mysore	Sharma M, and Prasad K

Sr No	Title of the paper/poster	Name of the Seminar/ Conference	Place	Author(s)
9	Synthesis of a polysaccharide based hydrogel with superior absorbent properties via graft copolymerization of acrylic acid/ acrylonitrile	Carbo XXVII December 13-15, 2012	CSIR-CFTRI, Mysore	Naresh D, Sanandiya ND, and Siddhanta AK
10	High temperature CO_2 adsorbent	International conference on Sustainable Technologies for Energy and Environment December 27-30, 2012	NIT, Jalandhar	Munusamy K, Swetamber S, Somani RS, and Bajaj HC
11	Use of transgenics for functional validation of genes	Workshop on Application of Genomics in Crop Improvement January 05, 2013	GB Pant University, Pantnagar	Mishra A.
12	Cross Linked Functional Polymers & Water Treatment	UGC & GUJCOST Sponsored National Conference February 02, 2013	R. R. Mehta Science College, Palanpur	Popat KM.
13	A dechlorination pathway for synthesis of horn shaped carbon nanotubes and its gas adsorption properties	National Conference on Innovative Interdisciplinary Ideas in Chemical Sciences February 08-09, 2013	Arts, Science and Commerce College, Chopda, Jalgaon	Sawant SY, Somani RS, Bajaj HC and Sharma SS.
14	Formation and characterization of onions shaped carbon soot from plastic wastes	National Conference on Innovative Interdisciplinary Ideas in Chemical Sciences February 08-09, 2013	Arts, Science and Commerce College, Chopda, Jalgaon	Sawant SY, Somani RS, Bajaj HC and Sharma SS.
15	Sulfated zirconia: an efficient and reusable solid acid catalyst for esterification of myristic acid with methanol	21st National Symposium on Catalysis February 10-13, 2013	CSIR-IICT, Hyderabad	Saravanan K, Tyagi B, and Bajaj HC.
16	Preparation and Adsorption properties of Banana peel (Musa acuminata) derived micro/meso porous carbons	21st National Symposium on Catalysis February 10-13, 2013	CSIR-IICT, Hyderabad	Munusamy K, Jagariya R, Somani RS, and Bajaj HC.

Sr No	Title of the paper/poster	Name of the Seminar/ Conference	Place	Author(s)
17	Hydrofluoric acid free Synthesis of MIL-101 (Cr) using Acetic acid and its Hydrogen Uptake Studies	21st National Symposium on Catalysis February 10-13, 2013	CSIR-IICT, Hyderabad	Raj MC, Rallapalli PBS, Somani RS, and Bajaj HC.
18	Enantioselective Strecker reaction: A practical approach for the synthesis of α-amino acids and chiral diamine	21st National Symposium on Catalysis February 10-13, 2013	CSIR-IICT, Hyderabad	Saravanan S, Khan NH, Kureshy RI, Abdi SHR, and Bajaj HC
19	The Asymmetric nitroaldol (Henry) reaction of trifluoromethyl ketone catalyzed by new chiral Cu(II) catalyst	21st National Symposium on Catalysis February 10-13, 2013	CSIR-IICT, Hyderabad	Das A, Kureshy RI, Khan NH, Abdi SHR, and Bajaj HC
20	Synthetically amenable amide derivatives of tosylated-amino acids as organocatalysts for enantioselective allylation of aldehydes: computational rationale for enantioselectivity	21st National Symposium on Catalysis February 10-13, 2013	CSIR-IICT, Hyderabad	Ghosh D, Abdi SHR, Khan NH, Kureshy RI, and Bajaj HC
21	Chiral Co(III) salen complexes- catalyzed aminolytic kinetic resolution of terminal epoxides with N-protecting groups: a practical strategy in the preparation of (S)-Naftopidil and (S)-Propanalol	21st National Symposium on Catalysis February 10-13, 2013	CSIR-IICT, Hyderabad	Kumar M, Kureshy RI, Khan NH, Abdi SHR, and Bajaj HC
22	Organic carbonate: an alternative to chlorinated solvent	21st National Symposium on Catalysis February 10-13, 2013	CSIR-IICT, Hyderabad	Maity N Ch., Abdi SHR, Khan NH, Kureshy RI, and Bajaj HC
23	Selective hydrogenation of biomass derived levulinic acid to γ-valerolactone over NiAl-LDH catalyst	21st National Symposium on Catalysis February 10-13, 2013	CSIR-IICT, Hyderabad	Gundekari S, and Kannan S

Sr No	Title of the paper/poster	Name of the Seminar/ Conference	Place	Author(s)
24	Asymmetric aza-Henry reaction catalyzed by chiral Cu(II)-amino alcohol based complexes and its extention for the synthesis of (*R*)-Phenylglycine	21st National Symposium on Catalysis February 10-13, 2013	CSIR-IICT, Hyderabad	Chaudhary M, Kureshy RI, Khan NH, Abdi SHR, and Bajaj HC
25	Fructose dehydration to 5-hydroxymethylfurfural: Influence of solvent on recyclability of Amberlyst-15	21st National Symposium on Catalysis February 10-13, 2013	CSIR-IICT, Hyderabad	Sampath G, and Kannan S
26	Liquid phase epoxidation of ethyl linoleate using CoCuAl layered double hydroxides	21st National Symposium on Catalysis February 10-13, 2013	CSIR-IICT, Hyderabad	Shanmugam S, Sharma A, and Kannan S
27	Tailoring of ultrafiltration membrane morphology: Effects of different membrane preparation parameters	International Conference on Advancement in Polymeric Materials March 01-03, 2013	CIPET, Lucknow	Vyas BB, Bhattacharya A, Singh PS, and Ray P.
28	Seaweed Biotechnology: Current Status and the Way Forward	ASEAN-India Marine Biotechnology Workshop March 09-22, 2013	National Institute of Oceanography Goa	Reddy CRK.
29	Asymmetric Cyanoethoxy Carbonylation Reaction of Aldehydes Catalyzed by a Ti^{IV} Macrocyclic Complex: A Protocol for β-Blocker and α_1-Adrenergic Receptor Agonists	19th ISCB International Conference on Recent Advances and Current Trends in Chemical and Biological Sciences March 02-05, 2013	Mohanlal Sukhadia University, Udaipur	Sadhukhan A, Khan NH, Kureshy RI, Abdi SHR, and Bajaj HC.
30	Modulation of oxidative stress mediated cytotoxicity of butylparaben in human by O. sanctum polyphenols: An *in vitro* and *in silico* analysis	National Seminar on MD Simulation and QSAR in Drug Design March 29, 2013	Gujarat Cancer Research Institute Ahmedabad, Gujarat	Shah K, Shukla RS, Shrivastav P, Patel S, and Verma RJ.
31	Studies on the Effects of Membrane Surface Charge on the Rejection of Amino acids by Nanofiltration Membranes	National seminar on Advances in membrane processes and materials April 06, 2013	MS University, Vadodara	Vyas BB, and Ray P.

Sr No	Title of the paper/poster	Name of the Seminar/ Conference	Place	Author(s)
32	Diatoms may thrive over dinoflagellate due to climate change-mediated shift in tropical region	International Workshop on Ocean Acidification: Consequences for Marine Ecosystems September 20-21, 2013	IISER, Kolkata	Mandal SK, and Patel VR
33	Scientific lay-out, mechanization, modernization and automation of solar salt works	Training Programs arranged by Salt Dept., Govt. of India October 22, 2013	Vedaranyam, Tamil Nadu	Bhatt AM.
34	Utilization of Plastic Wastes For Synthesis of Carbon Micro spheres: A Template For Nano Crystalline Copper (ii) Oxide Hollow Spheres	7th International Symposium on Feedstock Recycling of Polymeric Materials October 23-26, 2013	India Habitat Centre, New Delhi	Sawant SY, Somani RS, Panda AB, and Bajaj HC.
35	Poster presentation on Biamphiphilic Ionic Liquid Induced Folding Alterations in the Structure of Bovine Serum Albumin in Aqueous Medium	5th Asian Conference on Colloid and Interface Science November19-24, 2013	Darjeeling (West Bengal)	Bharmoria P.
36	Subject based paper Presentation	5th Asian Conference on Colloid and Interface Science November 19-24, 2013	Darjeeling (West Bengal)	Rao KS.
37	Exploration of indigenously developed nanofiltration membrane modules in the removal of pesticides	International conference on Membranes and Applications November 22-23, 2013	CSIR-CGCRI, Kolkata	Polisetti V, Bhattacharya A, Singh PS, Trivedi GS, and Ray P
38	Continuous vapor phase dehydration of 2-octanol to industrially important 1-octene over solid acid catalysts	Indus COP Workshop on Intensification and Up-scaling of Continuous Processes December 13-14, 2013	NCL, Pune	Saroja A, and Kannan S
39	Functional Modification Mediated Value Addition of Gelling Seaweed Polysaccharides	Carbohydrate Symposium January 12-17, 2014	IISc, Bangalore	Siddhanta AK
40	Relative discussion on salt production as knowledge partner	CII salt conclave February 07-09, 2014	Chennai	Bhat AM, Kumar A, and Upadhyay SC.

Sr No	Title of the paper/poster	Name of the Seminar/ Conference	Place	Author(s)
41	Enantioselective Ring Opening Reaction of Epoxides with Anilines Catalyzed by Organo-catalyst	16th CRSI National Symposium in Chemistry February 07-09, 2014	IIT, Bombay	Kumar M, Kureshy KI, Khan NH, Abdi SHR and Bajaj HC.
42	Chiral Cu(II)-Amino Alcohol Based Complexes for Asymmetric Aza-Henry Reaction of N-Ts Imines	16th CRSI National Symposium in Chemistry February 07-09, 2014	IIT, Bombay	Choudhary MK, Das A, Kureshy RI, Kumar M, Khan NH, Abdi SHR, and Bajaj HC.
43	Dicationic aluminium salen complexes immobilized on montmorillonite clay: A highly recyclable catalyst for the synthesis of cyclic carbonate	16th CRSI National Symposium in Chemistry February 07-09, 2014	IIT, Bombay	Verma S, Kureshy RI, Roya T, Das A, Khan NH, Abdi SHR, and Bajaj HC.
44	Small molecule as chiral organocatalyst for asymmetric Strecker reaction.	16th CRSI National Symposium in Chemistry February 07-09, 2014	IIT, Bombay	Saravanan S, Khan NH, Jakhar A, Kureshy RI, Abdi SHR, and Bajaj HC
45	Asymmetric Friedel-Crafts addition of indoles to N-sulphonyl aldimines catalyzed by Cu (II) chiral amino alcohols based Schiff base complexes	16th CRSI National Symposium in Chemistry February 07-09, 2014	IIT, Bombay	Kumari P, Bera, PK, Kureshy KI, Khan NH, Sayed H. R. Abdi and Bajaj HC
46	Manganese complexes with non-porphyrin N4 ligands as recyclable catalyst for the asymmetric epoxidation of olefins.	16th CRSI National Symposium in Chemistry February 07-09, 2014	IIT, Bombay	Maity Nabin ch., Bera PK, Ghosh D, Abdi SHR, Kureshy RI, Khan NH and Bajaj HC.
47	Asymmetric organic transformations for the synthesis of bioactive compounds.	16th CRSI National Symposium in Chemistry February 07-09, 2014	IIT, Bombay	Gupta N, Abdi SHR, Kureshy RI, Khan NH and Bajaj HC.

Sr No	Title of the paper/poster	Name of the Seminar/ Conference	Place	Author(s)
48	Highly enantioselective sulphide oxidation with chiral iron complex using aqueous hydrogen peroxide as terminal oxidant.	16th CRSI National Symposium in Chemistry February 07-09, 2014	IIT, Bombay	Bera PK, Abdi SHR, Kureshy RI, Khan NH and Bajaj HC.
49	Delivered CRSI Bronze Medal Lecture entitled,"Asymmetric organic transformations for the preparation of biologically important chiral Compounds: Development of novel chiral catalysts"	16th CRSI National Symposium in Chemistry February 07-09, 2014	IIT, Bombay	Kureshy RI.
50	Expression of abiotic stress inducible gene *SbpAPX* is regulated by two novel *cis*-acting motifs under steady state.	International Conference of Frontier discoveries and emerging opportunities in life sciences February13-15, 2014	Dr. Harisingh Gour University, Sagar, M.P	Tiwari V, Chaturvedi AK, Mishra A, and Jha B.
51	Overexpression of *SbMT2* gene confers abiotic stress tolerance in transgenic tobacco	International Conference of Frontier discoveries and emerging opportunities in life sciences February13-15, 2014	Dr. Harisingh Gour University, Sagar, M.P	Chaturvedi AK, Patel MK, Mishra A, Tiwari V, and Jha B.
52	Influence of hexane on the pore structure modification of polysulfone ultrafiltration membrane	International Conference of Polymers: vision and Innovations. APA symposium February19-21, 2014	IIT, Delhi	Saxena M, Bhattacharya A, Ray P, and Singh PS.
53	Highly-porous hydrophobic PVDF membranes for effective desalination of seawater by vacuum membrane distillation	International Conference of Polymers: vision and Innovations. February19-21, 2014	IIT, Delhi	Devi S, Gandreti L, Ray P, Singh PS, Bhattacharya A, and Singh K.
54	Monitoring the performance of Polyvinyl alcohol nanofiltration membranes by varying the support membrane topography.	APA international conference on Polymers: Vision and Innovations February19-21, 2014	IIT, Delhi	Vyas BB, A. Bhattacharya A, and Ray P.

Sr No	Title of the paper/poster	Name of the Seminar/ Conference	Place	Author(s)
55	Production of chitin nanofibers in deep eutectic solvents and its hybrid gel beads with Calcium alginate for slow drug delivery	20th ISCB International Conference on Chemistry and Medicinal Plants in Translational Medicine for Healthcare March 01-04, 2014	Department of Chemistry, University of Delhi, Delhi	Chandrakant M, and Prasad K.
56	Molecular cloning of a novel salt responsive gene *SbSR1* from *Salicornia brachiata*	National Conference on "Science of omics for agricultural productivity: future prospective March 04-06, 2014	GB Pant University, Pantnagar, Uttarakhand	Udawat P, Mishra A, and Jha B.
57	Over-expression of the *SbNHXI* gene confers salt tolerance in transgenic castor (*Ricinus communis L*)	National Conference on "Science of omics for agricultural productivity: future prospective March 04-06, 2014	GB Pant University, Pantnagar, Uttarakhand	Patel MK, Joshi M, Mishra A, and Jha B.
58	Indian Seaweed Mari-culture with special reference to *Gracilaria*	Biotechnological approaches in medicine, agriculture and Environment- Current scenario March 06-07, 2014	J. J. College of Arts & Science, Pudukkottai, Tamilnadu	Veeragurunathan V.

