आज़ादी का अमृत महोत्सव

प्रौद्योगिकी संग्रह

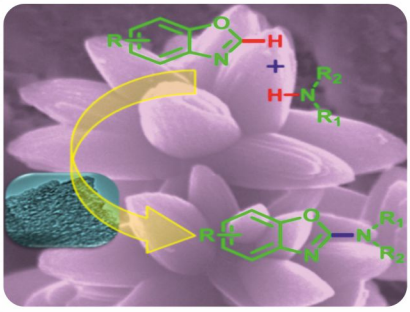
Technology Compendium

सीएसआईआर-केन्द्रीय नमक व समुद्री रसायन अनुसंधान संस्थान

CSIR-Central Salt & Marine Chemicals Research Institute

जनमानस तक पहुँचने वाले नवाचार

Innovations that reach the people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CSMCRI


DYNAMIC EQUILIBRIUM SALT
SALONI
VEGETABLE SALT

हमारा मिशन

संस्थान और इसके लोगों का मिशन हमारी तटीय बंजर भूमि, समुद्री जल, समुद्री शैवाल, सौर ऊर्जा और सिलिकेट्स के कुशल उपयोग के लिए आवश्यक ज्ञान और नवाचारों को उत्पन्न करने के लिए दूरदर्शी प्रायोजकों और सहयोगियों के साथ साझेदारी में कार्य करना है। संस्थान इस क्षेत्र में और इससे परे उद्योगों और संगठनों की संकेंद्रित आवश्यकताओं को पूरा करने के लिए जैवविज्ञान, रासायनिक रुपांतरण, प्रक्रिया इंजीनियरिंग, पर्यावरण निगरानी, पृथक्करण विज्ञान और विश्लेषण में अपनी क्षमताओं का भी उपयोग करेगा।

हमारी परिदृष्टि

सीएसआईआर-सीएसएमसीआरआई की परिदृष्टि नमक और समुद्री रसायनों, मेम्ब्रेन आधारित जल प्रशोधन, विलवणीकरण और पृथक्करण, समुद्री माइक्रो व मैक्रोशैवाल तथा हेलोफाइट्स की कृषि, आनुवंशिक इंजीनियरिंग व डाउनस्ट्रीम प्रसंस्करण, उत्प्रेरण सम्मलित स्वच्छ रासायनिक/ऊर्जा रुपांतरण, कार्यात्मक और निकेत पदार्थों व उपकरण, कचरे के मूल्य स्थिरीकरण के क्षेत्र में अत्याधुनिक अनुसंधान के माध्यम से एक वैश्विक अगुआ बनना है और विज्ञान तथा प्रौद्योगिकी के नेतृत्व वाले सतत नवाचारों के माध्यम से मानव संसाधन का निर्माण करना जो उद्योग आवश्यकता की पूर्ति करता है और सर्कुलर अर्थव्यवस्था को सक्षम करने के प्रयास साथ बड़े स्तर पर समाज और राष्ट्र के हित को समृद्ध करता है।

सीएसआईआर-केन्द्रीय नमक व समुद्री रसायन अनुसंधान संस्थान
CSIR-Central Salt & Marine Chemicals Research Institute

OUR MISSION

The mission of the Institute and its people is to work in partnership with visionary sponsors and collaborators to generate the knowledge and innovations required for efficient utilization of our coastal wasteland, sea water, marine algae, solar power and silicates. The Institute will also harness its capabilities in biosciences, chemical transformation, process engineering, environmental monitoring, separation science and analysis to address focused needs of industries and organizations in the region and beyond.

OUR VISION

The vision of CSIR-CSMCRI is to become a global leader through cutting-edge research in the domains of salt & marine chemicals, membrane based water purification, desalination & separations, marine micro and macro algae and halophytes cultivation, genetic engineering & downstream processing, clean chemical/energy transformations including catalysis, functionalized & niche materials & devices, valorisation of waste, and build human resource through S&T-led sustainable innovations that caters industry and enhance the well-being of the society and nation at large with an endeavour of enabling circular economy.

प्रकाशन / Published by

प्रो. (डॉ.) कन्नन श्रीनिवासन / Prof. (Dr.) Kannan Srinivasan

निदेशक, सीएसआईआर-सीएसएमसीआरआई / Director, CSIR-CSMCRI

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2021

प्रौद्योगिकी संग्रह

Technology Compendium

MAKE IN INDIA

Har Ghar Jal
Jal Jeevan Mission

Skill India
कौशल भारत-कुशल भारत

#startupindia

स्वच्छ भारत
एक कदम स्वच्छता की ओर

Swasth Bharat

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सूची / Index ... 2

Organic Chemicals including Pharmaceuticals

Bio-based Fuels & Chemicals

Membranes, Resins & Materials for Water Desalination, Water Purification and Separation Processes

सूची / Index ... 3

Seaweeds and their Downstream Processed Products

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Waste to Value

Devices & Sensors

Miscellaneous

निदेशक का संदेश

सीएसआईआर-केंद्रीय नमक व समुद्री रसायन अनुसंधान संस्थान में आपका स्वागत है !!

मैं समझता हूँ कि आप के द्वारा इस प्रौद्योगिकी संग्रह के अवलोकन का उद्देश्य तकनीक और तकनीकी समाधानों के संदर्भ में हमारी विशेषज्ञता, विनिर्माण के लिए आगे बढ़ने/विस्तारित करने के लिए तैयार उत्पाद, परिवर्तन लाने की क्षमता वाली नई विकसित प्रक्रियाएं, उद्यमियों/एमएसएमई/स्टार्ट-अप के लिए प्रस्ताव, वे क्षेत्र/परियोजनाएं/प्रौद्योगिकियां जिसमें सहयोग कर सकते हैं और उसे अगले/बड़े स्तर ले जाया जा सकता है, भविष्य की तैयारी के लिए किन तकनीकी क्षेत्रों का प्रयास किया जा रहा है, हम अपनी विज्ञान व तकनीकी दक्षताओं के माध्यम से आपकी किन समस्याओं का समाधान कर सकते हैं, शोध के कौन से व्यापक क्षेत्र में अंतरराष्ट्रीय स्तर के लक्ष्य रखे गए हैं और इसकी स्थिति क्या है, संस्थान का बौद्धिक मूल्यांकन या संभवतः हमारे जैसे सार्वजनिक वित्त पोषित अनुसंधान संस्थानों के विज्ञान एवं अनुसंधान परिदृश्य का अध्ययन करने की ललक व अन्य जैसे विविध कारणों से होगा ।

मैं, वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद के गुजरात स्थित इस एकमात्र संस्थान का नेतृत्व कर गौरवान्वित हूँ जिसका 67 वर्ष से अधिक का लंबा इतिहास है । यह संस्थान नमक और समुद्री रसायन, जल विलवणीकरण और शोधन सहित मेम्ब्रेन आधारित पृथक्करण प्रक्रियाओं, विशिष्ट अकार्बनिक रसायन, जैवनवीकरणीय और कार्बन अधिग्रहण, उपयोग और भंडारण (CCUS) सहित उत्कृष्ट व विशिष्ट रसायनों के लिए व उत्प्रेरण, समुद्री मैक्रोअल्गी (समुद्री शैवाल) एवं माइक्रोअल्गी की कृषि और उनके डाउनस्ट्रीम प्रसंस्करण से मूल्यवर्धित पदार्थ, लवणसह पौधों की कृषि सहित जैविक और जैवप्रौद्योगिकीय विधियों के माध्यम से लवणीय भूमि सुधार और विश्व स्तर की प्रौद्योगिकियों को विकसित करने के प्रयास के साथ स्वास्थ्यसेवा के लिए संवेदी और नैदानिक रसायन, समाज और उद्योग की सेवा करने के लिए अंतरण के लिए तैयार प्रौद्योगिकियों हेतु बुनियादी और अनुप्रयुक्त विज्ञान के विभिन्न डोमेन में काम कर रहा है। पिछले चार वर्षों में संस्थान ने 22 कंपनियों/उद्यमियों/स्टार्ट-अप को कई तकनीकों के लाइसेंसीकरण, 112 पेटेंट के स्वीकृतीकरण और विभिन्न माध्यमों से समाज की सेवा की है ।

संस्थान अपने वैज्ञानिक और तकनीकी नवाचारों के माध्यम से समाज और उद्योगों के लाभ हेतु पूरे जोश के साथ योगदान करता है। मुझे विश्वास है कि आप इस प्रौद्योगिकी संग्रह को दिलचस्प और उपयोगी पायेंगे । समाज/उद्योगों को बेहतर बनाने में हमारा हिस्सा बनने हेतु सीएसआईआर-सीएसएमसीआरआई में आपका स्वागत है ।

प्रो. (डॉ.) कन्नन श्रीनिवासन
निदेशक

Message from the Director

Welcome to CSIR-Central Salt & Marine Chemicals Research Institute!!

I do understand your interest to read this technology compendium might be for various reasons: like, what we offer in terms of technical & technological solutions, what products ready to take forward/expand for manufacturing, what new processes developed that are making difference, what it offers to entrepreneur/MSME/Start-ups, what areas/projects/technologies one can collaborate and translate to next/larger level, what technology domains being attempted for future preparedness, what problems we can address for you through our S&T competencies, what broad areas of research being pursued and positioned internationally, what intellectual value it has and creating or possibly a craving to study the technology development scenario of public funded research institutions like ours, to name a few.

I am privileged to head this institution, the only institute in Gujarat under the Council of Scientific & Industrial Research, which has a history of around 67 years. The institute is working in different domains of basic and applied sciences ranging salt and marine chemicals, membrane based separation processes including water desalination & purification, speciality inorganic chemicals, catalysis for fine & speciality chemicals including bio-renewables and carbon capture, utilization, and storage (CCUS), marine macroalgae (seaweeds) and microalgae cultivation and their downstream processing to value added materials, saline land reclamation through biological and biotechnological interventions including cultivation of halotolerant plants, and sensing & diagnostic chemicals for healthcare, waste-to-value with relevance on chemical processing industries, with an endeavour to develop world class sustainable technologies and transfer/translate them readily to serve the industry and society. In the last four years, the institute has licensed several technologies to 22 companies/entrepreneurs/start-ups, granted 112 patents and served the society through different means.