5. Inter Agency Linkages

2012-2013

(A) GRANT–IN–AID PROJECTS

Sr. No.	Project Title	Funding Agency	Amount Received (Rs. in Lakhs)
1.	Synthesis of nanostructured materials using metal ammonium carbonate complex as precursor	SERB, New Delhi	6.86
2.	The Dye sensitized solar cell/Q-DSSC area of TAPSUN programme	IICT, Hyderabad	17.00
3.	Scientific understanding of De-fluoridation employing indigenous resin and comparison with activated alumina	DST, New Delhi	12.18
4.	Thermodynamic acoustic and viscometric behaviour of imidazolium based room temperature ionic liquid in polar organics solvents	DST, New Delhi	2.50
5.	Ion-specific resins and membrane and membrane based system/processes to bring the level of arsenic to WHO limits in drinking water	DST, New Delhi	11.63
6.	Development, demonstration and field trial of indigenous solar powdered electro-dialysis (EDR) technology for providing safe drinking water to the remote village	DST, New Delhi	5.00
7.	Silicone rubber membrane prepared from polysiloxanes of various sizes and types for enhances separation of ethanol from water	SERB, New Delhi	20.00
8.	Studies on the dynamics of interfacial electron/ energy transfer processes involving designer molecules and semiconductor particles and of hydrogen bond rapture/reformation processes	DoAE,	
9.	V-through concentrator as technology platform – case study for enhanced output from photovoltaic array powering a community scale reverse osmosis unit	DST, New Delhi	12.14
10.	Improving the quality and yield of salt produced from sea brines by the marginal agraias of amreli district through up-gradation and improving their income through value addition of bittern under the cluster development program	IC, Gandhinagar	40.46
11.	Development of ion-exchange membranes and mixed bed resin based electro-deionization process for fluoride removal from groundwater	DST, New Delhi	72.00
12.	Ion Conducting polymer-metal nanocunductive (ICMPN) based electrochemical sensors for Biological Fluids	DST, New Delhi	NR

Sr. No.	Project Title	Funding Agency	Amount Received (Rs. in Lakhs)
13.	Synthesis, Characterization and catalytic application of lonic Liquid supported on Nano-Crystalline Metal Oxides	DST, New Delhi	NR
14.	Organic- Inorganic nano composite ion-exchange membranes for the removal toxic metal ions from waste water by electrodialysis	DST, New Delhi	3.00
15.	Establishment of model salt farm in Markanam salt factory, Tamilnadu	Salt Commissioner Jaipur	NR
16.	Synthesis and Characterization of Recyclable chiral transition metal complexes for asymmetric nitroaldol or Henry reaction under homogenous and heterogeneous reaction condition	DST, New Delhi	3.00
17.	Development of Ploymer Electrolyte Membrane For Non-Conventional Electrochemical Energy Devices	MNRE, New Delhi	13.98
18.	Green and sustainable room temperature ionic liquids from bio renewable feed stocks: Synthesis, physicochemical characterization, self -assembly and interaction with biopolymers gelatin and agarose	DST, New Delhi	2.25
19.	Studies on the activity of Nano-building block based MgO microstructures as heterogeneous base catalyst in industrially important chemical conversions	DST, New Delhi	4.00
20.	Colorimetric sensing of ions with calixarene functionalized gold nanoparticles	DST, New Delhi	NR
21.	Development of prototype point of care blood gas and electrolytes analyzer	DST, New Delhi	5.00
22.	Test bed for integrated production of 0.75 TPD FCO grade SOP (Sulphate of Potash), 0.75 TPD of ammonium sulphate and 0.3 TPD of ultra-pure magnesia from seawater bittern-based mixed salt through patented process	DST, New Delhi	NR
23.	Synthesis of poly(meth) acrylates and polyesters-based thermoplastic elastomers and their clay Nano composites for hydrolytically / oxidatively stable coatings	DST, New Delhi	3.50
24.	Large scale micro propagating of elite genotypes of *J. curcas*	MNRE, New Delhi	NR
25.	SANS investigation of the silicon rubber membranes	UGC –DAE, Mumbai	0.21
26.	Understanding the reactivation of organophosphate inhibited acetylcholinesterase (AChE) with incleophiles and examining competing aging processes	DST, New Delhi	2.50

Sr. No.	Project Title	Funding Agency	Amount Received (Rs. in Lakhs)
27.	Development of Nano filtration membrane technology for drinking water purification and water reclamation for industrial use	MWR, New Delhi	NR
28.	Design and fabrication of UV-LED based photocatalytic reactor for the purification on contaminated water	DST, New Delhi	2.50
29.	Design, Synthesis and DNA interaction studies with novel photosensitizer molecules as efficient photodynamic therapeutic reagents	DBT, New Delhi	4.47
30.	Structure-property correlation studies of imidazolium based room temperature ionic liquids in ethylene glycol derivatives: thermodynamic and spectroscopic investigation	DST, New Delhi	3.00
31.	The WRKY family transcription factors in Jatropha: genome-wide cloning and functional analysis	DST, New Delhi	0.27
32.	Disinfection of river/pond/ground waters by Novel disinfecting polymers	MoEF, New Delhi	0.24
33.	Enhancing power output from commercial silicon PV modules by concentration and selective filtration of incoming solar radiation	DST, New Delhi	045
34.	Development of Chiral catalysts for asymmetric hydro formulation of olefins for the synthesis of chiral drug intermediates	DST, New Delhi	2.00
35.	Development of Bipolar Membrane Technology for water purification and salt recovery as their corresponding acid and base from industrial effluent	MoEF, New Delhi	0.37
36.	Functional modification of agar and *Kappacarrageenan* for their wider utility in diverse applications	DST, New Delhi	1.25

NR- Funds were not received in the financial year.

2012-2013

(B) COLLABORATIVE PROJECTS

Sr. No.	Project Title	Funding Agency	Amount Received (Rs. in Lakhs)
1.	To Prepare Bio-diesel from Jatropha Seeds of different origin and carry out performance evaluation by various users	Sasan Gir, Gir	10.19
2.	Study on storage of natural gas using nano materials by IISC to undertaken experimental study in order to evaluate the theoretical study carried out in the project	SID, Bangalore	26.54
3.	Developing 2 acre Jatropha plantation at Talegaon, Maharashtra	General Motors India Pvt. Ltd., Halol	1.47

Sr. No.	Project Title	Funding Agency	Amount Received (Rs. in Lakhs)
4.	Determination of the economic viability & technical feasibility of commercial Jatropha curcas production for generation of Jatropha oil as bio-fuels feedstock from wastelands	General Motor Corporation,	54.85
5.	Biowaste and Algae knowledge for the production of 2nd generation Biofuel Development of protoplast based seeding technique and their cultivation using outdoor tank culture system for select seaweed species	University of Rome, Roma	35.90
6.	Research and Development of adsorbent materials for adsorption based space cooling system	Thermax Ltd., Pune	11.23
7.	Development Of Adsorbent For Hybrid-Sorption Enhance Steam Reforming Process For Production Of Hydrogen	BPCL, Greater Noida	NR

NR- Funds were not received in the financial year.

2012-2013
(C) SPONSORED PROJECTS

Sr. No.	Project Title	Funding Agency	Amount Received (Rs. in Lakhs)
1.	Pre-feasibility study to ascertain in the suitability of Jafarabad coast for cultivation of *Kappaphycus alverezii*	Assistant Director for Fisheries, Jafarabad	0.65
2.	Evaluation of Poly aluminum chloride liquid (Brand name arya PAC, High basicity) and powder (Brand name AC/100S, Medium Basicity) Vis-à-vis alumino-ferric (Ferric alum), grade I as per IS 299: 1989 for its efficacy as a coagulant / flocculent for the treatment of raw water and the effect on removal of heavy metals	Aditya Birla Group, Nagda	0.78
3.	Preparation and supply of 5 kg material of synthesis hydrotalcite for evolution at their end.	Farmson Chemicals Industries, Ankleshwar	0.25
4.	Physiochemical and electrochemical characterization of used and unused cation and anion-exchange membrane	Kanoria Chemicals & Industries Ltd., Ankleshwar	1.20
5.	Know demonstration for various technologies transferred by CSMCRI to entrepreneurs on charge basis	Amit Hypophosphite, Credo Minerals, TCL, Marinelixers, GLPC etc.	NR
6.	Supply of RO plants of different capacities to various parties	Govt. of Rajasthan, IICB, APCOST, RSMML, FORRAD, CMFRI, Central Uni. of Panjab, NCC Camp etc.	643.87

NR- Funds were not received in the financial year.

2012-2013

(D) CONSULTANCY PROJECTS

Sr. No.	Project Title	Funding Agency	Amount Received (Rs. in Lakhs)
1.	Study of present status of salt pans and assessment of social, economical and environmental Impact (Positive and Negative) in context to the proposed site of the Kalpasar reservoir	Kalpasar Technical Cell Gandhinagar	NR
2.	Survey and assessment of Mangrove population in Gulf of Khambhat – Kalpasar Project	Kalpasar Technical Cell Gandhinagar	NR
3.	Assessment of baseline, environmental quality and social status on coastal, tidal and marine areas of kalpasar project	Kalpasar Technical Cell Gandhinagar	NR
4.	Collection of Physiochemical and marine biological data for regional EIA study for Dholera SIR	GICC, Gandhinagar	NR
5.	The preliminary survey of the site of solar salt production and assessing techno-economic feasibility of land for manufacture of common salt	GACL, Vadodara	1.65
6.	Exploring the possibility of valuable chemicals from ZLD projects of tannery sector	TNPCB, Chennai	3.30

NR- Funds were not received in the financial year.

2013-2014
(A) GRANT-IN-AID PROJECTS

Sr. No.	Project Title	Funding Agency	Amount Received (Rs. in Lakhs)
1.	INSPIRE fellowship under INSPIRE program for pursuing full time doctoral (PhD) program at Central Salt & Marine Chemicals Research Institute, Bhavnagar Gujarat	DST, New Delhi	2.50
2.	Enantiomeric separation of catalytically important metallohelicates and their application	SERB, New Delhi	8.00
3.	Tunable acidic and alkaline ion-exchange membranes for electro-membrane processes	SERB, New Delhi	9.30
4.	Synthesis and biological evaluation of functionalized imidazo [1,2-a] pyridine and 1,8-naphthyridine scaffolds	SERB, New Delhi	13.00
5.	Assessment of micro-algal biodiversity along different habitats of Gujarat coast and its exploitation for pigment production	SERB, New Delhi	11.00
6.	Remediation of pesticides from water through tailor made membranes: factor and strategies	SERB, New Delhi	13.40
7.	Synthesis of relevant biomaterials from seaweed derived polyscaccharides for potential application	SERB, New Delhi	13.00
8.	High valent organopalladium complexes in catalysis	SERB, New Delhi	7.45
9.	Modelling bio-geochemical cycles in coastal oceans	ISRO, Ahmedabad	3.00
10.	INSPIRE Faculty Award [IFA12-CH84] "Enhancing high power super capacitor and battery applications using novel bicontinuous nanostructure electrode technology	DST, New Delhi	19.00
11.	The Grant of C V Raman International Fellowship for African Researchers 2012-13 for Mr. Juste Geraud BONI	FICCI, New Delhi	1.60
12.	Selective extraction of Li & Sr ions from sea/sub-soil brines using ionophores/task specific ionic liquids	SERB, New Delhi	17.00
13.	Synthesis and characterization of chiral transition metal complexes/ organo-catalysts for hydrocyanation of functionalized and non-functionalized alkenes	SERB, New Delhi	12.00
14.	INSPIRE Faculty Award and Research Grant for Dr Soumitra Maity [IFA13 - CH 90] for implementation of the Award at CSIR-Central Salt & Marine Chemicals Research Institute, Bhavnagar	DST, New Delhi	19.00

Sr. No.	Project Title	Funding Agency	Amount Received (Rs. in Lakhs)
15.	Fellowship, HRA and contingency grant for the financial year 2013-14 to Ms Sweta (JRF)	DBT, Pune	1.30
16.	Investigations on ionic liquids induced structural changes in proteins: binding behaviour and colloidal formulations	SERB, New Delhi	12.50
17.	In silicostudies to understand the interactions and design of reversible and irreversible proton pump inhibitors to H^+, K^+ -ATPase using quantum chemical studies and molecular dynamics simulations	DAE, Mumba	13.76
18.	Transnational approaches to resolving biological bottlenecks in macroalgal biofuel production (SuBBSea)	DBT, New Delhi	47.79
19.	Improving the quality and yield of salt produced from sub soil brines by the marginal agarias of Adesar region of Kutch district through technology up-gradation and improving their income through value addition of bittern	IC, Gandhinagar	126.00
20.	SANS investigation of the silicon rubber membranes	UGC –DAE, Mumbai	0.35
21.	Understanding the reactivation of organophosphate inhibited acetylcholinesterase (AChE) with incleophiles and examining competing aging processes	DST, New Delhi	1.50
22.	Development of ion-exchange membranes and mixed bed resin based electro-deionization process for fluoride removal from groundwater	DST, New Delhi	5.95
23.	Ion Conducting polymer-metal nanocunductive (ICMPN) based electrochemical sensors for Biological Fluids	DST, New Delhi	8.00
24.	Synthesis, Characterization and catalytic application of lonic Liquid supported on Nano-Crystalline Metal Oxides	DST, New Delhi	NR
25.	Organic- Inorganic nano composite ion-exchange membranes for the removal toxic metal ions from waste water by electro dialysis	DST, New Delhi	7.00
26.	Establishment of model salt farm in Markanam salt factory, Tamilnadu	Salt Department, Jaipur	8.00
27.	Synthesis and Characterization of Recyclable chiral transition metal complexes for asymmetric nitroaldol or Henry reaction under homogenous and heterogeneous reaction condition	DST, New Delhi	4.00

Sr. No.	Project Title	Funding Agency	Amount Received (Rs. in Lakhs)
28.	Development of polymer electrolyte membrane for non-conventional electrochemical Energy devices	MNRE, New Delhi	NR
29.	Synthesis of nanostructured materials using metal ammonium carbonate complex as precursor	SERB, New Delhi	NR
30.	The Dye sensitized solar cell/Q-DSSC area of TAPSUN programme	IICT, Hyderabad	NR
31.	Scientific understanding of De-fluoridation employing indigenous resin and comparison with activated alumina	DST, New Delhi	NR
32.	Ion-specific resins and membrane and membrane based system/processes to bring the level of arsenic to WHO limits in drinking water	DST, New Delhi	NR
33.	Development, Demonstration and field trial of indigenous solar powdered electro-dialysis (EDR) technology for providing safe drinking water to the remote village	DST, New Delhi	2.06
34.	Silicone rubber membrane prepared from polysiloxanes of various sizes and types for enhances separation of ethanol from water	SERB, New Delhi	NR
35.	Studies on the dynamics of interfacial electron/ energy transfer processes involving designer molecules and semiconductor particles and of hydrogen bond rapture/reformation processes	DAE, Mumbai	NR
36.	V-through concentrator as technology platform – case study for enhanced output from photovoltaic array powering a community scale reverse osmosis unit	DST, New Delhi	NR
37.	Improving the quality and yield of salt produced from sea brines by the marginal agraias of Amreli district through up-gradation and improving their income through value addition of bittern under the cluster development program	IC, Gandhinagar	NR
38.	Development of Chiral catalysts for asymmetric hydro formulation of olefins for the synthesis of chiral drug intermediates	DST, New Delhi	2.50
39.	Colorimetric sensing of ions with calixarene functionalized gold nanoparticles	DST, New Delhi	2.50
40.	Green and sustainable room temperature ionic liquids from bio renewable feed stocks: Synthesis, physicochemical characterization, self -assembly and interaction with biopolymers gelatin and agarose	DST, New Delhi	6.00

Sr. No.	Project Title	Funding Agency	Amount Received (Rs. in Lakhs)
41.	Test bed for integrated production of 0.75 TPD FCO grade SOP (Sulphate of Potash), 0.75 TPD of ammonium sulphate and 0.3 TPD of ultra-pure magnesia from seawater bittern-based mixed salt through patented process	DST New Delhi	165.00
42.	Sensitized Nano particles as new hybrid photo-driven devices	DST New Delhi	3.11

NR- Funds were not received in the financial year.

2013-2014
(B) Collaborative Projects

Sr. No.	Project Title	Funding Agency	Amount Received (Rs. in Lakhs)
1.	Impact of large scale cultivation of seaweed on coastal environment of India	NCSCM, Chennai	33. 96
2.	To Prepare Bio-diesel from Jatropha Seeds of different origin and carry out performance evaluation by various users	Rolling project	NR
3.	Developing 2 acre Jatropha plantation at Talegaon, Maharashtra	General Motors India Pvt. Ltd., Halol	NR
4.	Determination of the economic viability & technical feasibility of commercial Jatropha curcas production for generation of Jatropha oil as bio-fuels feedstock from wastelands	General Motor Corporation, Warren	77.27
5.	Bio waste and Algae knowledge for the production of 2nd generation Biofuel Development of protoplast based seeding technique and their cultivation using outdoor tank culture system for select seaweed species	University of Rome, Roma	9.16
6.	Research and Development of adsorbent materials for adsorption based space cooling system	Thermax Ltd., Pune	NR
7.	Development Of Adsorbent For Hybrid-Sorption Enhance Steam Reforming Process For Production Of Hydrogen	BPCL, Noida	NR

NR- Funds were not received in the financial year.

2013-2014
(C) SPONSORED PROJECTS

Sr. No.	Project Title	Funding Agency	Amount Received (Rs. in Lakhs)
1.	Testing, Evaluation and performance checking of RO Modules	Darsh Ventures India Pvt. Ltd., New Delhi	0.57
2.	Design; Fabrication, Installation, Operational training and supply of 4000 LPH capacity Brakish water RO plant (One No.)	Central University of Punjab, Punjab	17.,43
3.	Feasibility study on separation of inorganic salts from soilds obtained after drying effluent of organic solvent plant	Viral Alkalis Limited, Maharashtra	10.78
4.	Pre-feasibility study for production of potassium nitrate from sea bittern	Laxmi Industries, Madurai	2.24
5.	Assessment of deterioration in properties and stabilities of used and unused cation and anion-exchange membrane	Kanoria Chemicals & Industries Ltd., Ankleshwar	1.50
6.	Exploratory work to ascertain the potential and possibility of producing SOP using the bittern produced in the little Rann of Kutch (Kharaghoda Region)	NFL, Noida	4.50
7.	Know demonstration for various technologies transferred by CSMCRI to entrepreneurs on charge basis	N M S Pharma, Pepsico India Holding Ltd., Eco Organics etc.	31.39
8.	Supply of RO plants of different capacities to various parties	Govt. of Rajasthan, Uniqflux Membrane, CMFRI, NCC Camp etc.	341.52
9.	Development of nanoclays based on bentonite deposits of Gujarat	GMDC, Ahmedabad	NR
10.	Beneficiation studies of attapulgite for their application in bleaching, oil well drilling & pharmaceutical industries	GMDC, Ahmedabad	NR
11.	Developing process for producing activated clay for suitable hydrocarbons purification from Gujarat natural bentonite clays	GMDC, Ahmedabad	NR
12.	Pre-feasibility study to ascertain in the suitability of Jafarabad coast for cultivation of *Kappaphycus alvarezii*	Assistant Director for Fisheries, Jafarabad	NR

NR- Funds were not received in the financial year.

2013-2014
(D) CONSULTANCY PROJECTS

Sr. No.	Project Title	Funding Agency	Amount Received (Rs. in Lakhs)
1.	Study on pollution level at various beaches of Gujarat	GPCB, Gandhinagar	25.28
2.	Monitoring of coastal waters off Kalatalav surrounding seawater intake and effluent release locations	Nirma Limited, Ahmedabad	21.00
3.	Study of present status of salt pans and assessment of Social, Economical and environmental impact (Positive and Negative) in context to the proposed site of the Kalpasar reservoir	Kalpasar Technical Cell Gandhinagar	NR
4.	Survey and assessment of Mangrove population in Gulf of Khambhat – Kalpasar Project	Executive Engineer, Kalpasar Bhavnagar	NR
5.	Assessment of baseline, environmental quality and social status on coastal, tidal and marine areas of Kalpasar Project	Executive Engineer, Kalpasar Bhavnagar	NR
6.	Collection of physiochemical and marine biological data for regional EIA study for Dholera SIR	GICC, Gandhinagar	6.12

NR- Funds were not received in the financial year.

6. Human Resources Development

A. Training programmes attended by staff members (2012-14)

Sr. No.	Title of the programme	Organizer	Date	Name of the staff
1.	Bi-lingual Workshop on e-auction	SERC, Chennai	30 April-01 May, 2012	Mr. S. S. Chodhari, SPO Mr. B. Rajender Kumar, S.O. (S & P)
2.	Planning for life after Retirement	HRDC, Gaziabad	23-27 July, 2012	Dr. J. Chikara, Sr. Principal Scientist Dr. K. J. Langalia, Principal Scientist Mr. K. Rajagopalan, A.O
3.	Induction Training Programme for newly recruited Scientists	HRDC, Gaziabad	26 Aug.-04 Sept., 2012	Dr. Alok Ranjan Paital, Scientist
4.	Project Management: Tools & Techniques	HRDC, Gaziabad	19-21 Sept., 2012	Mr. Pratyush Maiti, Sr. Scientist Mr. Shibaji Ghosh, Scientist
5.	Taxation Laws-Direct and Indirect Taxes	HRDC, Gaziabad	15-16 Oct., 2012	Mr. V. Harikrishnan, SO (F & A) Mr. M. M. Rathod, Sr. Technician
6.	Modified Accounting Software	HRDC, Gaziabad	18-19 Oct., 2012	Mr. Anil Chandra Gairola, FAO
7.	Innovation: begin doing right away	HRDC, Gaziabad	29-31 Oct., 2012	Mr. Hiren D Raval, Scientist Dr. Mangal Singh Rathore, Scientist
8.	Policies & Procedures on Finance & Accounting	NCL, Pune	5-6 Nov., 2012	Mr. K. Rajagopalan, A.O. Mr. Arvind Kumar, SO Mr. S. D. Chauhan, Assistant Mr. C. B. Gohel, Assistant
9.	Hands on training for ERP HR Portal related processes and configuration of HR Processes for ESS, PMS & Assessment modules	HRDC, Gaziabad	5-6 Nov., 2012	Mr. K. Rajagopalan, A.O. Mr. Arvind Kumar, SO Mr. S. D. Chauhan, Assistant Mr. C. B. Gohel, Assistant
10.	CSIR IT Nodal Officers Meet 2012 and Training of Trainers Programme for ERP modules development under CSIR Enterprises Transformation Project	CSIR-SERC, Chennai	29-30 Nov., 2012	Mr. Sandip Vaniya, Scientist Mr. Vinay Kumar Jaiswal, Section Officer

Sr. No.	Title of the programme	Organizer	Date	Name of the staff
11.	Induction training Programme for newly recruited Scientists	HRDC, Gaziabad	27, Jan., -05 Feb., 2013	Dr. S. B. Kamble, Scientist Mr. S. M. Vaniya, Scientist
12.	Orientation Training Programme for PS/Pas'/ Sr. Stenographers	HRDC, Gaziabad	18-22 Feb., 2013	Mr. V. M. Rajan, PS
14.	राजभाषा कार्यान्वयन - अेक नया दृष्टिकोण	HRDC, Gaziabad	24-26 Oct., 2013	Mr. V. Harikrishnan, SO (F & A) Mr. T. Rambabu, SO(G)
15	Skill Development Programme in Financial Accounting	HRDC, Gaziabad	18-11 Nov., 2013	Mr. Vinay Kumar Jaiswal, SO Mr. R. H. Patel, Assistant (F & A) Gr. II

B. Ph.D Awarded

2012-2013

Sr. No.	Name of the Student	Title of the Thesis	Name of Supervisor	Name of the University
1.	Anupama Srivastava	Production Purification and characterization of the Bipolymer (PHAs) from Biodiesel byproduct (Glyceral) by microbes.	Dr. Sandhya Mishra	Bhavnagar University
2.	Gopalakrishnan	Studies on marine microbes of west coast of india for their potential to produce industrially important enzymes	Dr.(Mrs.) Kalpana H. Mody	Bhavnagar University
3.	Asif A Dabbawala	Hydroformylation and hydrogenation of alkenes catalyzed by transition metal complexes	Dr. H.C. Bajaj	Bhavnagar University
4.	Manoj Kumar	Studies on physiological stress and their biological response in seaweeds	Dr. C.R.K. Reddy	Bhavnagar University
5.	Ghanshyam Joshi	Clay as Drug Delivery Vehicle : Studies on Adsorption and Release Kinetics of Drug Molecules	Dr. H.C. Bajaj	Bhavnagar University

Sr. No.	Name of the Student	Title of the Thesis	Name of Supervisor	Name of the University
6.	Gaurav K Mehta	Chemical studies on polysaccharides derived from Indian seaweed with special reference to sulphated polysaccharides	Dr. A.K. Siddhanta	Bhavnagar University
7.	Sudheesh N.	Development of efficient heterogeneous catalyst systems for the selective synthesis of aldehydes and amines using carbon monoxide	Dr. R.S. Shukla	Bhavnagar University
8.	Rajendra D Patil	Studies on the novel oxidative methods using green bromine as an alternative approach for functional group transformation reactions in organic synthesis	Dr. S. Adimurthy	Bhavnagar University
9.	Trivedi Kunal	Studies on the basic understanding of coagulation and disinfectation by inorganic/Bio-coagulants and other reagents for water treatment	Dr. R.V. Jasara	Bhavnagar University
10.	Nirali Pandya	Studies on the interaction of chiral transition metal complexes with DNA and protein	Dr. Sandhya Mishra	Bhavnagar University
11.	Jinesh C.M.	Catalytic and Ion-exchange Applications of Hydrotalcite-like Materials	Dr. S. Kannan	Bhavnagar University
12.	Prasanjit Mahto	Design and syntheses of New Receptor Molecules for Recognition of Biologically Important Ions and Studies on Supramolecular Self- assembly	Dr. Amitava Das	Bhavnagar University
13.	Amal Kumar Mandal	Design and Synthesis of Receptor Molecules for biologically important analytes & supramocular assemblies	Dr. Amitava Das	Bhavnagar University
14.	Prakash S.	Studies on ion conducting membranes for electrochemical applications	Dr. V.K. Shahi	Bhavnagar University

Sr. No.	Name of the Student	Title of the Thesis	Name of Supervisor	Name of the University
15.	Pravin Ingole	Synthesis, development and comparative study of different chiral polymer material for their efficacy in optical resolution	Dr. H.C. Bajaj	Bhavnagar University
16.	Patil Mallikarjun Vithalrao	Catalysts for eco-friendly organic transformations used for the synthesis of fine chemicals	Dr. R.V. Jasra	Bhavnagar University
17.	Sanjay Kumar	Chemical studies on the polysaccharides of some red seaweed species of Indian coast.	Dr. A.K. Siddhanta	Bhavnagar University
18.	Jaya Prathap	Synthesis and characterization of chiral inorganic Metal complexes as active catalysts for enantio-selective synthesis of chiral B – Amino alcohols via epoxide-ring opening reaction	Dr.(Mrs.) R.I.Kureshy	Bhavnagar University
19.	Kunal Shah	Isolation and characterization of bacteria tolerant to organic solvent for their exploitation in bioremediation	Dr.(Mrs.) Kalpana Mody	Bhavnagar University
20.	Manu V.	Synthesis and characterization of functional mesoporous silica for diverse application like metal adsorption and drug delivery system.	Dr. H.C. Bajaj Dr. H.M. Mody	Bhavnagar University