The institute has a great passion to contribute to the welfare of society and industry through its scientific and technological interventions. I am sure you will find the details in this compendium useful and interesting. Pleasure to welcome you to CSIR-CSMCRI and be part of us in making our country/society better.

Prof. (Dr.) Kannan Srinivasan
Director

Salt and Marine Chemicals

Production of industrial grade high purity salt from sea water/subsoil and lake brines suitable for chlor-alkali manufacture

Application/Uses/Problem being Addressed:

For production of salt to be used as raw material in chlor alkali industries.

Salient Technical Features including Competing Features/Impact:

The process is an improvement over the existing process of producing salt of high purity from alum-treated brine. More particularly, the invention rectifies the ratio of Ca^{2+} to Mg^{2+} from a value <1 to a value in the range of 2-3 desired by chlor-alkali and soda ash industries.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

The technology is ready for technology transfer and can be implemented on commercial scale. The product has high demand in chlor-alkali industrial sector.

Environmental Considerations, if any:

Eco-friendly.

Status of Licensing:

Technology transferred to-

- DCM Shriram Consolidated Ltd, New Delhi.
- Grasim Industries Ltd, Chemical Division, Birlagram, Nagda.
- DCW Ltd., Tuticorin, Tamil Nadu.

Status of Commercialization:

Commercialized.

Major Raw Materials Needed:

Sea/Subsoil brine, flocculating agents, mineral acid.

Major Plant Equipment and Machinery Required:

Material handling equipment such as pumps, belt conveyors, ridger, harvesters, loaders, crushers, tractors, trailers, washery, etc.

Technology Package:

- Collection of brine samples and their physical and chemical characterization.
- Characterization of soil samples and assessing its suitability for construction of salt works.

IPR Status & IPR Details
US 8021442B2, US 8282690B2

TRL Level & Scale of Development : TRL-7

- Assessment of percolation of brine through the soil based on the soil characteristics.
- Assessment of the quality and yield of salt likely to be produced in the area based on the initial brine density and chemical composition.
- Study of possibilities of inundation of the area during monsoon with an aim to assess the suitability of the land for construction of salt works.

Techno-Economics
To be worked out based on proposed capacity

- Preparation of feasibility report based on the above mentioned study.
- Design and layout of solar salt works.
- Demonstration of solar salt production process.
- License fee and other financial details would be provided on specific request.

Figs. : Demonstration of the process in
(1) CSIR-CSMCRI experimental salt farm.
(2) Commercially operated solar salt works.
(3) In one of the marginal salt works in Gujarat.

Process for the preparation of solar salt with reduced levels of trace impurities and having high purity and whiteness suitable for edible and industrial applications

Application/Uses/Problem being Addressed:

The process finds its application in producing solar salt of high purity from seawater, which minimizes the need for downstream purification in chemical industries where salt is used as basic raw material.

Salient Technical Features including Competing Features/Impact:

Below mentioned processes developed by CSIR-CSMCRI find its application in producing solar salt of high purity which minimizes the need for downstream purification in chemical industries where salt is used as basic raw material.

- Process for the preparation of solar salt having high purity and whiteness: The process of deals with significant improvements in salt purity and whiteness. The improvements realized are partly on account of elimination of suspended impurities like gypsum and clayey matter in the brine, which may otherwise be carried along with the brine in the crystallizer and finally end up in the salt, and partly due to the improved crystal size and morphology that minimizes embedded impurities in the salt. Rain washing of the heaped salt has resulted in a salt with greatly reduced calcium and sulphate impurity levels hitherto not achieved in solar salt production.

- Process for production of high purity salt with reduced levels of impurities: The process is an improvement over the existing process of producing solar salt of high purity from seawater and minimizes the need for downstream purification. More particularly, the process involves recrystallization of salt in solar salt pans using seawater itself as the dissolving medium. The salt is obtained with a yield up to 80% and with much reduced levels of impurities. Special mention is made of the bromide level which is reduced 7-10 fold. The process is most ideal for trace impurities which reside in the salt crystal lattice and are difficult to dislodge by conventional methods adopted for salt purification and where conventional recrystallization would be cost ineffective and scalability would pose a problem. The invention can be practiced by solar salt works based on seawater and where spare land is available to set up additional crystallizers required for the purpose of recrystallization.

IPR Status & IPR Details
US 8282690B2, US 20150059129A1

Status of Licensing:
Technology is ready for transfer.

Status of Commercialization:
Ready for commercialization.

Major Raw Materials Needed:
Sea/Subsoil brine and flocculating agents.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):
The technology is ready for technology transfer and can be implemented on commercial scale. The product has high demand in industrial sector.

Major Plant Equipment and Machinery Required:
Material handling equipment such as pumps, belt conveyors, ridger, harvesters, loaders, crushers, tractors, trailers, washery, etc.

Environmental Considerations, if any:
Eco-friendly.

Technology Package:

- Collection of brine samples and their physical and chemical characterization.
- Assessment of the quality and yield of salt likely to be produced in the area based on the initial brine density and chemical composition.
- Demonstration of process.
- License fee and other financial details would be provided on specific request.

Techno-Economics
The additional area required for this process will be approx. 10% for salt production from seawater having 3°Be' (Specific gravity 1.02)

TRL Level & Scale of Development : TRL-7


After Upgradation


Before


Upgradation

Manufacture of sodium chloride and potassium chloride of any percentage ratio (low sodium edible salt) from mixed salt/bittern and manufacture of pure potassium chloride therefrom

Application/Uses/Problem being Addressed:
The process is for recovery of low sodium salt and potassium chloride (a fertilizer).

Salient Technical Features including Competing Features/Impact:
The excessive exertion in the present day world has created lot of health problems in humans such as hypertension. Sodium is responsible for increasing nerve impulses and low sodium salt, primarily a mixture of sodium chloride and potassium chloride is useful for those persons who have been advised to eat less sodium on account of medical ailments. Realizing the demand of low sodium salt which is commonly prepared by homogeneous mixing of NaCl and KCl, CSIR-CSMCRI has developed a cost effective process for the production of low sodium salt using the bittern, the mother liquor left out after production of salt in solar salt works. The process involves the desulphatation of bittern using cheap agents like distiller waste liquor of soda ash plants and processing the desulphated bittern for the recovery of low sodium salt via the intermediate product carnallite. The low sodium salt of required specifications can be made by controlling the ionic composition of desulphated bittern during its processing.

The process comprises of desulphatation of bittern (by-product of salt industry), evaporation of bittern in solar pans and processing of solid mixture with water to produce a mixture of sodium and potassium chlorides and optionally preparing "free flowing" and iodized salt or Potassium Chloride, by known techniques.

Business Scope & Oportunity (in terms of scale, cost, market, etc.):
The technology for Low Sodium Salt process has been validated in CSIR-CSMCRI ESF/pilot plant and one of the commercially operated solar salt works in Tamil Nadu for one of the multinational companies.

TRL Level & Scale of Development
TRL-7

IPR Status & IPR Details
US 6890509B2, CA 2473900A1, CA 2473900C, CN 1304292C, CN 1617834A, US 20030143152, WO 2003064323A1, WO 2003064323B1

The process/technology is ready for technology transfer and can be implemented on commercial scale. The product has high demand in industrial sector.

Environmental Considerations, if any:
Eco-friendly.

Status of Licensing:
Technology is ready for transfer.

Techno-Economics
To be worked out based on proposed capacity

Status of Commercialization:
Ready for commercialization.

Major Raw Materials Needed:
Sea/Subsoil bittern.

Major Plant Equipment and Machinery Required:
Material handling equipment such as pumps, belt conveyors, ridger, harvesters, loaders, crushers, tractors, trailers, washery, etc.

Technology Package:
- Basic technical details for design of commercial plant.
- Demonstration of process.
- License fee and other financial details would be provided on specific request.

Process for recovery of common salt, potassium chloride and high purity magnesia from brine in an integrated manner

Application/Uses/Problem being Addressed:

- The majority of the potassium chloride produced is used for making fertilizer, since the growth of many plants is limited by their potassium intake.
- As a chemical feedstock, it is used for the manufacture of caustic potash, potassium carbonate, potassium sulphate, etc.

Salient Technical Features including Competing Features/Impact:

The process relates to a process for recovery of common salt and marine chemicals of high purity in integrated manner, which boosts the viability of such recovery. The process is amenable to a wide range of brine compositions but especially attractive for brine compositions that are low in sulphate content and yield impure salt when the conventional process of solar salt production is followed.

TRL Level & Scale of Development : TRL-7

The process is for recovery of common salt, potassium chloride, concentrated magnesium chloride with enriched bromide and high purity magnesia from brine in an integrated manner, said process comprises preparation of calcium chloride by reaction of hydrochloric acid generated in the process with limestone, desulfatation of brine with calcium chloride, production of sodium chloride of superior quality in solar pans, solar evaporation of

bittern thereby producing carnallite and end bittern, processing carnallite through established processes to produce potassium chloride, recovering end bittern containing highly concentrated magnesium chloride and enriched bromide and calcination of a part of the end bittern after solidification to produce high purity magnesia and hydrochloric acid utilizable in the process.

IPR Status & IPR Details

US 20030080066A1, US 6,776,972, WO 03/035550, US 6776972B2

Environmental Considerations, if any:

Eco-friendly.

Status of Licensing:

Technology is ready for transfer.

Status of Commercialization:

Ready for commercialization.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

The technology has been validated in CSIR-CSMCRI ESF/ pilot plant.