2013-2014

Sr. No.	Name of the Student	Title of the Thesis	Name of Supervisor	Name of the University
1.	Priyadip Das	Design and Development of different types of molecular probes for selective recognition of biologically important analytes based on supramolecular chemistry	Dr.Amitava Das	Bhavnagar University
2.	Mukul Kamleshchandra Joshi	Genetic transformation of *Jatropha curcas* Linn. with salt responsive gene(s) cloned from *Salicornia brachiata*	Prof. Bhavnath Jha	Bhavnagar University

Sr. No.	Name of the Student	Title of the Thesis	Name of Supervisor	Name of the University
3.	Jitendra Keshri	Metagenomics of alkaliphiles from sodic soil of Gujarat	Prof. Bhavnath Jha	Bhavnagar University
4.	Ulka Sharma	Synthesis and Characterization of Layered double hydroxides (LDHs) for Anion Exchange, Adsorption and Catalysis	Dr.R.V.Jasara	Bhavnagar University
5.	Narendra Singh Yadav	Cloning and Characterization of the Salt *Overly Sensitive 1 (SOS1)* Gene from *Salicornia brachiata* Roxb.	Prof. Bhavanath Jha	Bhavnagar University
6.	P.B.Somayajulu Rallapalli	Porous Metal-Organic Framework (MOF) Materials for Adsorptive and Catalytic Applications.	Dr.R.S.Somani	Bhavnagar University
7.	Sumit V. Jadhav	Inorganic Materials for Green Chemistry: Studies on the Applications of Inorganic Materials to Carry out Environment Friendly Organic Syntheses	Dr.H.C.Bajaj	Bhavnagar University
8.	Sukhdeb Saha	Synthesis of Photoactive Molecular Probes for the Recognition of Cations and Anions of Biological Significance	Dr.Amitava Das	Bhavnagar University
9.	Puja Kumari	Study of lipids, fatty acids and their derivatives in seaweeds.	Dr.C.R.K. Reddy	Bhavnagar University
10.	Kapil Gupta	Isolation and functional analysis of a DREB2 transcription factor from salicornia brachiata.	Dr.Pradeep K Agarwal	Bhavnagar University
11.	Rakeshkumar Jain	Application of alkaliphilic bacteria in Bioremediation	Dr.(Mrs.) Kalpana Mody	Bhavnagar University
12.	Anik Sen	Computational Studies towards Understanding the Role of Solvation on Inorganic, Organic and Biological Systems and Their Possible Applications	Dr.B.Ganguly	Bhavnagar University

Sr. No.	Name of the Student	Title of the Thesis	Name of Supervisor	Name of the University
13.	Arghya Sadhukhan	Synthesis and characterization of chiral catalysts for hydrokinetic resolution (HKR) of racemic epoxides and asymmetric cyanation reactions.	Dr.N.H.Khan	Bhavnagar University
14.	Mr.Ganga Prasad Dangi	Computational studies on Gas adsorption in zeolites and metal-organic frameworks	Dr. R. S. Somani	AcSIR
15.	Mr.Tushar J. Trivedi	Studies on Utilization of Room Temperature Ionic Liquids for the Processing of Biopolymer Agarose	Dr. Arvind Kumar	AcSIR
16.	Mr.Gore Mastan Shaik	Studies on Genetic, Epigenetic Polymorphism in Jatropha curcas L. and Isolation of Novel Molecular Markers"	Dr. Arup Ghosh Dr Mangal Singh Rathore (Co-Guide),	AcSIR
17.	Mr.Apurba Sinhamahapatra	Zirconia Based Mesoporous Materials: Synthesis, Characterization and Heterogeneous Catalysis	Dr. Asit B. Panda Dr. Subhash C. Ghosh (Co-Guide)	AcSIR
18.	Mr.Dinesh Vinayak Patil	Metal-Organic Framework (MOF) Materials For Gas Adsorption And Wastewater Treatment Application	Dr. R. S. Somani	AcSIR
19.	Mr. Mudassar Anisoddin Kazi	Molecular characterization of Caulerpa (Bryopsidales) from Indian waters	Dr. C. R. K. Reddy Dr. Asish K. Parida (Co-Guide)	AcSIR
20.	Mr. Chejara Dharmeshkumar Radheshyam	Chemical studies on the polysaccharides of Indian seaweed species and alginic acid based new materials	Dr. A. K. Siddhanta, Sr. Principal Scientist (Guide), & Dr. Kamlesh Prasad (Co Guide)	AcSIR

D. Project/ Short Term Training Provided

2012-2013

Sr. No.	Name of the Student	Title of the Thesis	Name of Supervisor	Name of the University	Degree
1.	Mr. Yesh Shethiya	Industrial training at institute workshop	Nirma University	Mr. J. K. Pothal	B.Tech
2.	Ms. Ankita Arrora	Extraction of lipids from microalgae and its study on antibacterial activity	Amity University, Noida	Dr. Sandhya Mishra	M.Sc
3.	Ms. Pooja Bachani	Studies on encapsulation, Regeneration and Molecular assessment of invitro shoot cultures	Jayoti Vidyapeeth women's University	Dr. Mangal Singh	M.Sc
4.	Mr. Sachin Nandanwar	Synthesis of ruthenium nano catalyst for hydrogenation of benzene	SVNIT - Surat	Dr. H. C. Bajaj	Ph.D
5.	Mr. Vikrant P. Vadher	Bioflocculant production by an alkaliphilic Bacillus subtilis and its chemical characterization	ARIBAS-V.V. Nagar	Dr. Kalpana Modi	M.Sc.
6.	Mr. Arnab Mondal	Short term training	Heritage Institute of Technolog Kolkata	Prof. B. Jha	B.Tech.
7.	Mr. Virendra P. Vadher	Production, purification & Characterization of Halothermotolerant solvent & ditergent stable lipase from *Bacillus sp.*	ARIBAS-V.V. Nagar	Dr. Sandhya Mishra	M.Sc.
8.	Ms. Aalapi Ajaybhai Bhatt	Short term training	Chaudhari Technology Institute – Gandhinagar	Dr. Parag M Solanki	M.B.A.
9.	Ms. Aastha Jain	Efficacy of oxime drugs towards reaction of Tabun Inhibited Ache: A Docking and Computational study	Birla Institute of Technology Mesra-Ranchi	Dr.B. Ganguly	IASc-INSA-NASI (IIN) summer research fellow

Sr. No.	Name of the Student	Title of the Thesis	Name of Supervisor	Name of the University	Degree
10.	Mr. P. L. Meena	Photocatalytic Degradation of Dyes Using Tio2 Nanotube	Kochin University	Dr. H. C. Bajaj	IIN summer research fellow
11.	Dr. Meghshyam K. Patil	Synthesis and Characterization of Tantalum Based Photocatalysts and its Application for Methylene Blue Degradation	Babasaheb Ambedkar Marathawada Univessity	Dr. H. C. Bajaj	IIN summer research fellow
12.	Mr. Bajaj Anurag	Employee Management System	SVNIT - Surat	Mr. andeep Vaniya	B.Tech
13.	Mr. Sagar Swetamber	Development of High Temperature CO2 adsorbent for steam reforming of natural gas	Rajiv Gandhi Institute of Petroleam Technology, Rae Bareli	Dr.H.C. Bajaj	M.Tech
14.	Ms. Devarshi Patel	Short term training	N.C. Gandhi Mahila Arts and Commerce Collage Bhavnagar	Dr. P. M. Solanki	BMS
15.	Ms. Priya Parekh	Short term training	N.C. Gandhi Mahila Arts and Commerce Collage Bhavnagar	Dr. P. M. Solanki	BMS
16.	Ms. Amanjot Kaur	Study on antibacterial activity of lipid extracts from different marine microalgae	Amity University	Dr. Sandhya Mishra and Dr. Shruti Chatterjee	M.Tech
17.	Ms. Monika Patel	Project work	Project work M.B.Patel College, Anand	Prof. B. Jha	IIN summer research fellow
18.	Mr. Saravanan Jankiram	Energy balance for a photovoltaic pond in a v-through system with external heat dissipation arrangement	Anna University, Chennai	Dr. Pratap S. Bopat	IIN summer research fellow

Sr. No.	Name of the Student	Title of the Thesis	Name of Supervisor	Name of the University	Degree
19.	Mr. Priyank Patel	Design, Synthesis and Structural analysis of two binary Co-crystal derived from (IR,33)-(+)-Canpheric acid and different exobidentate pyridyl doner-ligands	SVNIT - Surat	Dr. E. Suresh	M.Sc
20.	Mr. Nilesh Kanani	Preparation and characterization of charge- transfer complex of TCNQ with various metal ions	SVNIT - Surat	Dr. D. N. Srivastava	M.Sc
21.	Mr. Jigar Patel	Synthesis and spectral characterization of some novel carboxylic Bolamphiphiles	SVNIT - Surat	Dr. P. S. S. Manian	M.Sc
22.	Mr. Yashvant M Khimsuriya	Carried out work on technique of plant tissue culture	ARIBAS- V. V. Nagar	Dr. Aneesha Singh	M.Sc
23.	Ms. Bishnupriya Chhatriya	Project work	IIT – Roorkee	Prof. B. Jha	IIN Summer Research Fellow
24.	Mr. Arijit Ghosh	Short term training	Indus Institute of Technology, Ahmedabad	Dr. A. B. Pandya	B.E.
25.	Mr. Jiten Doshi	Project work	Amity University – Jaipur	Dr. J. Chikara	B.Tech.
26.	Ms. Tahin Subhra sahu	Short term training	Indian School of mines, Dhanbad	Dr.Amitava Das	M.Sc.
27.	Mr. Ravi Kumar	Ionic liquid: green designer's solvent and catalyst	Dayal singh collage, Karnal	Dr.Arvind Kumar	IIN Summer Research Fellow
28.	Mr. Nikunj R Solanki	Short term training	Nirma University	Dr.Subarna Maiti	M.Tech.
29.	Mr. Vivek P Kalariya	Short term training	Nirma University	Dr.Subarna Maiti	M.Tech.
30.	Mr. Vishal Kumar Gohil	Short term training	Nirma University	Dr.Subarna Maiti	M.Tech.

Sr. No.	Name of the Student	Title of the Thesis	Name of Supervisor	Name of the University	Degree
31.	Mr. Kushal J. Parekh	Intranet management system	Govt. Engineering Collage, Bhavnagar	Mr.Sandip M. Vania	B.E.
32.	Mr. Dhruvit. T. Shah	Intranet management system	Govt. Engineering Collage, Bhavnagar	Mr.Sandip M. Vania	B.E.
33.	Ms. Mansi Mukherjee	Short term training	Delhi University	Dr. P. Paul	B.Sc.
34.	Ms. Rutu Majithiya	Turbidimetric analysis of agarose-surface active ionic liquids coacervates in aqueous media	SVNIT - Surat	Dr. Arvind Kumar	M.Sc.
35.	Mr. Chauhan Kuldeep singh	Preparation of estimates for quality control Lab.(Rajula), rain water harvesting system of Vadodaria Park and Hilldrive Colony	Maharshi Arvind International Institute of Technology - Kota	Mr.B.L. Raval	B.Tech.
36.	Ms. Pooja M. Jani	Short term training	Govt. Engineering Collage, Bhavnagar	Mr.H.S. Vasudeva	B.E.
37.	Ms. Unnati K. Dave	Short term training	Govt. Engineering Collage, Bhavnagar	Mr.H.S. Vasudeva	B.E.
38.	Ms. Komal J. Mehta	Short term training	Govt. Engineering Collage, Bhavnagar	Mr.H.S. Vasudeva	B.E.
39.	Mr. Yatrik Bhatt	E-Notice Board	Bhavnagar University	Mr.Sandeep Vania	M.C.A.
40.	Mr. Dipakkumar Rajyaguru	E-Notice Board	Bhavnagar University	Mr.Sandeep Vania	M.C.A.
41	Ms. Niyati Shaileshhai	E-Notice Board	Bhavnagar University	Mr.Sandeep Vania	M.C.A.
42	Ms. Shraddha Patel	Studies on –Distribution of impurities in Salt during natural crystallization- in the field	Bhavnagar University	Dr.A.M. Bhatt	M.Sc.

Sr. No.	Name of the Student	Title of the Thesis	Name of Supervisor	Name of the University	Degree
43.	Ms. Desai Rinkal	PCR based identification of presumptive E.coli isolated from ground water resources of Pohal region	Bhagwan Mahavir College of Biotechnology, Surat	Dr.Kalpana Mody	M.Sc.
44.	Ms. Neena	Synthetic and physicochemical studies of room temperature ionic liquids	Deenbandhu Chhotu Ram University of S & T – Sonepat	Dr.Arvind kumar	Ph.D.
45.	Ms. Gohil Divya M.	Effect of different hormones on in vitro cultures of *Jatropha curcas* and *Simmondsia chinansis*	Bhagwan Mahavir College of Biotechnology, Surat	Dr.Aneesha Singh	M.Sc
46.	Ms. Easha Andharia	Synthesis, Characterization and photocatalytic Application of TiO2 Nanotubes for degradation of Dyes	SRM University Tamil Nadu	Dr.H.C. Bajaj	Project Fellow

2013-2014

Sr. No.	Name of the Student	Title of the Thesis	Name of Supervisor	Name of the University	Degree
1.	Mr. Chirag B. Mehta	Isomerization reaction in continuous flow reactor over solid acid catalyst	Nirma University	Dr. Ms. Beena Tyagi	M.Tech.
2.	Ms. Uma Dwivedi	Synthesis of delaminated layered double hydroxides and their polymer nano composites for water remediation	SVNI -Surat	Dr.S.Kannan	M.Tech.
3.	Mr. Kaushal R. Parmar	Removal of ammonical nitrogen and due by grapheme Tid2 neno composite	SVNIT-Surat	Dr. Shakh Basha	M.Tech.
4.	Mr. Atul Raut	Hydrogenation of phenol using nano-catalyst	SVNIT-Surat	Dr.H.C.Bajaj	M.Tech.

Sr. No.	Name of the Student	Title of the Thesis	Name of Supervisor	Name of the University	Degree
5.	Ms. Sitapara Chandni	Extraction and purification of phycoerythrin from selected strains of cyanobacteria.	Bhagwan Mahavir College of Biotechnology Surat	Dr. Sandhya Mishra	M.Sc.
6.	Mr. Hiren Gaywala	NaOH – Catalyzed *N* – alkylation of 2-Aminobenzothiazoles through *in – situ* generation Aldehyde from Benzyl Alcohols	SVNIT-Surat	Dr. S. Adimurthy	M.Sc.
7.	Mr. Niraj Sarang	Water mediated De-protective Intramolecular Hydroamination ; Synthesis of Imidazo (1,2-a) pyridines.	SVNIT-Surat	Dr. S. Adimurthy	M.Sc.
8.	Mr. G.Praveen Kumar	Synthesis, Characterization and Photocatalytic Application of Graphene-Tio2 Nanocomposite	Bharathiar University, Coimbatore	Dr.H.C.Bajaj and Dr.Rajesh J.Tayade	M.Sc.
9.	Mr. Kukadiya Bipin Rameshbhai	Establishment and multiplication of invitro cultures of economically important plant species	Shree RKICEAS Surat	Dr.Mangal Singh Rathore	M.Sc.
10.	Mr. Bhavik Kumar K. Barmeda	Salinity stress and LSF application induced Physico-Chemical changes in Guar/Maize	Shri A N Patel P.G. Institute Anand	Dr. Mangal Singh Rathore	M.Sc.
11.	Mr. Taher Godhrawala	Preparation and characterization of polymer composite of ue-TCNQ CT complex.	SVNIT-Surat	Dr. D.N. Srivastav	M.Sc.
12.	Mr. Priyank Patel	Design, synthesis and structural analysis of binary cocrystals derived from API 1,4-bis(4-pyridyl)-2,3-diaza-1,3-butadiene and camphoric acid	SVNIT-Surat	Dr. E. Suresh	M.Sc.
13.	Ms. Meghana Chudasama	Extraction,purification and stability studies on C- Phycocyanin from *Spirulina platensis*	Forensic Sciences University Gandhinagar	Dr.Sandhya Mishra	M.Sc.

Sr. No.	Name of the Student	Title of the Thesis	Name of Supervisor	Name of the University	Degree
14.	Ms. Meenaxi Paswan	Studies on various applications of fluorescent property of c-phycocyanin in biological sciences	Forensic Sciences University Gandhinagar	Dr. Sandhya Mishra	M.Sc.
15.	Ms. Ekta B. Jani	Research publication information system	Atimya Institute of Technology and Science Rajkot	Mr.H.S. Vasudeva	M.C.A.
16.	Mr. Jemish B. Patel	Phenotypic and biochemical characterization in response to salt in a halophytic plant	C.G.Bhakta Institute of Biotechnology Surat	Dr.P.K. Agarwal	M.Sc.
17.	Ms.Rupendra Kaur	Self-assembly Behaviour of Surface Active Ionic Liquid, [C4mim][AOT] in Aqueous Media: A physicochemical study	Dr.B.R. Ambedkar National Institute of Technology Jalandhar	Dr.Arvind Kumar	M.Sc.
18.	Ms. Shivani Sharma	Induced Alterations in the Structure of Cytochrome C due to [Choline][AOT] binding: A Spectroscopic Study	Dr.B.R. Ambedkar National Institute of Technology Jalandhar	Dr.Arvind Kumar	M.Sc.
19.	Ms. Shvani Bhardwaj	Short term training	Ashok & Rita Patel Institute of Integrated study and Research in Biotechnology & Allied Sciences VV. Nagar	Dr.Aneesha Singh	M.Sc.
20.	Ms. Anjali Trivedi	Short term training	CHARUSAT VVNagar	Dr.Aneesha Singh	M.Sc.
21.	Mr.Mohit Saini	Short term training	Kurukshtra University	Dr.Arvind Kumar	Ph.D.
22.	Ms. Nupur Shah	Solar Intensity Distribution & Optical Analysis of Solar Still Using ASAP Software	Maulana Azad NIT Bhopal	Dr.S.Maiti	M.Tech

Sr. No.	Name of the Student	Title of the Thesis	Name of Supervisor	Name of the University	Degree
23.	Mr.Brijesh Nanavati	Short term training completed	Pandit Deendayal Petroleum University Gandhinagar	Dr.S.Maiti	B.Tech.
24.	Ms. Archana Kanada	Programming PIC16F877 for Spectrophotometer	Dharmsinh Desai University Nadiad	Mr. Shobit Singh Chauhan	B.Tech.
25.	Ms. Payal Solanki	Programming PIC16F877 for Spectrophotometer	Dharmsinh Desai University Nadiad	Mr. Shobit Singh Chauhan	B.Tech.
26.	Mr. Divyarajsinh A. Zala	Project work	Amity Institute of Biotechnology Jaipur	Dr.P.K. Agarwal	B.Tech.
27.	Mr.M.R.Krishna Prashanth	Siderophore production from bacteria and their chemical characterisation	Madurai Kamaraj University	Dr.K.H. Mody	M.Sc.
28.	Ms. Saloni S. Brahmbhatt	Interaction of greenhouse gases over nitrogen with commercial activated carbon: An adsorption study	Hemchandra charya North Gujarat University Patan	Dr.R.S. Somani	M.Sc.
29.	Ms.Nikita Bhavsar	Phenol adsorption on commercial activated carbon: Equilibrium, kinetics and thermodynamic study	Hemchandra charya North Gujarat University Patan	Dr.R.S. Somani	M.Sc.
30.	Ms. Meera Gaur	Allocation of funds in CSMCRI and its utilization	NBN Singhad School of Management Studies Pune	Finance and Accounts Section	M.B.A.
31.	Mr. Chintan R. Trivedi	Short term training completed	Ashok & Rita Patel Institute of Integrated study and Research in Biotechnology and Allied Sciences V.V.Nagar	Dr.P.K. Agarwal	M.Sc.
32	Ms. Patel Drashti P.	Report on Human Resources Management	Bhavnagar University	Dr.S.C. Upadhyay	M.B.A

Sr. No.	Name of the Student	Title of the Thesis	Name of Supervisor	Name of the University	Degree
33.	Ms. Lokesh Gandreti	Seawater desalination through Vacuum membrane distillation (VMD) using PVDF membranes	MRPG College Vijaynagar A.P.	Dr.Puyam Singh	IIN summer research fellow
34.	Mr.Ch. Nageswara Rao	Esterification of glycerol with stearic acid over sulfated zirconia solid acid catalyst	Andhra University Vizag	Dr.H.C.Bajaj	IIN summer research fellow
35.	Mr.S.Gobi	Solid base catalyzed isomerization of linoleate to conjugated linoleates	University of Madras	Dr.S.Kannan	IIN summer research fellow
36.	Mr. Ch. Siva Prasad	In vitro culture generation and multiplication of Guayule (Parthenium argentatum) - A Potential Source for Rubber	Acharya Nagarjuna University	Dr.Mangal Singh Rathore	M.Sc.
37.	Mr. G. Prabhakaran	Design,Synthesis of Chiral N,O and O,O Donors and their Copper complexes for asymmetric Catalytic Applications	Karunya University Coimbatore	Dr.P.S. Subramanian	M.Sc.
38.	Mr. Omkar Shastri	Solar cells	Vel Tech University Chennai	Dr.Subarna Maiti	B.Tech
39.	Ms.R. Muthu Dharani	Recovery of organic solvent from aqueous organic mixture	Anna University of Technology Coimbatore	Mr.Hiren D. Raval	IIN summer research fellow
40.	Mr. Himanshu Solanki	Short term training completed	DDU Nadiad	Dr.P.S. Bapat	B.E.
41.	Ms. Sowmiya Yessaian	Biochemical and Molecular Characterization of a Soil Bacterium	K.S. Rangasamy College of Arts and Science Tiruchengode	Prof. B.Jha	IIN summer research fellow
42.	Ms. B. Subhikshaa	Human Skin associated microbial diversity	Madurai Kamaraj University	Prof. B.Jha	IIN summer research fellow

Sr. No.	Name of the Student	Title of the Thesis	Name of Supervisor	Name of the University	Degree
43.	Mr.Mihir Kumar Mishra	In Silico Studies Towards The Design of Bowl Based Organic Superbases and Annulene Based Organic Superacids	BITS Pilani	Dr.B.Ganguly	IIN summer research fellow
44.	Mr.Tejas Raval	Short term training completed	Nirma University Ahmedabad	Mr.S.D. Patil	IIN summer research fellow
45.	Mr.P. Steven	Heat and mass Transfer Mathematical Model on Solar Still	Anna University Channai	Dr.P.S. Bapat	IIN summer research fellow
46.	Mr.Nishad Farooqui	Hand Gesture Recognition	Jamia Hamdard University New Delhi	Mr.Sandip Vaniya	M.Sc. student
47.	Ms.Hemali Mody	Training discontinued due to personal reasons	Bhavnagar University	Mr.H.S. Vasudeva	B.E.
48.	Ms.Krupali Chauhan	Training discontinued due to personal reasons	Bhavnagar University	Mr.H.S. Vasudeva	B.E.
49.	Mr.Sandip Solanki	Pressure drop calculations in pipe and pack bed	Government Engineering College, Bharuch	Mr.Pratyush Maiti & Dr.P.S. Bapat	B.E.
50.	Ms. Jasoliya Nitika	IP Address Management System of CSMCRI, Bhavnagar.	Bhavnagar University	Mr.H.S. Vasudeva	B.E.
51.	Ms. Ladhava Jigna H	IP Address Management System of CSMCRI, Bhavnagar.	Bhavnagar University	Mr.H.S. Vasudeva	B.E.
52.	Mr. Sitharam Meesala	Removal of pharmaceutical components from the waste water using adsorption-photocatalysis	SVNIT Surat	Dr.Shaikh Basha	M.Tech.
53.	Ms. Nilpa Prafulbhai Patel	Extraction and purification of c-phycoerythrin and its application as a food colorant	Shri A.N. Patel P.G. Institute, Anand	Dr.S.C. Mishra	M.Sc.

Sr. No.	Name of the Student	Title of the Thesis	Name of Supervisor	Name of the University	Degree
54.	Ms. Aswathi C.S.	Synthesis and Characterization of Binuclear Cu(II) Double stranded Helicate and its Role as Catalyst in Nitroaldol Reaction	Cochin University of Science and Technology	Dr.P.S. Subramanian	M.Sc.
55.	Ms. Vijyalaxmi	Short term training comleted	Kendrya Vidyalaya, Bhavnagar	Dr.Subarna Maiti	XII Std. Student
56.	Mr. Abhishek K Kanbar	Training Report on Instrumentation for \microalgal Research	Government Engineering College Chandkheda	Dr.Sandhya Mishra	M.E.
57.	Dr.G.S. Kamble	Chemo-selective synthesis of aromatic esters from biomass derived levulinic acid with aromatics using solid acid catalysts	KIT'S College of engineering Kolhapur	Dr.S. Kannan	IIN summer research fellow
58.	Mr. Chirag M Thathagar	Short term training completed	Dharmsinh Desai University Nadiad	Dr.P.S. Bapat	Diploma
59.	Mr.Steven Spielberg	Short term training completed	Anna University Chennai	Dr.P.S. Bapat	B.Tech
60.	Ms. Anjana Devi S.	Comparative assessment of nutrient uptake by two commercially important red seaweed at varying degree of exposure : Implication for seed transportation	Muthayammal College of Arts and Science	Dr.Vaibhav Mantri	M.Sc.
61.	Ms. Esaikala M.	Studies on Interaction between the red algae Gelidiella acerosa and Jania and green alga Chactomorpha linum in laboratory condition	Muthayammal College of Arts and Science	Dr.Vaibhav Mantri	M.Sc.

7. Awards and Recognitions

Sr. No	Awards and Recognition	Awardee(s)
1	CIPET National Award by Ministry of Chemicals & Fertilizers for Innovation in Green Polymeric Materials & Products, 2012	Dr. Sandhya Mishra
2	Recognition for Top Cited Papers by Chemical Engineering Journal, Elsevier, Amsterdam, 2012	Dr. T. S. Natarajan, Dr. M.Thomas, Dr. K.Natarajan, Dr. H. C. Bajaj, Dr. R. J.Tayade
3.	Raman Research Fellowship by CSIR, New Delhi, 2012	Dr. Puyam Singh
4.	CSIR-Young Scientist Award in Biological Sciences-2012	Dr. Avinash Mishra
5	Raman Research Fellowship by CSIR, New Delhi, 2012	Dr. Pradeep Agarwal
6	The Best Citizens of India Award by International Publishing House, New Delhi, 2013	Dr. Ramavtar Meena
7	CRSI Bronze Medal by CRSI, Bangalore, 2013	Dr. R. I. Kureshy
8	Outstanding Achievement Award in ERP Implementation by CSIR and DST, Govt. of India, 2013	Mr. Sandipkumar Vaniya
9	Best Poster Award during IUMRS-ICA by The Material Research Society of India, 2013	Mr. Provas Pal
10	Bharat Jyoti Award by International Friendship Society, India, 2013	Mr. Hiren Raval
11	Member, Editorial Board, Indian Journal of Materials Science, 2013	Dr. Ramavatar Meena
12	Project Champion Award for ERP Implementation by CSIR, New Delhi, 2013	Mr. Sanjay Chauhan
13	Brainpool Fellowship by The Korean Federation of Science and Technology, Korea, 2013	Dr. Rajesh Tayade
14	VASVIK Award by Vividhlaxi Audyogik Samsodhan Vikas Kendra, Mumbai for Innovation in Chemical Sciences and Technology, 2013	Dr. A.V. R. Reddy
15	Certificate of distinguished Reviewer by Chemical Physics Letter, and Materials Research Bulletin Elsevier, Amsterdam, 2014	Dr. Rajesh Tayade
16	Best Poster Award during ICRANN by Special Centre for Nanoscience, JNU, New Delhi, 2014	Mr. Provas Pal
17	Young Scientist Award for the 'Best Poster' presentation during conference at GB Pant University of Agriculture & Technology, Uttarakhand, 2014	Ms. Pushpika Udawat
18	Fellow of Indian National Science Academy,New Delhi, 2014	Prof. B. Jha

Membership of Scientific Societies and Committees

S No	Name of the scientist	Name of the committee
1.	Dr. K. Eswaran	▪ Life member & Assistant secretary - Seaweed Research & Utilization Association ▪ Member, 01Research Advisory Group (RAG) Gulf of Mannar Biosphere Reserve Trust.
2.	Dr. A K Siddhanta	▪ Member, American Chemical Society (till March 2014) ▪ Fellow, Indian Chemical Society ▪ Life Member, Seaweed Research & Utilisation Association, Chennai ▪ Life Member, Indian Society of Chemists and Biologists, Lucknow
3.	Dr. R S Somani	▪ Life Member, The Catalysis Society of India ▪ Life Member, The Clays & Clay Minerals Society of India ▪ Member, Purchase committee; ▪ Member, CSIR-UGC Exam committee
4.	Dr. S. Adimurthy	▪ Life Member, Chemical Research Society of India
5.	Dr. Divesh N. Srivastava	▪ Life member, Electron Microscopy Society of India
6.	Dr. R.I. Kureshy	▪ Life Member, The Catalysis Society of India ▪ Life Member, Chemical Research Society of India ▪ Life Member, Indian Society of Chemist & Biologist
7.	Dr. N. H. Khan	▪ Life Member, The Catalysis Society of India ▪ Life Member, Indian Society of Chemist & Biologist
8.	Dr. S. H. R. Abdi	▪ Life Member, Catalysis Society of India ▪ Life Member, Indian Society of Chemist & Biologist
9.	Mr Amit Bhattacharya	▪ Life Member, Indian Chemical Society ▪ Life Member, Indian Science News Association ▪ Life Member, Indian Membrane Society
10.	Dr. Kannan Srinivasan	▪ Member, Executive Committee, The Catalysis Society of India
11.	Ms. Bhoomi R Andharia	▪ Life Member-Indian Society for Wind Engineering, Roorkee,India ▪ Life Member-Association of Hydraulogist of India (AHI), Visakhapatnam, India ▪ Life Member-Indian Society for Hydraulics (ISH), Pune.