The process / technology is ready for transfer and can be implemented on commercial scale. The product has high demand in industrial sector.

Techno-Economics

To be worked out based on proposed capacity

Major Raw Materials Needed: Bittern.

Major Plant Equipment and Machinery Required:

Material handling equipment such as pumps, belt conveyors, ridger, harvesters, loaders, crushers, tractors, trailers, washery, etc.

Technology Package:

- Basic technical details for design of commercial plant.
- Demonstration of process.
- License fee and other financial details would be provided on specific request.

Process for the recovery of high purity salts-sodium chloride and sodium sulphate from crudes (sulphate-rich brine)

Application/Uses/Problem being Addressed:

High purity salt (NaCl): Edible as well as Industrial use.

Sodium sulphate:

- As filler in powdered home laundry detergents.
- In textile industry (helps in "levelling", reduces negative charges on fibers so that dyes can penetrate evenly).
- In manufacture of wood pulp.
- As a fining agent in glass industry.
- As diluent for food colors.

Salient Technical Features including Competing Features/Impact:

- The leather industry has received criticism on environmental grounds. Due to high pollutant loading, this tannery effluent is not suitable for direct discharge and requires downstream treatment/ processing.
- Similarly, composition of salt brine of Rajasthan is typical and different with sea brine as it does not have much calcium and Magnesium impurities and contains high level of sulphate impurities in the brine as Sodium Sulphate. The salt produced is highly contaminated with sodium sulfate and not suitable even for edible as well as industrial purpose.

The process relates to the recovery of high purity salt (NaCl) and sodium sulphate ($Na_2SO_4.10H_2O$) from crudes such as solid waste from tannery effluents and common salt produced from Rajasthan lakes (India) containing sodium sulphate.

IPR Status & IPR Details : IN 202011009669
TRL Level & Scale of Development : TRL-7

Status of Licensing:
Technology is ready for transfer.

Status of Commercialization:
Ready for commercialization.

Major Raw Materials Needed:
Crude salt.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):
The technology has been validated in CSIR-CSMCRI ESF/pilot plant and one of the commercially operated solar salt works in Rajasthan.
The process/technology is ready for technology transfer and can be implemented on commercial scale. The product has high demand in industrial sector.

Techno-Economics
To be worked out based on proposed capacity

Major Plant Equipment and Machinery Required:
Material handling equipment such as pumps, belt conveyors, crushers, tractors, trailers, washery, etc.

Environmental Considerations, if any:
Eco-friendly.

Technology Package:
- Basic technical details for design of commercial plant.
- Demonstration of process.
- License fee and other financial details would be provided on specific request.

Technology for the production of sulphate of potash & refractory grade magnesia from sea bittern

Application/Uses/Problem being Addressed:

Sulphate of Potash (SOP)

- SOP is a premium two nutrient fertilizer (50% K_2O and 18% S) with the highest total nutrient value (68%) and the lowest salt index (46.1).
- SOP (K_2SO_4) offers an advantage over MOP (KCl) currently used by farmers with special focus on chloride sensitive crops, dryland agriculture, sulphur responsive crops, drip irrigation and areas deficient in K & S.

Ultra-pure Magnesia

- Ultra-pure magnesia is used in refractory lining for primary steelmaking as well as in magnesium metal production.

Salient Technical Features including Competing Features/Impact:

- No floatation is used for NaCl separation and recycle system designed leaches away NaCl with simultaneous increase in potash recovery.
- The sea bittern and many of subsoil bitterns in the country are sulphate rich and hence the potash is recovered in form of SOP which is agronomically better fertilizer.
- The recovery/yield of potash is high because of integration and recycle of intermediate streams.
- The unit operations used are simple and most of the operations are carried out at ambient temperature except drying and calcinations of magnesium hydroxide to form MgO.
- The technology developed is environmentally benign.
- There is no fear of IPR infringement in view of the strong patent position.

IPR Status & IPR Details
US 7,041,268, US 7,811,535 B2
TRL Level & Scale of Development
TRL-6 & Pilot Plant Scale

Status of Licensing:

The process technology has been licensed to M/s. Archean Chemical Industries, Chennai; M/s. Tata Chemicals Limited, Mithapur.

Status of Commercialization:

Not yet commercially deployed.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Economical viable integrated process with potash and magnesia production.

Techno-Economics
Economically feasible as integrated process

Major Raw Materials Needed:

Sea bittern (mother liquor left after production of salt) & lime.

Environmental Considerations, if any:

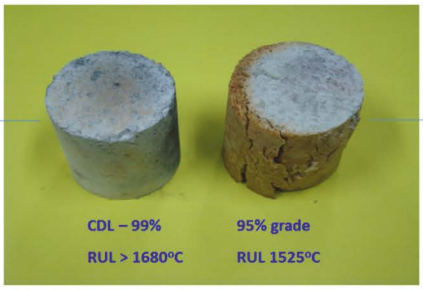
The technology developed is environmentally benign.

There is no effluent generated in the process that poses environmental problems.

Major Plant Equipment and Machinery Required:

Belt conveyor, crushing unit, vessels with agitator, centrifuges, rotary calciner, intermediate storage tanks, fluid bed dryer, pumps, filter, packaging units, etc.

Suitable for LD converter for primary steel making



Suitable for backup liner

"The undersigned and Dr. Haldar had developed the magnesite refractory from your magnesia. The refractory properties along with the photographs of the samples after the test is given in the attached file. The 99% MgO grade gave excellent results. "
11 May 2010

"Currently the import price of Chinese dead burned magnesia is Rs. 36,000/- per ton. So the price of dead burned MgO developed from CSMCRI MgO should be below Rs. 25,000/- per ton to make it attractive."
2 Jun 2010

Dr. Arup Ghosh
Scientist F, Refractories Division
Central Glass and Ceramic Research Institute

Technology Package:

Technology package is ready and would be provided to the party at the time of technology transfer; license fee and other financial details would be provided on request.

CSIR-CSMCRI

Process for production of potassium nitrate from sea bittern through selective K-precipitation technique

Application/Uses/Problem being addressed:

Production of potassic chemicals and fertilizers, viz. potassium nitrate, potassium sulphate, mono potassium phosphate, potassium ammonium sulphate, potassium ammonium phosphate etc. by recovering potassium from sea bittern.

Salient Technical Features including Competing Features/Impact:

- Recovery of potassium directly from sea bittern, without requiring production of mixed salt.
- Can be applied to other potassic feed-stocks, viz., biomass ash/char, seaweed sap, etc.
- Efficient K-recovery (ca. 75%).
- Safe and environmentally benign process.

IPR Status & IPR Details
IN 318659, US 9540248

TRL Level & Scale of Development
TRL 7;
Know-how licensed & practiced commercially

Major Raw Materials Needed:

Sea bittern, lime, magnesia, nitric acid, sulphuric acid, etc.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Potential client base:

Major sea salt producers in India & abroad.

Major Plant Equipment and Machinery Required:

Generic equipment required in chemical plant, viz., reactors, settlers, filter press, dryers, etc.

Environmental Considerations, if any:

Effluent contains <50 ppm of tartaric acid. May be discharged following protocols related to marine chemicals.

Technology Package:

Know-how transfer document would be made available on specific request.

Status of Licensing:

The technology has been licensed to M/s Laxmi Industries, Madurai, Tamil Nadu.

Status of Commercialization:

Client produces potassium nitrate commercially.

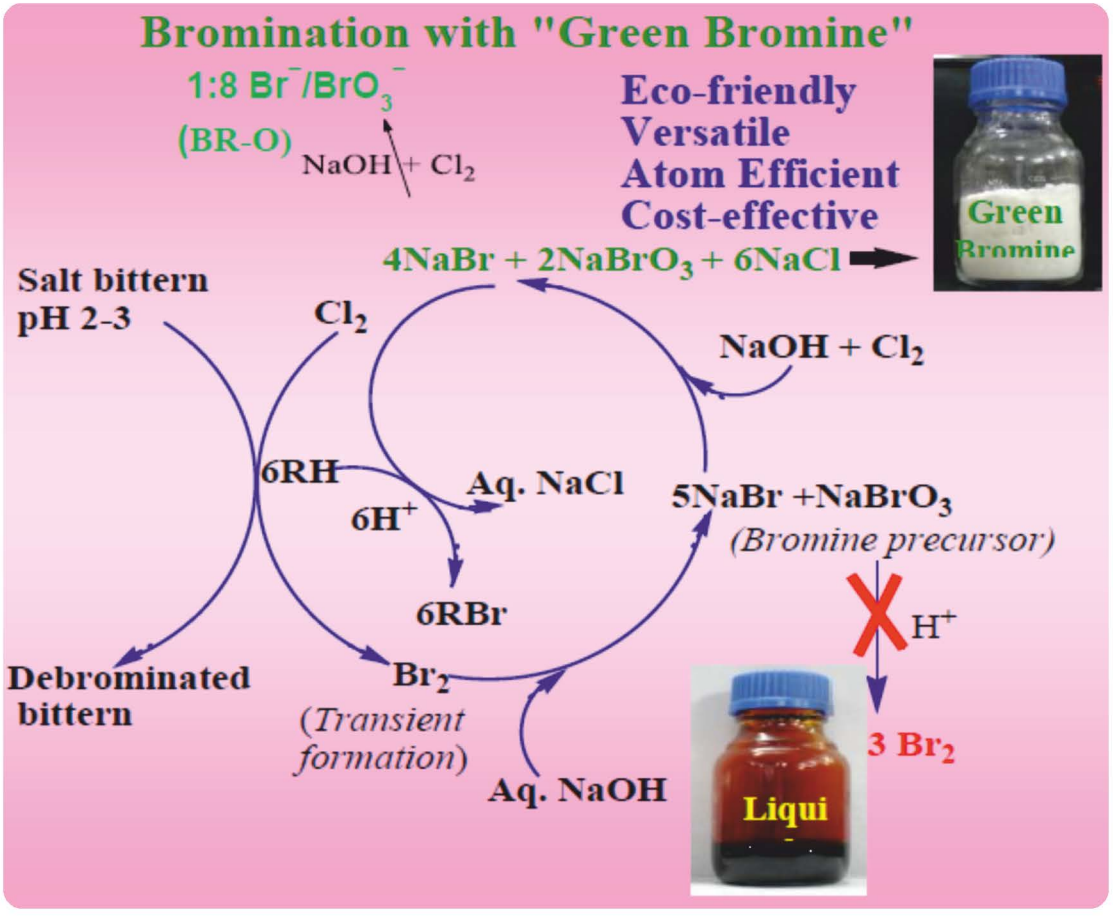
Techno-Economics
Broadly, for a 1 tpd plant, Rs.1-1.5 crore would be the initial investment towards plant and machinery with a payback period of < 3 years