8. Deputation abroad: CSMCRI Scientists & Research Scholars

2012-2013

Sr. No	Name	Purpose of Visit	Duration	Country
1	Dr. Arup Ghosh	Participation in Indo Brazil workshop on Bioenergy	18-20/4/2012	Brazil
2.	Dr. C R K Reddy	Participation during the governing board and technical committee meeting of the EU collaborative project	26-27/4/2012	Denmark
3.	Dr. Subarna Maiti	Visited under INSA -Royal Society of Edinburg exchange program	01-30/8/2012	Scotland
4.	Dr. Pradeep Kumar Agarwal	On award of Raman Research Fellowship for the year 2012-13	04/8/2012 to 02/12/2012	South Australia
5.	Dr. Puyam Singh	On award of Raman Research Fellowship for the year 2012-13	31/8/2012 to 30/12/2012	Germany
6.	Prof. B. Jha	To attend 10 European Nitrogen Fixation Conference and to participate in microrihyza meeting	02/9/2012 to 07/9/2012	Germany
7.	Dr. P K Ghosh	To participate on seminar on energies for future	29/11/2012 to 01/12/2012	France
8.	Dr. Shatabdi Porel Mukherjee	To avail IRCSET Empower PDF	03/12/2012 to 02/12/2013	Ireland

2013-2014

Sr. No	Name	Purpose of Visit	Duration	Country
1	Mr. J. Sahoo	Visited University of Aachen, under CSIR-DAAD, Indo-German project	01-30/6/2013	Germany
2	Dr. Rakesh K Jain	To participate in APCSSET 2013	05-08/7/2013	Japan
3.	Ms.Kumari Kavita	Under award of DAAD-Short term Scholarship for Ph.D registered scholar	01/8/2013 to 31/1/2014	Germany
4.	Dr. Sandhya Mishra	To participate in workshop on algal research	02/8/2013 to 05/8/2013	Brazil
5.	Dr. R J Tayade	Under award of Brainpool Fellowship from Korean Federation of Scienec and Tchnology	01/9/2013 to 31/8/2014	Korea
6.	Dr. S. Kannan	To attend and present key note lecture during YQ-India workshop and round table discussion on research activity	05/11/2013 to 11/11/2013	Australia

9. Visitors from abroad to CSMCRI

Sr. No	Name	Name of Organizations	Duration	Purpose of Visit
1	Dr. Renata Perpetuo Reis	Biological Research of Botanical Garden of Rio De Janeiro, Brazil	30/05/2012 to 31/05/2012	Interaction with the team working on Phycological Research
2	Dr. Henrique Geromel De Góes	Autonomy Professional at Algamar Industrial Brazil	30/05/2012 to 31/05/2012	Interaction with the team working on Phycological Research
3	Mr. Nobuhiro Kounoike	Miki Tokushu Paper Manufacturing Company Ltd., Tokyo, Japan	26/06/2012	To discuss on nonwoven fabric at low cost for membrane manufacturing
4	Mr. Shinichiro Miki	Miki Tokushu Paper Manufacturing Company Ltd., Tokyo, Japan	26/06/2012	To discuss on nonwoven fabric at low cost for membrane manufacturing
5	Mr. Raphael Tirivanhu	Ministry of Energy and Power Development Zimbabwe	27/06/2012 to 28/06/2012	To learn crafting and Implementation of Biofuel Polices, Strategies and other Biofuesl Related Research Facilities
6	Mrs. Dorothy Chasi	Environmental Management Agency (EMA), Zimbabwe	27/06/2012 to 28/06/2012	To learn crafting and Implementation of Biofuel Polices, Strategies and other Biofuesl Related Research Facilities
7	Mrs. Danisile Hikwa	Ministry of Agriculture, Mechanization and Irrigation Development Zimbabwe	27/06/2012 to 28/06/2012	To learn crafting and Implementation of Biofuel Polices, Strategies and other Biofuesl Related Research Facilities
8	Mr. Abisai Mafa	WWW International Zimbabwe Country Office, Zimbabwe	27/06/2012 to 28/06/2012	To learn crafting and Implementation of Biofuel Polices, Strategies and other Biofuesl Related Research Facilities
9	Mrs. Tanja Königs, née Rhyen	Institute fuer Organische Chemie, RWTH Aachen University Germany	15/10/2012 to 14/11/2012	To carry out some experimental work under one ongoing project between CSMCRI and University of Achen

Sr. No	Name	Name of Organizations	Duration	Purpose of Visit
10	Dr. Rao Rammohan Visweshwar	Buck Institute for Research on Aging, Novato, California, USA	30/10/2012	Delivered lecture on "Chronic Stress and Brain Aging: Turning Back the aging clock naturally"
11	Dr. Derwenskus Karl-Heinz	Innovation Strategy Technology Office Chemicals, Merck KGaA, Darmstadet, Germany	31/10/2012	To discuss on collaborative work based on water topics amongst others
12	Mr. El-Shtewi Houssein Faraj	Company for Chemical Industries Building, Abu Kammash Area, Libya	19/12/2012	Technical discussion with ESENEM-INIDA for Future Cooperation
13	Mr. Bashir Khalifa Miloud Al Shibani	Ministry of Industry, Libya	19/12/2012	Technical discussion with ESENEM-INIDA for Future Cooperation
14	Ms. Zeglam Verch Iman Mahmoud	Electrolysis Engineer Stiftsgeholz 4, 44265 Dortmund, Germany	19/12/2012	Technical discussion with ESENEM-INIDA for Future Cooperation
15	Mr. Nabin Sarmah	Institute of Mechanical Process and Energy Engineering , School of Engineering and Physical Sciences Heriot-Watt University, Edinburgh, UK	02/01/2013 to 12/01/2013	To explore future research collaborations in the area of applied solar energy research
16	Miss Amanda J Hughes	Institute of Mechanical Process and Energy Engineering , School of Engineering and Physical Sciences Heriot-Watt University, Edinburgh, UK	02/01/2013 to 12/01/2013	To explore future research collaborations in the area of applied solar energy research
17	Ms. Amanda Hughes	Heriot Watt University, Edinburgh, UK	06/01/2013 to 12/01/2013	To explore possibilities on collaboration research on concentrated photovaltial system
18	Dr. Nabin Sharmah	Heriot Watt University, Edinburgh,UK	06/01/2013 to 13/01/2013	To explore possibilities on collaboration research on concentrated photovaltial system

Sr. No	Name	Name of Organizations	Duration	Purpose of Visit
19	Mr. Jan Alexander Stuberuch	Instiut für Organische Chemie, Aachen, Germany	04/02/2013 to 04/03/2013	To carry out research work under the project under common project Aachen and Bhavnagar.
20	Mr. Jan A. Stubenrauch	University of Aachen, Germany	04/02/2013 to 04/03/2013	Visit under CSIR – IB – BMBF program
21	Mr. Andrew Celoka-Eboka	Federal Universal of Agriculture, Nigeria	24/09/2013 to 08/12/2013	To avail JNCASR – CICS fellowship
22	Mr. Banjo Semire	Federal Universal of Agriculture,Nigeria	16/11/2013 to 14/02/2014	To avail JNCASR – CICS fellowship
23	Mr. Just-Geraud Boni	Republic of Cot D Ivory (Ivory Coast)	01/12/2013 to 28/02/2014	To avail CV Raman international fellowship for African researchers
24	Dr. Roda Nuvunga Luis	Water Research Institute, Mozambique	20/01/2014 to 22/01/2014	To discuss possibilities of technology transfer
25	Dr. Laurinda Macamo Zefanias	Water Research Institute, Mozambique	20/01/2014 to 22/01/2014	To discuss possibilities of technology transfer
26	Mr. Ravindra Abhyankar	Minister of S&T, Govt. of Mozambique	20/01/2014 to 22/01/2014	To discuss possibilities of technology transfer
27	Mr.Philip Arish	United Kingdom	27/03/2014	Scientific and publishing discussion

10. Distinguished Visitors & Lectures

2012-2013

Sr. No.	Date	Speaker	Title of the lecture
1	29.06.2012	Dr.Santanu Karan National Institute for Materials Science ,Namiki, Tsukuba, Japan	Free-standing carbon nanosheets for ultrafast oil filter: Purification on a molecular level
2	11.07.2012	Prof. Vinayak Sinha Indian Institute of Science Education and Research (IISER) , Mohali	Applications of proton transfer reaction mass spectrometry (PTR-MS) for real time organic trace gas studies
3	16.07.2012	Dr. Punyasloke Bhadury IISER-Kolkata	Phytoplankton communities of the Indian Sundarbans mangroves- a view through the molecular window
4	18.07.2012	Prof. Rekha S Singhal Institute of Chemical Technology, Mumbai	Fermentative Production and Downstream Processing of Poly(g)-Glutamic Acid
5	30.10.2012	Dr. Rammohan Rao Buck Institute for Research on Aging, California, USA	Chronic stress and brain aging: turning back the aging clock naturally

2013-2014

Sr. No.	Date	Speaker	Title of the lecture
1	09.05.2013	Dr. Santanab Giri Univerdsidad de Chile and QTC Pontificia Universidad Catolica de Chile,Chile	Stability, reactivity and aromaticity of molecules: A conceptual DFT and *ab-initio* molecular dynamics study
2	31.05.2013	Prof. Dr. Vilas G. Gaikar Institute of Chemical Technology, Mumbai	engineering aspects of algal growth in photobioreactors and thermochemical conversion of biomass
3	14.06.2013	Dr. Gyanendra Gupta Dr. Darshan Shukla Dr. Vipul Parikh Sterling Hospital, Bhavnagar	1. How to relax during work? 2. How to handle chemical burns and poisoning during work 3. Basics of CPR (Cardio Pulmonary Resuscitation)
4	17.06.2013	Prof. K. Veluthambi Madurai Kamaraj University Madurai	Selectable marker elimination in transgenic rice

Sr. No.	Date	Speaker	Title of the lecture
5	05.07.2013	Dr. Sujay Chattopadhya Indian Institute of Technology, Roorkee	Drug delivery through liposome- a brilliant scope
6	11.07.2013	Dr. Sounak Roy BITS Pilani, Hyderabad	Environmental catalysis: from mechanism and materials properties to catalytic performance
7	12.07.2013	Dr. I. N. N. Namboothiri Indian Institute of Technology, Mumbai	Catalytic asymmetric synthesis of aminophosphonates: the transition state analogs of amino acids
8	13.07.2013	Dr. Ajay Mishra University of Johannesburg, South Africa	Nanomaterials for waste water application
9	30.07.2013	Dr. Sunil Mukherjee Univ of Delhi, New Delhi	RNAi and its suppression
10	30.07.2013	Dr. Parichay Kumar Das Institute of Chemical Technology, Hyderabad	The Importance of being a reaction calorimeter
11	22.08.2013	Ms. Seema Singh Forbes India, Bangalore	Why communicate science (Science Communication)
12	23.08.2013	Mr. R K Gupta IPU, CSIR, New Delhi	IP management in Publically funded R&D and academic institutions
13	22.10.2013	Prof. S. Ramasesha IISc, Bangalore JNCASR, Bangalore	Modeling electronic, optical and magnetic molecular materials
14	26.11.2013	Prof. Rajendra Prasad Jawaharlal Nehru University New Delhi	Multi drug resistance: From microbes to man
15	9.12.2013	Prof. A N Lahiri Majumder Bose Institute, Kolkata	Physiological and molecular basis of salt-tolerance in plants: Role of the Inositol metabolic pathway.
16	30.12.2013	Prof. Anant Vallabhbhai Patel University of Applied Sciences Bielefeld, Germany	Fermentation and formulation of biologicals and chemicals
17	17.02.2014	Prof. Dinesh O. Shah University of Florida, Gainesville, USA	How to conduct an innovative research on surface science and nanotechnology to meet global needs