A process for production of non-hazardous brominating reagent

IPR Status & IPR Details
US 6,740,253, US 7,459,139

Application/Uses/Problem being Addressed:

CSIR-CSMCRI has developed a green brominating reagent-a better alternative to the hazardous liquid bromine. This green brominating agent is an attractive source of bromine for bromination of various organic substrates. The reagent has been designed for three main functionalities: 1) Brominating reagent for substitution (BR-S); 2) Brominating reagent for addition Reactions (BR-A); and 3) Brominating reagent for oxidations (BR-O). The reagent can be prepared cost-effectively from the intermediate of bromine recovery plants.



TRL Level & Scale of Development
TRL 6;
Kg scale preparation

Salient Technical Features including Competing Features/Impact:

- Recovery of potassium directly from sea Replacement of the corrosive elemental bromine.
- Safe, easy to handle & transport.
- Avoids the need of special equipments.
- Avoids need of catalyst.
- Maximum bromide atom efficiency.
- Operates under ambient reaction conditions.
- Easy to scale-up for the processes develop-ment.
- No formation of hazardous byproducts.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Bromo-compounds manufacturers.

Environmental Considerations, if any:

The process does not generate hazardous by-products.

Status of Licensing:

Licensed to industry.

Status of Commercialization:

Not yet in commercial practice.

Major Raw Materials Needed:

Bromine intermediate, chlorine and alkali.

Major Plant Equipment and Machinery Required:

As desired by the customer for the their production.

Technology Package:

Preparation of non-hazardous brominating reagents ; Pilot scale demonstration.

Techno-Economics

The technology is feasible for the large-scale production of green brominating reagents from the intermediate of bromine manufacturing process. The reagent is equivalent (alternate) to liquid bromine in many transformations. The brominating reagent cost will be approximately equivalent liquid bromine + 20%

IPR Status & Details

US 6929809, IN 221049, AU 2002244907, BR PI0205773-5, CA 2429700, CN ZL02802456.7, EP 1487283, IL 154973, JO 2336, JP 4206343, MX 243499, SE 1487283, US 6929809, PCT/IN02/00063, WO 03079817

TRL Level & Scale of Development
TRL-9 (salt) and TRL-6 (cultivation)

Preparation of low sodium salt of botanic origin - Saloni - with backward integration of cultivation of *Salicornia brachiata*

Application/Uses/Problem being Addressed:

Low sodium salts, Saloni are preferred by strict vegetarians and useful for those persons who have been advised to eat less common salt because of medical problems like hypertension.

Cultivation technology helps in generating large amount of biomass of *Salicornia* helps in coastal farmers/fishermen community as livelihood option besides contributing to an extent on GHGs emission.

Fig. : Salts in market

Figs. : *Salicornia brachiata* cultivation at Sartanpur (Gujarat Coast) under different fertilizer application and agronomic condition at maturity stage

Salient Technical Features including Competing Features/Impact:

Salient features for preparation of low sodium nutrient rich salts (Saloni), from high salt accumulating and edible oil-bearing salt tolerant plant, *Salicornia brachiata* (as a source of NaCl) are:

- Simple, efficient, reproducible and scalable.
- Sufficient quantities of micronutrients including K in the salt.
- Fine white crystalline and free flowing refined herbal salt.
- Offers additional opportunity in making oil.

- Optimized cultivation protocol that involves both agronomy and treatment for high yield of biomass per unit area scale.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Health consciousness among the people is on increasing trend, augmented by pandemic, and such healthy salt would be preferred; further, in food processing industry that are branded for use of excess salt in the products like pickles, papads, etc. use of healthy salt create a new business market.

Techno-Economics

One hectare saline land can produce approximately 41 ton fresh biomass, 11 ton dry biomass, 3.8 ton ash content. From the one ha land, approximately 1.9 ton salt can be prepared

Environmental Considerations, if any:

Environmentally friendly process.

Status of Licensing:

Technology is transferred-

1. N M S Pharma, Bhavnagar[#].

[#]Technology ready for licensing.

Status of Commercialization:

N M S Pharma, Bhavnagar is commercially producing the salt and selling in both domestic/international market for last few years although in very small scale (couple of tons).

Major Raw Materials Needed:

Dried plant material (dry biomass); Land near to coastal belt is ideal for cultivation.

Major Plant Equipment and Machinery Required:

Reactor, filter, evaporator, dryers, etc. General agriculture equipment and machinery are required.

Technology Package:

Available on specific request.

IPR Status & Details

US 7208189, IN 245319, AU 2004318169, BR PI0418592(A), CA 2562109, CN 100515945(C), EP 1735239(A1), IL 178410, JP 4955538, MX 266374, WO 2005097681(A1)

Preparation of low sodium salt of botanic origin - Saloni K - with backward integration of cultivation of *Salicornia brachiata* and *Kappaphycus alvarezii*

TRL Level & Scale of Development
TRL-9 (salt) and TRL-6 (*Salicornia* cultivation)
TRL-9 (*Kappaphycus alvarezii* cultivation)

Application/Uses/Problem being Addressed:

Low sodium salt, Saloni K, is a mixture of sodium chloride and potassium chloride and is useful for those persons who have been advised to eat less common salt because of medical problems like hypertension.

Cultivation technology helps in generating large amount of biomass of *Salicornia*, which helps in coastal farmers/fishermen community as livelihood option besides contributing to an extent on GHGs emission.

Kappaphycus alvarezii is cultivated on bamboo raft in sea it helps the fishermen community for livelihood option besides source of potassium chloride.

Salient Technical Features including Competing Features/Impact:

Salient features for preparation of low sodium nutrient rich salts (Saloni K), from high salt accumulating and edible oil-bearing salt tolerant plant, *Salicornia brachiata* (as a source of NaCl) and a red alga, *Kappaphycus alvarezii*, a carrageenophyte, (as a source of KCl) are:

- Simple, efficient, reproducible and scalable.
- Sufficient quantities of micronutrients including K in the salt.
- Fine white crystalline and free flowing refined herbal salt.

Figs. : *Salicornia brachiata* cultivation at Sartanpur, Gujarat under different fertilizer application and agronomic condition at maturity stage

Fig. : Salts in market

Fig. : *Kappaphycus alvarezii* cultivation by raft method at Tamil Nadu coast

- Offers additional opportunity in making oil.
- Optimized cultivation protocol that involves both agronomy and treatment for high yield of biomass per unit area scale.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Health consciousness among the people is on increasing trend, augmented by pandemic and such healthy salt would be preferred. Further, in food processing industry, that are branded for use of excess salt in the products like pickles, papads, etc. use of healthy salt will create a new business market.

Techno-Economics

For *Salicornia*, one-hectare saline land can produce approximately 41 ton fresh biomass, 11 ton dry biomass, 3.8 ton ash content. From the one hectare land, approximately 1.9 ton salt can be prepared

Kappaphycus alvarezii is cultivated on bamboo raft. One hectare cultivation of *K. alvarezii* on bamboo raft can produce approximately 780 ton fresh biomass, 78 ton dry biomass and 19.50 ton salt

Environmental Considerations, if any:

Environmentally friendly process.

Status of Licensing:

- Salt technology is transferred- N M S Pharma, Bhavnagar.
- *Kappaphycus* cultivation technology is licensed to few industries.
- *Salicornia* cultivation technology is ready for licensing.

Status of Commercialization:

N M S Pharma, Bhavnagar is commercially producing the salt and selling in both domestic/international market for last few years although in very small scale (couple of tons).

Major Raw Materials Needed:

Dried plant material (dry biomass); land near to coastal belt is ideal for *Salicornia* cultivation. *Kappaphycus alvarezii* is cultivated in the sea.

Major Plant Equipment and Machinery Required:

Reactor, filter, evaporator, dryers, etc. General agriculture equipment and machinery are required. Bamboo raft is needed for *kappaphycus* cultivation.

Technology Package:

Available on specific request.

IPR Status & IPR Details
US 9765098 B2, IN 30285,
WO 2013128474, AU 2013227207,
CA 2865711, EP 13719626.7

TRL Level & Scale of Development
6; Kg scale for fortifying agent and hundreds of Kg for salt

Double fortified salt technology for fortification of salt with iron and iodine

Application/Uses/Problem being Addressed:

Double Fortified Salt is an innovative new cost-effective fortified food product-delivering small but crucial amounts of iodine and iron to human beings through their diet for mental capacity, maternal and infant survival and human productivity with an endeavor of "Anaemia Mukt Bharat".

Salient Technical Features including Competing Features/Impact:

This inventive process helps in retaining the white colour of the salt and preserving the effective concentration of iodine and iron intact over a long period of time for an extended shelf-life.

- Fortified with iron in form of Fe^{3+} which is a more stable form of iron and white in colour.
- The stability of Fe^{3+} and that of iodine are excellent.
- Better free flow ability and aesthetic appearance.
- The process is easily scalable and cost effective.

- The additional nutrition that one gets out of this salt is magnesium, an important nutrient needed in the body that helps in preventing mellitus diabetes.
- Safe, affordable, stable and can be used without compromising on appearance, stability, taste and texture of the salt.
- Community-based limited efficacy trial of CSIR-CSMCRI DFS for long term safety and improvement in iron and iodine in blood serum confirms efficacy of DFS in boosting the iron and iodine levels in humans (sample size 300 adult human) without any side effect.

Techno-Economics

Economically viable process; The cost of fortification for fortifying salt to contain 1000 ppm of iron and 30 ppm of iodine works out to be Rs.1.5 per kg of salt

Business Scope & Opportunity (in terms of scale, cost, market etc.):

The total iodized salt production in India is 4.8 million MT per year (2016-17). Similar way demand for double fortified salt can be envisaged as 0.5 million MT per year considering 10 % of iodized salt's demand. The process uses abundantly available bittern as magnesium source.

Environmental Considerations, if any:

Environmentally friendly process.

Status of Licensing:

Not licensed.

Status of Commercialization:

Not applicable.

Major Raw Materials Needed:

Soda ash, caustic soda, magnesium chloride, iron compound, potassium iodate.

Major Plant Equipment and Machinery Required:

General chemical process equipment like reactors, filter, boiler, dryer, pulverizer, etc.

Technology Package:

Process know-how for the preparations of fortifying agents; Process for fortification of salt using the agents for DFS; Bio-availability, clinical studies, FSSAI analysis data; Basic engineering package; License fee and other financial details would be available on specific request.

A process for pharma-grade sodium chloride

Application/Uses/Problem being Addressed:

The process is to manufacture pharma-grade salt. Main uses are in pharmaceutical industry. Pharmaceutical grade sodium chloride has many applications in injections, hemodialysis, oral rehydration salts (ORS), channeling agents/osmotic agent and dietary formulations, etc.

TRL Level & Scale of Development

TRL 4; Technology validated in lab scale at Kg level in CSIR-CSMCRI ESF/ pilot plant

IPR Status & Details : Patent filed

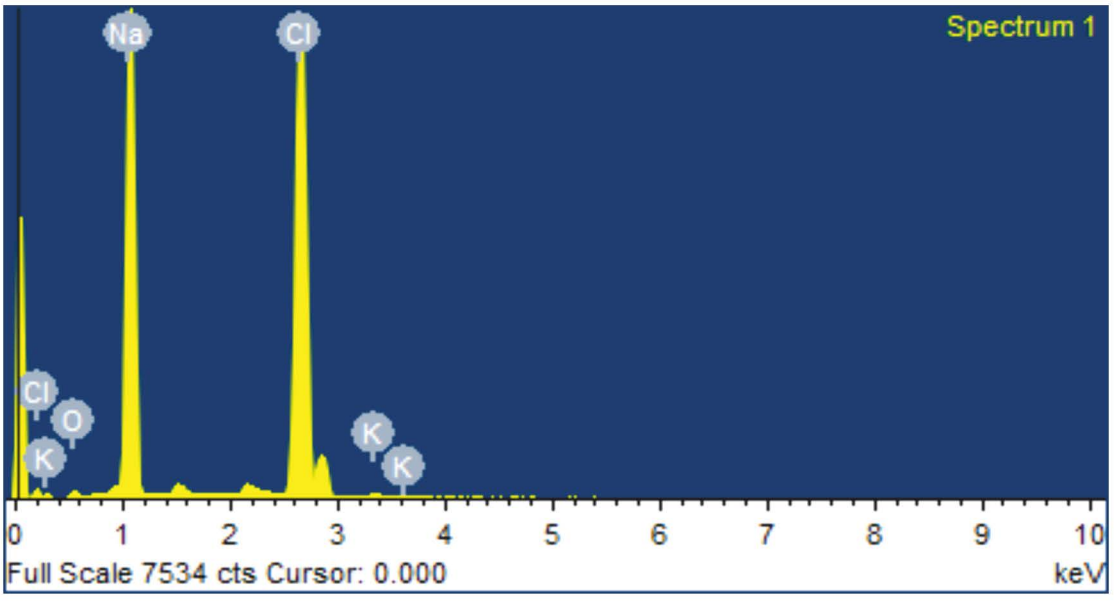
Salient Technical Features including Competing Features/Impact:

- It is a combination of chemical and physical method to separate the impurities to get the pharma-grade salt.
- The process does not use expensive $BaCl_2$ which is toxic in nature.
- This process can be scaled-up as a continuous process without the necessity of time-consuming recrystallization step.
- The production cost is less to sustain in the market.
- Complies with the specifications of IP grade.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Few companies have approached us for discussion regarding commercialization scope with capacity in the range ~250 ton/month.

As there are no major manufacturer of pharmaceutical sodium chloride in India, indigenous process developed can fulfill both domestic need and offers export potential.



Environmental Considerations, if any:

The process is environmentally friendly. The solid by-product magnesium hydroxide along with other metal hydroxides can be used for derive other magnesia chemicals.

Status of Licensing:

Not licensed so far; The process / technology is ready for licensing.

Status of Commercialization: Not applicable.

Major Raw Materials Needed:

Raw NaCl (sea/subsoil brine), NaOH/CaO/ Na_2CO_3.

Major Plant Equipment and Machinery Required:

Brine tank with agitator, Nutsche filter, single/multi-stage evaporator, ultrafiltration unit, centrifuge, process pump and dryer.

Technology Package:

Technical specification of each component, design drawing & layout, installation & commissioning, demonstration, basic training for the process (SOP). License fee and other financial details would be provided on request.

Techno-Economics

Production cost of the salt will be around Rs.6-7/kg

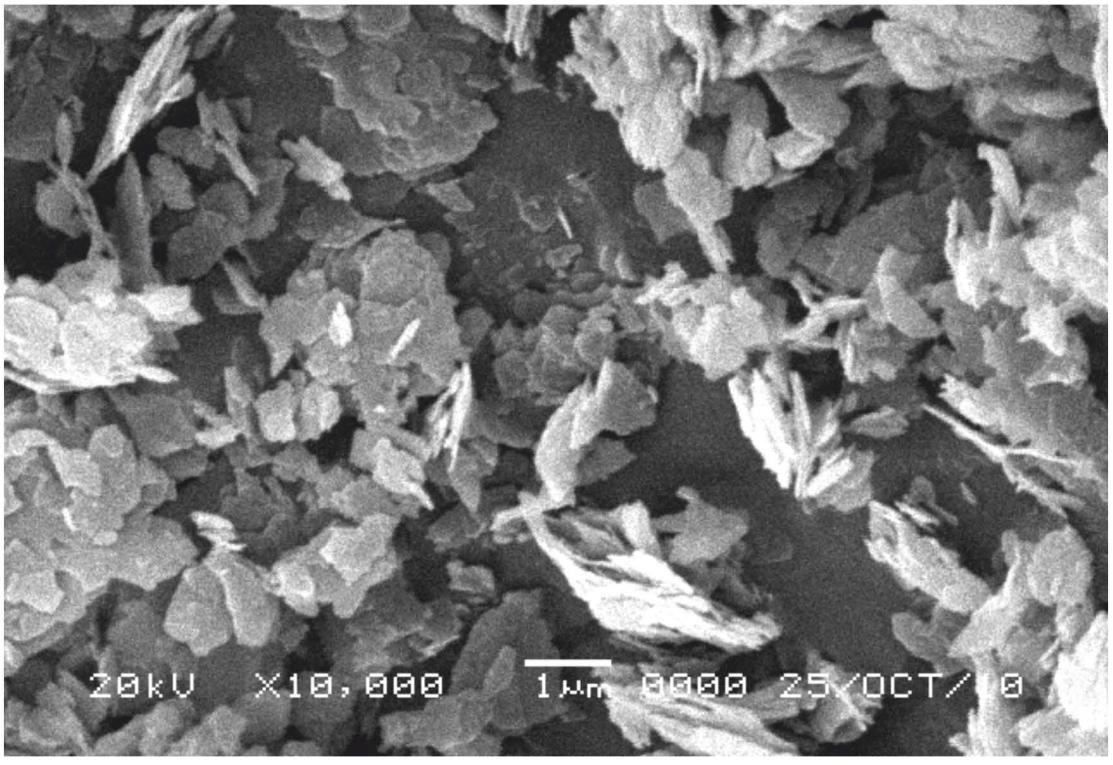
Production of high purity heavy basic magnesium carbonate from bittern

Application/Uses/Problem being Addressed:

Heavy basic magnesium carbonates are used in pharmaceuticals as an inert vehicle and an adsorbent. Due to its fine texture and high absorbency, it is used in cosmetic manufacturing as a carrier and retainer of perfumes. It is also used in the rubber industry as a reinforcing agent and as an extender for titanium dioxide in paint, lithographing inks and as a precursor for other magnesium based chemicals.

Salient Technical Features including Competing Features/Impact:

- Moderate reaction conditions are involved to produce desired density product using sea bittern.
- Product meets benchmark internationally available product specification.



Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Rise in spending on lifestyle attributed to the rise in disposable income is boosting the

TRL Level & Scale of Development
9; Deployed at commercial scale

demand for cosmetics, personal care products further propelling the magnesium carbonate market. Additionally, adoption of magnesium carbonate in various end-use industries like plastic, rubber, automotive, aerospace, and pharmaceuticals is expected to drive the market potentially. It is used as antacid and filler in other tablets. Additionally, it is used as primary raw material for production of magnesium oxide and other derivatives. This chemical is extensively demanded as smoke suppressant, drying agent and as filler material.

Environmental Considerations, if any:

Environmentally friendly process.

Techno-Economics

Economically feasible

Status of Licensing:

Licensed.

Status of Commercialization:

Commercialized.

Major Raw Materials Needed:

The raw materials used in the process are sea bittern, as source of magnesium and soda ash as a source of carbonate.