Sr. No.	Date	Speaker	Title of the lecture
18	21.02.2014	Dr. Soumen Mukherjee Gulbrandsen Chemicals Vadodara	Homogeneous Catalysts for Olefin Oligomerization and Polymerization
19	20.03.2014	Dr. Geeta Gida Prasar Bharti All India Radio, Rajkot	Communication skill with psychological angle
20	24.03.2014	Prof. B. C. Harinath Mahatma Gandhi Institute of Medical Sciences,Sevagram	Mycobacterial Es-31 serine protease - an immunogen and biomarker of diagnostic interest and with potential as drug target
21	24.03.2014	Prof. Anamik Shah Gujarat Vidyapeeth	Synthesis and cancer pharmacology of some heterocyclic entities
22	24.03.2014	Ms. Supriya Kashikar GeNext Genomics Pvt. Ltd. Nagpur	Novel approach to identify and validate drug target in tuberculosis

11. Invited Talks / Lectures Delivered By CSMCRI Scientists

2012-2013

Sr No	Title of Talk / Lecture	Name of the Seminar / Conference / Institute	Place	Presenter(s)
1	Our Initiatives in harnessing renewable energy for sustainable development	Indian Institute of Science Education and Research April 18, 2012	Mohali	Dr. P.K. Ghosh
2	The work and the benefits of the Research Institute to the society	Akashwani, All India Radio July 11, 2012	Rajkot	Dr. P.K. Ghosh
3	Water for sustainable development	Bhavnagar University July 21-25, 2012	Bhavnagar	Dr. Vaibhav Kulshrestha
4	Quest for sustainable solutions to the problems of energy and water	Mahatma Gandhi University July 30, 2012	Kottayam	Dr. P K Ghosh
5	Recent innovations in green chemistry at CSIR-CSMCRI	Mahatma Gandhi University August 01, 2012	Kottayam	Dr. P K Ghosh
6	दैनिक कार्यों में सरल हिन्दी का प्रयोग	हिन्दी सप्ताह समारोह, दूरदर्शन अनुरक्षण केन्द्र, 14 सितंबर, 2012	भावनगर, गुजरात	डॉ. आर.एस. शुक्ला
7	Ionic liquids: alternative solvents for diverse chemical applications	Chemical Constellation Cheminar –2012. Dr. B R Ambedkar National Institute Of Technology September 09-12, 2012	Jalandhar	Dr. Arvind Kumar
8	Ionic liquid induced structural changes of bsa in aqueous media	Chemical Constellation Cheminar –2012. Dr. B R Ambedkar National Institute Of Technology September 09-12, 2012	Jalandhar	Dr. Arvind Kumar and Mr. Pankaj Bharmoria
9	Membrane separation for chemicals & allied process industries	G.H. Patel College of Engineering & Technology October 12, 2012	V. V. Nagar Gujarat	Dr. V. K. Shahi

Sr No	Title of Talk / Lecture	Name of the Seminar / Conference / Institute	Place	Presenter(s)
10	Valorization of biomass to fuels and chemicals	Workshop on Applications of Nanotechnology and Catalysis in Clean Energy, Biofuels, Chemicals and Hydrogen Generation November 7-8, 2013	University of Queensland Australia	Dr. S. Kannan
11	Latest trend in specialty glass and ceramics	APC Roy Seminar Hall, CSIR-CGCRI December 11, 2012	Kolkata	Dr. P K Ghosh
12	Invited Talk- Use of transgenics for functional validation of genes	Workshop on Application of Genomics in Crop Improvement at GB Pant University of Agriculture and Technology January 05, 2013	Pantnagar	Dr. Avinash Mishra
13	Keynote address	Indian Chemical Council January 10, 2013	Ahmedabad	Dr. P K Ghosh
14	Ion-exchange membranes and electrodialysis for the water: desalination, ultrapure water and mineral water with nutritious constituents	Chemistry Department, DDU Gorakhpur University January 16, 2013	Gorakhpur U.P.	Dr. V. K. Shahi
15	Organic–inorganic nanocomposite polymer electrolyte membranes for energy: Fuel cell and energy based on concentration gradient	Chemistry Department, DDU Gorakhpur University January 18, 2013	Gorakhpur U.P.	Dr. V. K. Shahi
16	Electro-membrane process for in-situ ion substitution and separation of biomolecules	Chemistry Department, DDU Gorakhpur University January 18, 2013	Gorakhpur U.P.	Dr. V. K. Shahi
17	राजभाषा– हिन्दी पर प्रासंगिक व्याख्यान	हिन्दी कार्यशाला, भारतीय विमानपत्तन प्राधिकरण 18, जनवरी, 2013	भावनगर, गुजरात	डॉ. आर.एस. शुक्ला

Sr No	Title of Talk / Lecture	Name of the Seminar / Conference / Institute	Place	Presenter(s)
18	Recent progress in selective separation and transport of metal ions using polymer inclusion membranes	DDU Gorakhpur University January 22, 2013	Gorakhpur U.P.	Dr. V. K. Shahi
19	Asymmetric Strecker Reaction Catalyzed by Chiral Catalysts	Mohanlal Sukhadia University March 02, 2013	Udaipur, Rajasthan	Dr. N. H. Khan
20	Chiral Catalysis an Important Tool for the Synthesis of Pharmaceutically Active Molecules	Mohanlal Sukhadia University March 02, 2013	Udaipur, Rajasthan	Dr. R. I. Kureshy
21	Membrane separation science- an introduction technical education quality improvement	Sardar Vallabhai National Institute of Technology September 03, 2013	Surat	Dr. Amit Bhattacharya
22	Pesticide in water - Awareness and encounter by membranes technical education quality	Sardar Vallabhai National Institute of Technology September 03, 2013	Surat	Dr. Amit Bhattacharya
23	Plenary talk on Surface Active Ionic Liquids and their Applications	International Conference at Arya College, Panipat February 24, 2013	Panipat, Haryana	Dr. Arvind Kumar
24	Cross Linked Functional Polymers & Water Treatment	UGC & GUJCOST Sponsored National Conference February 02, 2013	Palanpur	Dr. K M Popat
25	Ionic Liquids: Alternative Solvents for Diverse Chemical Applications	Department of Chemistry, Kurukshetra University Kurukshetra February 22, 2013	Haryana	Dr. Arvind Kumar

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Sr No	Title of Talk / Lecture	Name of the Seminar / Conference / Institute	Place	Presenter(s)
1	Popular scientific lecture	Indian Association for Cultivation of Science April 19, 2013	Kolkata	Dr. P K Ghosh
2	Invited talk	CSIR-URDIP May 13, 2013	Pune	Dr. P K Ghosh

Sr No	Title of Talk / Lecture	Name of the Seminar / Conference / Institute	Place	Presenter(s)
3	Vision and Innovation from a CSIR laboratory perspective	Hotel Ramada, Navi Mumbai May 17, 2013	Mumbai	Dr. P K Ghosh
4	Invited talk	IIT, Kanpur August 07, 2013	IIT, Kanpur	Dr. P K Ghosh
5	Distinguished lecture	CSIR-NGRI September 13, 2013	Hyderabad	Dr. P K Ghosh
6	Highly stable and conducting polymer electrolyte membranes for fuel cell and concentration gradient based energy devices	DAE-BRNS Theme meeting on membrane separations for fuel cycle applications at BARC September 16, 2013	Mumbai	Dr. V. K. Shahi
7	Effect of SHI on ion conducting polymer electrolyte membranes	International conference of Nanostructure by ion beam October 23-25, 2013	Jaipur	Vaibhav Kulshrestha
8	Materials science & society	Sardar Patel University October 24, 2013	V.V. Nagar Gujarat	Dr. P K Ghosh
9	Ionic liquids as novel solvents and surfactants	NIT October 06-07, 2013	Jalandhar	Dr. Arvind Kumar
10	Materials challenges for future & renewable energy	Science City November 16, 2013	Ahmedabad	Dr. P K Ghosh
11	International conference on membranes and applications	CSIR-CGCRI November 22, 2013	Kolkata	Dr. P K Ghosh
12	Isothermal titration microcalorimetry of self-assembling process of surfactant like ionic liquids in aqueous and ionic liquid medium	National Conference on Thermodynamics Babasaheb Bhimrao Ambekdar University November 25, 2013	Lucknow, U.P.	Dr. Arvind Kumar
13	Development of novel catalyst systems for the reactions of the C_1 chemicals	Refresher Course in Chemistry for teachers DDU Gorakhpur University January 23, 2014.	Gorakhpur, U.P.	Dr. R.S. Shukla

Sr No	Title of Talk / Lecture	Name of the Seminar / Conference / Institute	Place	Presenter(s)
14	Metal complex based catalysts in the reactions of carbon monoxide.	Refresher Course in Chemistry for teachers DDU Gorakhpur University January 23, 2014.	Gorakhpur, U.P.	Dr. R.S. Shukla
15	Rhodium complexes based heterogeneous catalyst systems in hydroformylation reactions.	Refresher Course in Chemistry for teachers DDU Gorakhpur University January 23, 2014.	Gorakhpur, U.P.	Dr. R.S. Shukla
16	Workshop on Facilitating Technology Acquisition Confederation of Indian Industry and Gujarat	NRE Knowledge Application & Facilitation Centre January 24, 2014	Ahmedabad	Dr. D B Shukla
17	Heterogeneous catalytic conversion of biomass to fuels and chemicals	Lecture under Dharamsi Morarji Chemical Company Visiting Fellowship in Chemistry February 03, 2014	ICT, Mumbai	Dr. S. Kannan
18	Structural and mechanistic understanding of catalytic reactions – Key to design new materials	16th National Workshop on Catalysis for Sustainable Development February 04-05, 2014	CSIR-NEERI, Nagpur	Dr. S. Kannan
19	Electro-membrane processes for desalination: Ultrapure and mineral-enriched drinking water	Indian Water Congress February 07-08, 2014	V. V. Nagar (Gujarat)	Dr. V. K. Shahi
20	Ionic liquids as surfactants and ionic liquids-polymers based advanced functional materials	National Conference at Arya College February 24, 2014	Panipat, (Haryana)	Dr. Arvind Kumar
21	Organic-inorganic hybrid membranes for water & energy	National conference on Organic/inorganic functional materials: A current perspective, DDU Gorakhpur University March 02, 2014	Gorakhpur U.P.	Dr. V. K. Shahi

12. Dateline CSMCRI

2012-2013

Date	Salient Details
10 April 2012	59th CSIR-CSMCRI Foundation Day Celebrations
07-08 May 2012	64th CSIR-UGC NET Examination
17 June 2012	CSIR-UGC NET Examination
13 July 2012	31th Management Council Meeting
14 सितम्बर 2012	हिन्दी दिवस समारोह
26 September 2012	CSIR Foundation Day Celebrations
05 October 2012	32nd Management Council Meeting
26 October 2012	Vigilance Awareness Week
18 December 2012	33rd Management Council Meeting
23 December 2012	CSIR-UGC NET Examination
28-29 December 2012	65th Research Council Meeting
13-15 February 2013	CPCB Sponsored training program on "EIA Studies & EMP of Contaminated Sites for Industrial Sector"
28 February 2013	National Science Day Celebrations
04 March 2013	National Safety Day Celebrations
18-19 March 2013	66th Research Council Meeting
11 March 2013	Erwadi, Tamil Nadu RO-Plant inauguration
25 March 2013	Bangla Pali, Andhra Pradesh, RO-Plant inauguration
24-26 June 2013	RO Bus departure to provide safe drinking water for the victims of Uttarakhand flood

2013-2014

Date	Salient Details
10 April 2013	60th CSIR-CSMCRI Foundation Day Celebrations
13 अप्रैल 2013	संसदीय समिति द्वारा संस्थान में राजभाषा के कार्यान्वयन एवं इसके प्रगामी प्रयोगों की प्रगति का निरिक्षण
23 June 2013	CSIR-UGC NET Examination
14 सितम्बर 2013	CSIR Foundation Day Celebrations
26 September 2013	हिन्दी दिवस समारोह
21 October 2013	34th Management Council Meeting
26 October 2013	Vigilance Awareness Week
29-30 November 2013	67th Research Council Meeting
22 December 2013	CSIR-UGC NET Examination
24 February 2014	TFC Membrane, Pune Plant inauguration by Dr. PK Ghosh
26-28 February 2014	Jaipur Exhibition
28 February 2014	National Science Day Celebrations

13. Seminars/ Workshops/ Events/ Meetings Organized



Prof. Devang Khakhar, Director IIT, Mumbai, was the Chief Guest on 10th April 2012 who addressed on CSMCRI Foundation Day by a video telecast.