Major Plant Equipment and Machinery Required:

General process equipment like reactors, filter press, dryer, etc.

IPR Status & Details : IN 301912

Technology Package:

Technology package is ready and would be provided to the party at the time of technology transfer.

Technology for production of micro nutrient enriched cattle licks - *'free to offer'*

TRL Level & Scale of Development
TRL 6; Pilot scale

Application/Uses/Problem being Addressed:

The mineralized cattle licks contain supplementary nutrient such as cobalt, zinc, iron, copper and manganese which help in growth, metabolism and other physiological processes of animals. It improves the quality & quantity of milk produced. This product is also useful for cattle having deficiency of elements.

Techno-Economics
Plant Capacity:
200 blocks of 2.5 kg each per day

Salient Technical Features including Competing Features/Impact:

Deficiency of micronutrients in the cattle causes many diseases. Micronutrients deficiency mainly effects on the rate of growth, fertility and milk production. Milk provides vital food supplement to human as well as animals and hence is considered as a balance and complete diet.

The institute has developed a process for the making the cattle licks. It's composed of different trace element/nutrients which remove the deficiency in the cattle. These cattle can enhance the reproduction systems by licks. It improves the quality & quantity of milk produced.

IPR Status & Details : Nil

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

The technology is ready for license under 'free to offer' and can be implemented on commercial scale. The product has high demand in animal sector. There may be huge demand in the future in the India and aboard.

Environmental Considerations, if any:

Eco-friendly.

Status of Licensing:

Technology licensed to Jony Bony Cattle Licks Industries, Muzzafarnagar.

Status of Commercialization:

Commercialized.

Major Raw Materials Needed :

1. Magnesium oxide.
2. Magnesium chloride.
3. Copper sulphate.
4. Cobalt chloride.
5. Manganese sulphate.
6. Iron oxide.
7. Zinc sulphate.
8. Potassium iodide.

Major Plant Equipment and Machinery Required:

Minor equipment to compress the material, vessel with agitator, mould.

Technology Package:

Plant Cost: Rs.7.50 lakhs approx.

Inorganic Chemicals

Preparation of halogen scavenger grade and pharmaceutical grade synthetic hydrotalcite (SHT)

Application/Uses/Problem being Addressed:

Hydrotalcite is used in a variety of applications, particularly in the chemical and pharmaceutical industry. The antacid properties of hydrotalcite make it significantly useful for healthcare and chemical industry end users.

SHT has also replaced heavy-metal based heat stabilizers for PVC. They are used as halogen scavenger in plastic processes such as the production of polypropylene. Hydrotalcite is used as halogen scavengers in heavy metal free stabilizer systems. Other applications include base or support catalysts, adsorbent for wastewater treatment, ion exchangers (good anion exchange capacity to capture both inorganic and organic anions), drug releasers, anticorrosive materials, nuclear waste treatment and CO_2 capture and wide range of environmental applications. Hydrotalcite increases the bioavailability of the active ingredient, especially for poorly soluble substances. These special features enable a huge number of applications with high added-value in several fields.

Salient Technical Features including Competing Features/Impact:

Bittern and soda ash are reacted to make magnesium precursor. Aluminium sulphate and soda ash solutions are reacted to make aluminium precursor. These precursors are blended and subjected to hydrothermal treatment under optimized process conditions. The slurry is filtered, dried, pulverized and sieved to obtain pharmaceutical grade SHT. To prepare halogen scavenger grade SHT, the

IPR Status & IPR Details
IN 192168, US 7,022,302, IN 238892, EP 1575874 (B1), JP 4387312 (B2), CN 1717368 (B). US 9567233 B2

TRL Level & Scale of Development
9; Commercial scale

slurry is treated with surface modifier to make the material hydrophobic prior to filtration. The cake is washed, dried, pulverized and sieved to obtain halogen scavenger grade SHT.

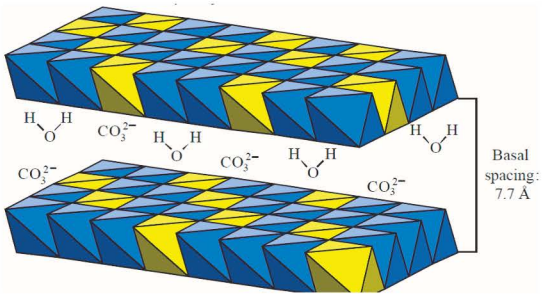
Business Scope & Opportunity (in terms of scale, cost, market, etc.):

The global demand of synthetic hydrotalcite is more than 75000 tons. Its demand is expected to grow further in the coming years to replace lead stabilizer due to regulatory norms in developed countries. In India most of the material is being imported hitherto. Major players are Kyowa Chemicals, Sud Chemie, Akzo Nobel, etc. Kyowa is selling their product under the brand name DHT-4A, L-55R-II and Alcamizer at 3-5 USD per kg.

Techno-Economics
Varies with scale;
nominally pay-back period is
< 3 years

Environmental Considerations, if any:

This lead free environmentally friendly halogen scavenger type hydrotalcite can be prepared from three industrial wastes such as aluminum chloride waste generated, bittern containing magnesium compounds generated in solar salt work and ammonium carbonate solution generated in organic pigment industries.



Status of Licensing:

Technology licensed.

Status of Commercialization:

Technology has been already commercialized at 3 TPD scale by M/s Huebach Color Pvt. Ltd., Ankaleshwar.

Major Raw Materials Needed:

Sea bittern / $MgCl_2$, $AlCl_3$ or $Al_2(SO_4)_3$, sodium hydroxide and sodium carbonate.

Major Plant Equipment and Machinery Required:

General chemical process plant equipment (viz. pressure vessel, reactor, filter, dryer, pulverizer, etc.).

Technology Package:

License to operate IP-protected know-how, demonstration of the process, technology transfer document including basic engineering package. License fee and other financial details are available on request.

Manufacture of Zeolite-A (Detergent Builder)from different raw materials - bauxite or bauxite leachate (Bayer liquor), low grade bauxite

TRL Level & Scale of Development

TRL 9, CSMCRI have successfully commissioned and undertaken trial runs for the production of Zeolite - A on commercial plant of the capacity 10,000 MT/annum

Application/Uses/Problem being Addressed:

Zeolite-A is used as a detergent builder to remove hardness causing calcium and magnesium ions from the water. Zeolite-A is used as an alternative to polluting sodium tripolyphosphate in the powder detergents.

Salient Technical Features including Competing Features/Impact:

- A world class technology for the manufacture of Zeolite-A powder is developed and commercialized.
- Prepared Zeolite-A has calcium binding capacity of 160-170 mg of CaO/g and particle size of less than 5 micron.
- The physicochemical properties of product Zeolite - A powder compete with those of produced by Degussa, PQ Corporation, SPIC Fine Chem., etc.
- In the process sodium silicate and sodium aluminate solution allowed to react in different steps under controlled conditions to prepare Zeolite-A.
- Expertise is available to produce Zeolite-A

powder using bauxite, Bayer liquor, sodium aluminate powder, waste alumina, kaolin and siliceous earth as starting materials.

Techno-Economics

Robust technology with capability to use waste and economic raw material for the preparation of Zeolite-A, will make the process techno-economical feasible and competitive in the open market

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

With stringent environmental regulations and demand for green alternatives causing water pollution, the Zeolite-A as a detergent builder has excellent opportunity.

Environmental Considerations, if any:

Technology has been licensed to different industries.

Major Raw Materials Needed:

Commercialized, Under commercial production by NALCO, Odisha and Gujarat Credo Minerals Industries Limited Gujarat.

Major Plant Equipment and Machinery Required:

Raw material storage tanks, solution preparation tanks, Jacketed Reactor with stirrer, Pumps, Filter press, spray drier, packing unit, etc.

Technology Package:

Process know-how for Zeolite-A; Demonstration of the process at 25 kg/batch; License fee, royalty and other financial details are available on request.

Comparison of properties of detergent builder zeolite-A produced as per the present process (Example 10) and SASIL (Degussa-Henkel)

Property	Example 10	SASIL
appearance:	Fine powder	Fine powder
Whiteness index, %	>98	>95
Calcium Binding Capacity, mg CaO/g of Absolute dry zeolite	160-170	>155
Loss on ignition, (I hour at 800 ^{0} C.), %	20-22	21.5-22.5
pH of 5 % aqueous slurry	11.0	~ 11
Average Particle Size, um,	~4.0	<5.0
Chemical Analysis		
SiO_2, %	33-36	32.5-33.5
Al_2O_3, %	27-29	27.5-28.5
Na_2O, %	14-16	7.5
Crystallinity, %,	>98	>98
Bulk Density, g/ml	0.45-0.55	-0.40

Application/Uses/Problem being Addressed:

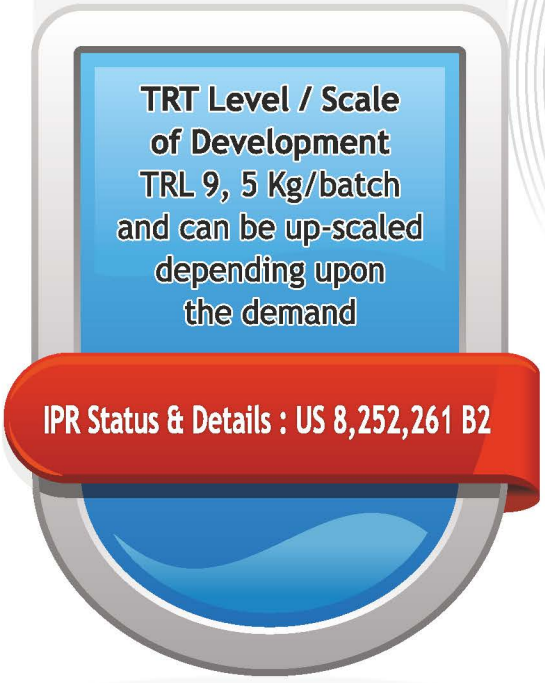
Precipitated silica with fine particle size and narrow particle size distribution finds many applications in polymer/elastomer, thixotropic agent in paints, cosmetics, toothpaste and carrier for insecticide and pesticides. Precipitated silica is used as an alternative to carbon black in the tyre industries.

Salient Technical Features including Competing Features/Impact:

- A process for the preparation of precipitated silica having more than 75% particles finer than 10µm on 5 kg batch scale has been developed.
- In the process neutral grade sodium silicate solution was treated with mineral acid and silica sol in different steps under controlled rate in presence of electrolyte.
- Expertise is available to produce precipitated silica powder of different grades/specification for various applications using sodium silicate, siliceous waste materials like kimberlite earth as starting materials, rice husk ash (RHA).

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

With stringent environmental regulations and demand for alternative for carbon black, the PPT silica has an excellent opportunity as a suitable replacement for carbon black in tyre industries.



Process for the preparation of finely divided precipitated silica for different applications

Environmental Considerations, if any:

The process generates acidic effluent containing sodium sulphate which can be treated using appropriate technique to recycle/reuse DM or RO water.

Status of Licensing:

Technology has been licensed to M/s Kadvani Chemicals Pvt. Ltd., Gujarat, M/s Bethel Chemicals Cochin and other industries.

Techno-Economics

Robust technology with capability to use waste and economic raw material for the preparation of precipitated silica will make the process techno-economically feasible and competitive in the open market

Status of Commercialization:

Commercialized, though scale is not known.

Major Raw Materials Needed:

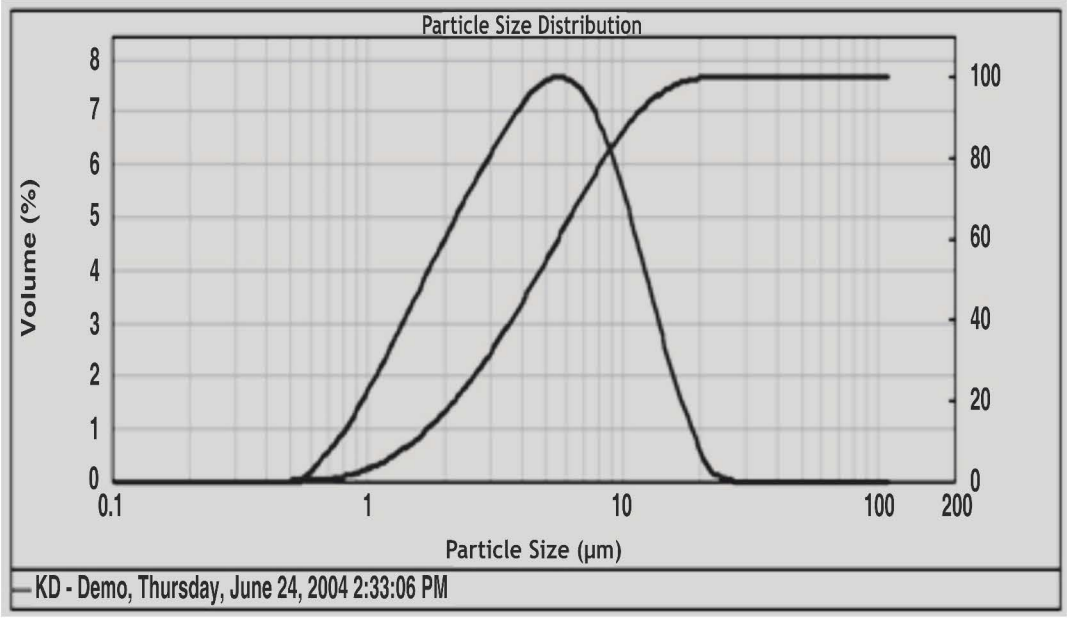
Neutral grade sodium silicate (liquid/solid), siliceous waste materials like kimberlite, mineral acid (sulphuric acid), sodium sulphate, RO or demineralized water, etc.

Major Plant Equipment and Machinery Required:

Raw material, storage tanks, solution preparation tanks, jacketed reactor with stirrer, pumps, filter press, spray drier, packing unit, etc.

Technology Package:

Process know-how for precipitated silica for customer desired grades; Demonstration of the process; License fee, royalty and other financial details are available on request.



Eco-friendly process for production of precipitated calcium carbonate (PCC) of customized grades from calcium carbonate rich by-product/calcium resources

Application/Uses/Problem being Addressed:

Precipitated calcium carbonate has various commercial applications such as manufacture of paper, rubber, plastics, glass, textiles, putties, chalks, sealant, adhesives, paints, inks, varnishes, food, cosmetics, chemicals and pharmaceuticals.

Commercial applications of PCC require specific powder characteristics, particularly, fine particles with a narrow size distribution, uniform shape and crystallinity and it should be free from impurities.

Salient Technical Features including Competing Features/ Impact:

There are physical as well as chemical processes for the treatment of solid waste containing calcium carbonate. But these are time consuming, require specific equipment, specific reagent and higher energy consumption.

To address this problem, CSIR-CSMCRI has developed an eco-friendly process to produce precipitated calcium carbonate from calcium carbonate rich by-product generated in a chemical processing industry. This process significantly purifies the calcium carbonate rich by-product in continuous manner.

It is a semi-continuous process which can be linked to the plant generating the calcium carbonate-rich by-product, especially in nitrophosphate fertilizer plant, minimizing the pollution related to solid waste. The

TRL Level & Scale of Development : 4, Pilot scale

IPR Status & Details

US 6790424B2, US 6761864 B2, IN 221619, CN 1257106, EP 1440037 B1, JP 4084715, WO 03037795

impurities associated with by-product can be removed, recollected and reused as fertilizers. The process significantly purifies the by-product and converts it to value added product.

Techno-Economics

As the process uses inexpensive solid waste as primary raw material, the process is technoeconomically feasible; Economics of the process is governed by the nature of PCC being manufactured for 'intended' applications

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Higher growth in segments such as poly vinyl chloride (PVC) and masterbatches offer significant potential for a supplier to target, primarily due to the large expansion plans of companies such as Plastiblends and Finolex in India. Additionally, there is significant import substitution potential for steric coated grades of ground calcium carbonate (GCC) and precipitated calcium carbonate (PCC) in masterbatches and PVC applications.

Environmental Considerations, if any:

This process provides pollution abatement measures in nitrophosphate fertilizer plant by utilization of the calcium carbonate rich by-product generated in such plant and similar waste calcium generated from plant as alternative source to limestone and is used for producing precipitated calcium carbonate useful for commercial applications.

Status of Licensing:

Licensed to GNFC, Bharuch.

Status of Commercialization:

Not yet put into commercial practice.

Major Raw Materials Needed:

Waste calcium carbonate; Calcium carbonate rich by-product generated from industrial processes.

Major Plant Equipment and Machinery Required:

General chemical process equipment like reactors, calciner and carbonation tower.

Technology Package:

License to operate IP-protected know-how, demonstration of the process, technology transfer document including basic engineering package. License fee and other financial details are available on request.

Organic Chemicals including Pharmaceuticals

Technology for the production of 2-phenyl ethyl alcohol (2-PEA): A synthetic rose aroma by hydrogenation of styrene oxide obtained via non-chlorine route from styrene

IPR Status

US 7235676, IN 02932DELNP2005, CN 1926124B, EP 1732910 (A1), JP 4733109, KR 101131207 (B1), WO 2005095370 (A1); US 9040755, IN 3656DEL2011, EP 2791095 (A1), WO 2013088454 (A1))

Application/Uses/Problem being Addressed:

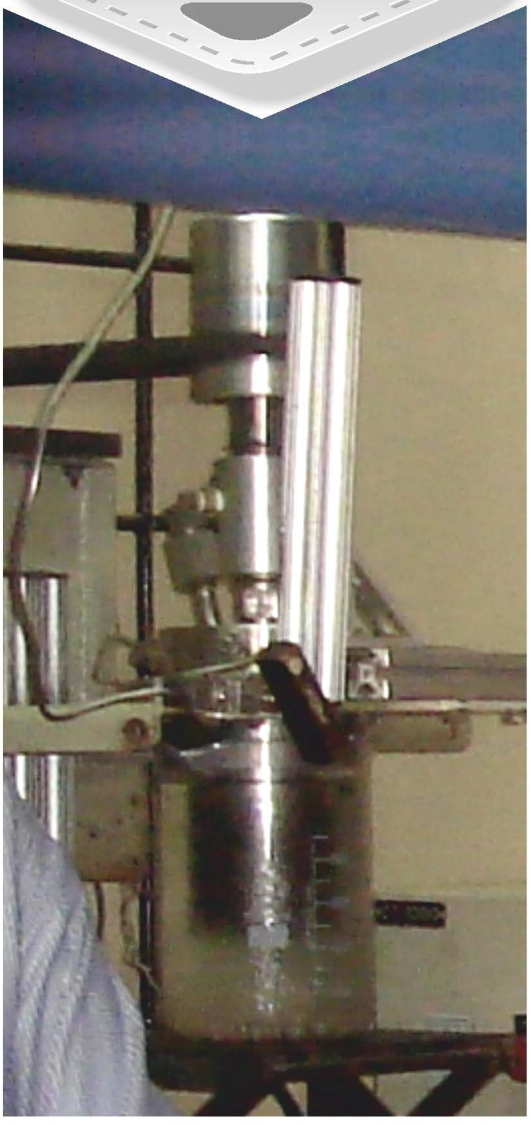
2-PEA is directly used as a rose fragrance in soap industry and in syrup formulations in pharmaceutical industries. 2-PEA is also a starting material for many industrially important aroma chemicals (e.g. synthetic Kevra) and bioactive compounds.