Dr. K Venkataraman, Director Zoological Survey of India, was the Chief Guest and delivered the CSIR Foundation Address on "Marine Biodiversity Conservation in India" on 25th September, 2012



Padma Bhushan Prof. Sukh Dev, was the Chief Guest and delivered the CSMCRI Foundation Address on "A Chemist's Journey through India's Biodiversity" on CSIR-CSMCRI Foundation Day on 10th April, 2013



Mr. M A Ansari, Salt Commissioner, Govt. Of India, was the Chief Guest and delivered the CSIR Foundation Address on "Economics of Salt Technology –Issues to be Addressed" along with Mr H D Shrimali, Additional Industries Commissioner, Govt. of India was the Guest of Honour on 26th September, 2013



Jaipur Exhibition held on 26-28 February, 2014 for State level National Science Day Exhibition



A workshop was organized at CGCRI, Kolkata on "Arsenic Removal Technology" on 23rd April, 2013

14. Appointments

Sr No	Name	Designation	Date
1	Mr. Sunilkumar G Dalal	Assistant(G) Gr.I	04.06.12
2	Mr. Arvind Kumar	Section Officer CASE-09	12.07.12
3	Dr. Subhash Chandra Ghosh	Scientist	28.12.12
4	Mr. Baraiya Narshibhai R	Technician(1)	24.07.13
5	Mr. Hitesh T Saravaia	Scientist	02.08.13
6	Mr. Bhupendra Kumar Markam	Scientist	16.08.13
7	Mr. Mahesh H Makwana	Technician (1)	12.08.13
8	Mr. Kaushik K Danddhariya	Technician (1)	08.08.13
9	Mr. Rathod Harpalsinh D	Technician (1)	06.08.13
10	Mr. Chetankumar G Vaghela	Technician (1)	06.08.13
11	Mr. Sunilbhai S Chaudhari	Technician (1)	04.09.13
12	Ms. Bhoomi R Andhariya	Scientist	09.09.13
13	Mr. Rajeshkumar K Dhandhukiya	Technician Officer	25.09.13
14	Mr. Vipin Chandra Joshi	Technician Assistant	09.10.13
15	Mr. Mayank S Roongta	TechnicalOfficer	23.10.13
16	Mr. Hardik V Makwana	Assistant(G) Gr.III	28.10.13
17	Dr. Ankkur Goel	Principle Scientist	01.11.13
18	Mr. Raijada Shaktipalsinh D	Technical Officer	31.10.13
19	Mr. Anand N Chaudhari	Technical Assistant	15.11.13
20	Mr. Sunny D Rathod	Trainee Atteendent Canteen	19.11.13
21	Mr. Nirav V Gadhiya	Technical Officer	25.11.13
22	Mr. Mohamad Vasim Abdul Vali Patel	Technical Officer	09.01.14
23	Mr. Amaliar Govindkumar Gavjibhai	Technical Assistant	09.01.14

15. Retirement/Voluntary/Transfer/Termination/Resignation

Sr No	Name	Designation	Date	Remarks
1	Mr. Kumar Rahul	SO(G)	27.04.12	Transferred to NML
2	Mr. Girja Shankar Verma	SO(S&P)	04.05.12	Transferred to NBRI
3	Mr. Dhiren J Patel	Tech.(1)	04.06.12	Resigned
4	Mr. D R Thakar	Sr. Tech.(2)	03.07.12	Expired
5	Mr. V Balakrishna	Sr. Pri. Scientist	31.07.12	Retired
6	Dr. S K Thampy	Sr. Pri. Scientist	30.09.12	Retired
7	Dr. P M. Solanki	Principal Scientist	17.10.12	Transferred
8	Mr. A S S Ahmed	Tech.(2)	16.11.12	Expired
9	Dr. J. Chikara	Sr. Pri. Scientist	30.11.12	Retired
10	Mr. K Rajagopalan	AO	31.12.12	Retired
11	Mr. B D Vala	Record Keeper	31.12.12	Retired
12	Dr. V P Mohandas	Sr. Pri. Scientist	31.12.12	Retired
13	Dr. J J Trivedi	Sr. Pri. Scientist	31.12.12	Retired
14	Dr.(Mrs) Nivedita Sahu	Scientist	25.01.13	Transferred to IICT
15	Dr.(Mrs) Sangita Goel	Scientist	01.03.13	Transferred to NEERI
16	Dr. Amitava Das	Sr.Pri. Scientist	01.04.13	Transferred to NCL
17	Mr. G G Kalena	Sr.Tech.(2)	30.04.13	Retired
18	Mr. D B Valodara	Sr.Tech.(2)	30.04.13	Retired
19	Mr. B T Rathod	Sr.Tech.(2)	31.05.13	Retired
20	Mrs. Hansaben D Rathod	Wash Person	21.06.13	Expired
21	Ms. Geeta S Tiwari	Lab. Attdt.(1)	28.06.13	Transferred to NEERI
22	Mr. L M Kachhadia	Sr.Tech.Officer	30.06.13	Retired
23	Dr. D B Shukla	Chief Scientist	31.08.13	Retired
24	Dr. K J Langalia	Principal Scientist	31.08.13	Retired
25	Mr. Anil C. Gairola	F&AO	13.12.13	Transferred to IIP
26	Dr. Soumyadeb Ghosh	Sr. Pri. Scientist	03.01.14	Resigned
27	Dr. H M Mody	Principal Scientist	31.01.14	Retired
28	Mrs. N A Trivedi	Asstt.(F&A) Gr.I	05.02.14	Voluntary Retired
29	Dr. S T Zodape	Sr. Pri. Scientist	28.02.14	Retired
30	Dr. A K Sidhanta	Sr. Pri. Scientist	31.03.14	Retired
31	Mr. C D Gohel	Bearer (Canteen)	31.03.14	Retired

16. Resources – Staff and Budgetary Details

Category	Particulars	Persons on Roll 31.3.2013	Persons on Roll 31.3.2014
Scientific	Group IV	89	87
Technical	Group III	35	42
	Group II	56	59
	Group I	15	14
	Total (Technical)	**106**	**115**
Non – Technical	Group A	08	07
	Group B	24	23
	Group C	18	17
	Group D	00	01
	Total (Non- Technical)	50	48
	Total 'A'	**120**	**116**
	Ad-hoc Scientist	0	0
	Scientist Fellow (QHS)	**0**	**0**
	EMR and project related temporary personnel		
	Project Advisor	0	0
	Emeritus Scientist	0	0
	Scientist (Fellow)	2	2
	Woman Scientist	1	1
	Csir-Twas Fellow	0	0
	Senior Research Associate	1	1
	Research Associate (Project)	2	4
	Senior Research Fellow [CSIR/UGC]	51	51
	Senior Research Fellow (Project)	5	1
	Junior Research Fellow (Project)	10	9
	Junior Research Fellow (CSIR/UGC)	33	26
	Project Assistant Iii,Ii,I	14+80+32=126	18+105+17=140
	Assistant Engineer	1	1
	Dsir Inspire Faculty	0	2
	Shift Incharge	2	1
	Project Technician	1	2
	Electrician	1	1
	Plant Supervisor	1	0
	Dst Young Scientist	0	2
	Summer Research Fellow	1	0
	Data Entry Opertor	0	0
	Technical Consultant	1	1
	Csir Nehru Pdf	2	0
	Executive Assistant (ACSIR)	0	1
	Total	**241**	**246**
	Apprentice	25	26
	Total 'B'	**266**	**272**
	Total A+B	**386**	**388**

CSIR Allocation

Financial Year	2012-2013 Rs. in Lakhs	2013-2014 Rs. in Lakhs
A. Revenue (National Labs.)		
Total Salaries	1825.369	1612.218
Budget (Including P04/P05/P06/P70-Staff Qtr.)	263.350	85.945
P07 Chemical/Consumables& Other Res.	968.610	306.000
Total Revenue	**3057.329**	**2004.163**
B. Capital (National Labs.)		
Budget (Including W & S/ Staff Qtrs. Capital)	82.113	60.000
P-50 Land Cost	0	0
P-50 (App. & Equipment / Computer Equipment / Off. Equipment)	554.500	0.000
P-50 (Furniture & Fittings/Workshop Machinery)	4.000	0.000
P-50 (Library Books/Lib. Journals)	90.000	76.761
P-50 Vehicles	0.000	0.000
P-26 (ICT) (Infrastructure/Facilities)	0.000	0.000
Total Capital	**730.613**	**136.761**
Total Revenue + Capital (A+B)	**3787.942**	**2140.924**
C. Total Network & RSP Projects	392.409	1729.739
Total National Lab. (A+B+C)	4180.351	3870.663
P-61 NMITLI	**78.554**	**1.599**

Revenue other than CSIR Allocation

Financial Year	2012-2013 Rs. in Lakhs	2013-2014 Rs. in Lakhs
Sponsored R&D	649.649	428.884
Collaborative/Cooperative R&D	134.770	121.784
Grant-in-Aid R&D	266.637	575.338
R&D Consultancy	4.418	52.408
SMM	0.000	0.000
SUB TOTAL (ECF)	**1055.47322**	**1178.414**
Analytical/Tech. Services	21.237	17.763
Knowhow transfer/Royalty	55.866	51.932
Sale of Lab Products	2.671	0.190
Conference/Seminar/Workshop	0.000	0.000
SUB TOTAL (credited to CSIR/Lab Reserve)	**79.774**	**69.88541**
Amount collected as service tax (Repaid to government)	27.395	46.935
GRAND TOTAL	**1162.642**	**1295.234**

Laboratory Reserve

Financial Year	2012-2013 Rs. in Lakhs	2013-2014 Rs. in Lakhs
Balance At The Beginning of The Year	**1168.508**	**1576.400**
Add Generation During the Year	422.855	390.119
Less Expenditure During the Year	14.963	598.791
Closing Balance at The End of The Financial Year	**1576.399**	**1367.728**

17. Research Council

2012-2013

Prof. G. D. Yadav Director (VC & R T Mody Distinguished Professor), J C Bose National Fellow, Institute of Chemical Technology Nathalal Parekh Marg, Matunga, Mumbai – 400 019	**Chairman**
Prof. Alok Bhattacharya Schools of Life Sciences and Computation & Integrative Sciences Jawaharlal Nehru University New Delhi – 110 067	**Member**
Dr. Prashant Puri President of R&D and JEP of Aditya Birla Nuvo Business Aditya Birla Nuvo Ltd. (IndoGulf Fertilizers and Aditya Birla Resume) Aditya Birla Centre, S. K. Ahire Marg, Worli Mumbai – 400 030	**Member**
Prof. G. Subramanian E - 204, Vasant Vihar Apartments, Cross West Extension, Thillai Nagar, Tiruchirapalli – 620 018	**Member**
Dr. R. R. Hirwani Head, CSIR-Unit for Research and Development of Information Products, Jopasana,85/1 Paud Road Pune – 411 038	**Member**
Dr. S. W. A. Naqvi Director, CSIR-National Institute of Oceanography Dona Pula, Goa – 403 004	**Member**
Prof. Anuradda Ganesh Department of Energy Sciences Engineering Indian Institute of Technology, Powai,Mumbai – 400 076	**Member**
Dr Pushpito K Ghosh Director, CSIR-CSMCRI Bhavnagar, Gujarat 364002	**Member**
Shri Gaurav Dave Joint Secretary National Manufacturing Competitiveness Council, Vigyan Bhawan Annexe, Maulana Azad Road, New Delhi – 110 011	**Member**
Dr. Suresh Das Director, CSIR-National Institute for Interdisciplinary Science & Technology Industrial Estate P.O. Thiruvananthapuram – 695 019	**Member**
Dr S H R Abdi DC, BDIM, CSIR-CSMCRI, Bhavnagar 364002	**Member Secretory**

2013-2014

Prof. G. D. Yadav Director (VC & R T Mody Distinguished Professor), J C Bose National Fellow, Institute of Chemical Technology Nathalal Parekh Marg, Matunga, Mumbai – 400 019	**Chairman**
Prof. Alok Bhattacharya Schools of Life Sciences and Computation & Integrative Sciences Jawaharlal Nehru University New Delhi – 110 067	**Member**
Dr. Prashant Puri President of R&D and JEP of Aditya Birla Nuvo Business Aditya Birla Nuvo Ltd. (IndoGulf Fertilizers and Aditya Birla Resume) Aditya Birla Centre, S. K. Ahire Marg, Worli Mumbai – 400 030	**Member**
Prof. G. Subramanian E - 204, Vasant Vihar Apartments, Cross West Extension, Thillai Nagar, Tiruchirapalli – 620 018	**Member**
Dr. R. R. Hirwani Head, CSIR-Unit for Research and Development of Information Products, Jopasana,85/1 Paud Road Pune – 411 038	**DG's nominee**
Dr. S. W. A. Naqvi Director, CSIR-National Institute of Oceanography Dona Pula, Goa – 403 004	**Member**
Prof. Anuradda Ganesh Department of Energy Sciences Engineering Indian Institute of Technology, Powai,Mumbai – 400 076	**Member**
Dr Pushpito K Ghosh Director, CSIR-CSMCRI Bhavnagar, Gujarat 364002	**Member**
Shri Gaurav Dave Joint Secretary National Manufacturing Competitiveness Council, Vigyan Bhawan Annexe, Maulana Azad Road, New Delhi – 110 011	**Member (Agency Reprentative)**
Dr. Suresh Das Director, CSIR-National Institute for Interdisciplinary Science & Technology Industrial Estate P.O. Thiruvananthapuram – 695 019	**Cluster Director**
Head or Nominee Planning & Performance division CSIR, Anusandhan Bhavan, 2, Rafi Marg New Delhi-110001	**Permanent Invitee**

18. Management Council

2012-2013

Dr. Pushpito K Ghosh Director, CSIR-CSMCRI, Bhavnagar.	**Chairman**
Dr. Parimal Paul Chief Scientist, CSIR-CSMCRI, Bhavnagar.	**Member**
Dr. (Ms.) Sandhya Mishra Principal Scientist, CSIR-CSMCRI, Bhavnagar.	**Member**
Dr. Ramavatar Meena Senior Scientist, CSIR-CSMCRI, Bhavnagar.	**Member**
Dr. Avinash Mishra Scientist, CSIR-CSMCRI, Bhavnagar. (From 02.09.2013 till 31.12.2013)	**Member**
Dr. A V R Reddy Principal Scientist, CSIR-CSMCRI, Bhavnagar. (From 01.01.2012 till 01.09.2013)	**Member**
Mr. P A Patel Senior Technical Officer (3), CSIR-CSMCRI, Bhavnagar.	**Member**
Dr. Sourav Pal Director, CSIR-NCL, Pune.	**Member**
Dr. SHR Abdi Senior Principal Scientist, CSIR-CSMCRI, Bhavnagar. (From 02.09.2013 till 31.12.2013)	**Member**
Dr. D B Shukla Senior Principal Scientist, CSIR-CSMCRI, Bhavnagar. (From 01.01.2012 till 01.09.2013)	**Member**
Finance & Accounts Officer CSIR-CSMCRI, Bhavnagar.	**Member**
Administrative Officer CSIR-CSMCRI, Bhavnagar.	**Member - Secretary**

2013-2014

Dr. Pushpito K Ghosh Director, CSIR-CSMCRI, Bhavnagar.	**Chairman**
Dr. R S Somani Senior Principal Scientist, CSIR-CSMCRI, Bhavnagar	**Member**
Dr. B Ganguly Principal Scientist, CSIR-CSMCRI, Bhavnagar	**Member**
Dr. Puyam Singh Senior Scientist, CSIR-CSMCRI, Bhavnagar	**Member**
Ms. Bhoomi R Andharia Scientist, CSIR-CSMCRI, Bhavnagar	**Member**
Mr. P A Patel Senior Technical Officer (3) CSIR-CSMCRI, Bhavnagar.	**Member**
Dr. Sourav Pal, Director, CSIR-NCL, Pune.	**Member**
Dr. SHR Abdi, Senior Principal Scientist, CSIR-CSMCRI, Bhavnagar.	**Member**
Finance & Accounts Officer CSIR-CSMCRI, Bhavnagar.	**Member**
Administrative Officer CSIR-CSMCRI, Bhavnagar.	**Member - Secretary**