Salient Technical Features including Competing Features/Impact:

- Non-pyrophoric reusable (up to 100 times) hydrogenation catalyst with high physical strength.

TRL Level & Scale of Development:

TRL - 6; Pilot scale (1 kg)



- Lesser Pd loading for hydrogenation and recoverable by an easy process.
- Recyclable solid urea-like organic promoter for epoxidation (lesser effluent generation).
- Generates no by-products in both steps.
- Intermediate styrene oxide is an important chemical for many other processes.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

2-phenylethanol (2-PEA) is a naturally occurring rose fragrant chemical currently used as aroma chemical in perfumery, cosmetic industries and in pharmaceutical formulations. The industry uses Pd/C as hydrogenation catalyst for the production of 2-PEA from styrene oxide which is pyrophoric besides producing several by-products, and due to its low physical strength, there is physical loss of the catalyst during recovery operations. Perfumery industry is expanding and 2-PEA would find improving indigenous market opportunity.

Techno-Economics

Attractive and tentatively the product cost would be ~2-2.5 times that of styrene; Available on request

Environmental Considerations, if any:

2-phenylethanol (2-PEA) is a naturally occurring rose fragrant chemical currently used as aroma chemical in perfumery, cosmetic industries and in pharmaceutical formulations. The industry uses Pd/C as hydrogenation catalyst for the production of 2-PEA from styrene oxide which is pyrophoric besides producing several by-products, and due to its low physical strength, there is physical loss of the catalyst during recovery operations. Perfumery industry is expanding and 2-PEA would find improving indigenous market opportunity.

Status of Licensing:

Technology licensed to-

1. Asian Azoles Pvt. Ltd., Vapi.
2. Aquila Organics Pvt. Ltd., Mumbai.
3. Eco organics, Rampur, Uttar Pradesh.
4. Bharati Rasayan Udyog, Raipur.

Status of Commercialization:

Some of the licensee have started putting up a plant for commercial scale manufacture of SO/2-PEA though details of their scale of manufacturing is not known.

Major Raw Materials Needed:

Styrene, solid urea, manganese sulphate, water, hydrogen peroxide, toluene, ethyl acetate and dichloromethane, Pd/solid base, hydrogen.

Major Plant Equipment and Machinery Required:

Reactor, high pressure reactor, distillation unit, centrifugal/filtration unit.

Technology Package:

Know-how for 2-PEA and SO; Demonstration of the process; License fee, royalty and other financial details are available on request.

A cost-effective and greener process for 3-methyl-5-phenylpentanol (Mefrosol)

Application/Uses/Problem being Addressed:

- Mefrosol is an important perfumery chemical having fresh, rosy, floral odour and is used to give freshness and volume in both floral and citrus fragrances.
- The existing industrial process utilizes toxic reagents and starting materials generating a large volume of industrial wastes.
- The CSIR-CSMCRI's technology is a greener alternative to the existing processes. The present method employs recyclable catalyst and benign starting materials with the formation of water as the only by-product, and is thus environment friendly.

Salient Technical Features including Competing Features/Impact:

Contrary to the existing protocols that employ toxic and corrosive reagents producing stoichiometric industrial wastes, the CSMCRI's process has the following important features:

- Currently no indigenous process for Mefrosol is available in India. CSMCRI's Technology is the first chemical process for the production of Mefrosol with a high yield and industrially relevant purity.
- The present process is very much clean giving water as the only by-product resulting in excellent yield and purity of the desired product Mefrosol.
- Cost-competitive as it utilizes commercial grade starting materials, reagents and solvents.
- The present process avoids any purification by chromatographic separation.
- The present process has been scaled up to 1 kg level.
- The present process is consistently reproducible and hence, reliable to industrial applications.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

India imports Mefrosol in large quantity for its use as a perfumery ingredient. The CSMCRI's process is the first indigenous technology for Mefrosol in India and when commercialized, we anticipate that the process may lead to reduce import substitution in significant degree for Mefrosol.

IPR Status & Details : IN 201611009444 A
TRL Level & Scale of Development
TRL 5; Demonstration is ready at 1 kg scale per batch with respect to Mefrosol

Environmental Considerations, if any:

All starting materials are non-toxic and non-corrosive in nature. A green, non-soot, industrially viable and cheap solvent is used in our process, thereby providing a cleaner

environment. Water is produced as the only by-product, which can be removed via azeotropic distillation from the reaction mixture followed by cheap water pre-treatment at ETP. Hence the process is environment friendly.

Status of Licensing:

Yet to transfer the technology know-how; Discussions are on-going with relevant industries.

Status of Commercialization:

Not applicable.

Major Raw Materials Needed:

Isoprenol, benzaldehyde.

Major Plant Equipment and Machinery Required:

1. Customized glass assembly equipped with two addition pumps.
2. High pressure reactor.
3. Glass/steel distillation units.

Technology Package:

Process know-how for Mefrosol + Demonstration at industry site; Basic Engineering Package for this process is ready; License fee, royalty and other financial details are available on request.

Techno-Economics

Process know-how for Mefrosol + Demonstration at industry site; Basic Engineering Package for this process is ready; License fee, royalty and other financial details are available on request

Application/Uses/Problem being Addressed:

The invention provides many hydrogenated and/or hydrodeoxygenated products.

Sugar alcohols preparation is an industrially relevant reaction and these products are used in food, cosmetics, polymer and pharmaceuticals.

Cyclohexanol is familiar in the polymer industry that serves as a precursor for Nylon-6 and Nylon-66.

In situ generated Ru(0) catalyst has been developed in this invention, which avoids the additional/external reduction step for the active Ru(0) catalyst.

IPR Status & Details :
IN 3219DEL2015, WO 060922 Al, US 10954185
TRL Level & Scale of Development
TRL-3 & lab scale (few to few 10s g scale)

An eco-friendly process for hydrogenation of organic molecules using hydrous ruthenium oxide catalyst

Salient Technical Features including Competing Features/Impact:

- Diverse reaction scope.
- Reactions under mild conditions in aqueous medium in shorter reaction time using lesser weight % of Ru.
- Nearly 100% conversion of organic molecules comprising alkenes, carbonyl compounds and aromatics with nearly 70-100% selectivity of the desired products.
- Better selectivity control of the desired product via flow-controlled variable pressure mode addition of H_2 besides rendering process safety.
- Higher wt. % of reactants.
- Does not require any catalyst prior reduction.
- Efficient recovery and reuse of the heterogeneous catalyst, in particular supported catalysts without any pre-treatment.

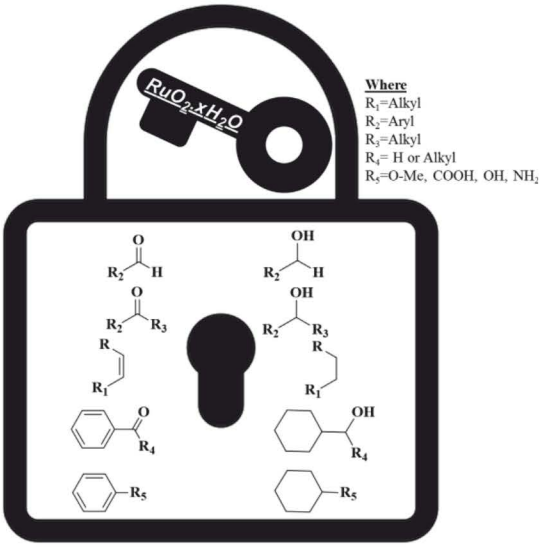
Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Hydrogenation of sugar to sugar alcohols and hydrodeoxygenation of methoxy phenols to cyclohexanol are tested at 5-10 g scale with good conversion/selectivity.

Sugar alcohols and cyclohexanol have good market.

Environmental Considerations, if any:

The invention process is eco-friendly; used aqueous medium as reaction solvent and the invention catalyst is recyclable.



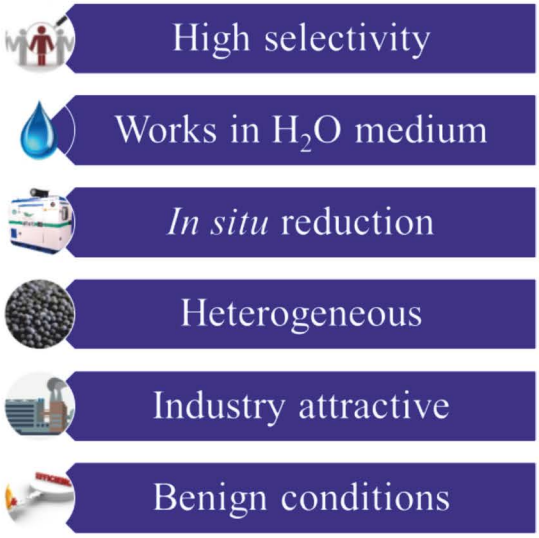
Status of Licensing:
Not yet licensed.

Status of Commercialization:
Not applicable.

Major Raw Materials Needed:
Sugars,
Methoxy phenols.

List of hydrogenated products synthesized (Reactant used):
Cyclohexane (Cyclohexene), γ-valerolactone (α-angelica lactone), 2-propanol (Acetone), 2-butanol (2-butanone), 2-hexanol (2-hexanone), Cyclohexanol (Cyclohexanone, phenol, Guaiacol, Syringol, 3-methoxyphenol and 4-methoxyphenol), 4-methylpentan-2-ol (Methyl isobutyl ketone), Sorbitol (Glucose), Mannitol (Mannose), Xylitol (Xylose), Furfuryl alcohol (Furfural), Cyclohexylmethanol (Benzyl alcohol), methoxycyclohexane (Anisole), Cyclohexanecarboxylic acid (Benzoic acid), Cyclohexanamine (Aniline), Piperidine-3-carboxylic acid (Methyl nicotinate), 1-cyclohexylethan-1-ol (Acetophenone), Cyclohexylmethanol (Benzaldehyde).

HRO and reaction highlights

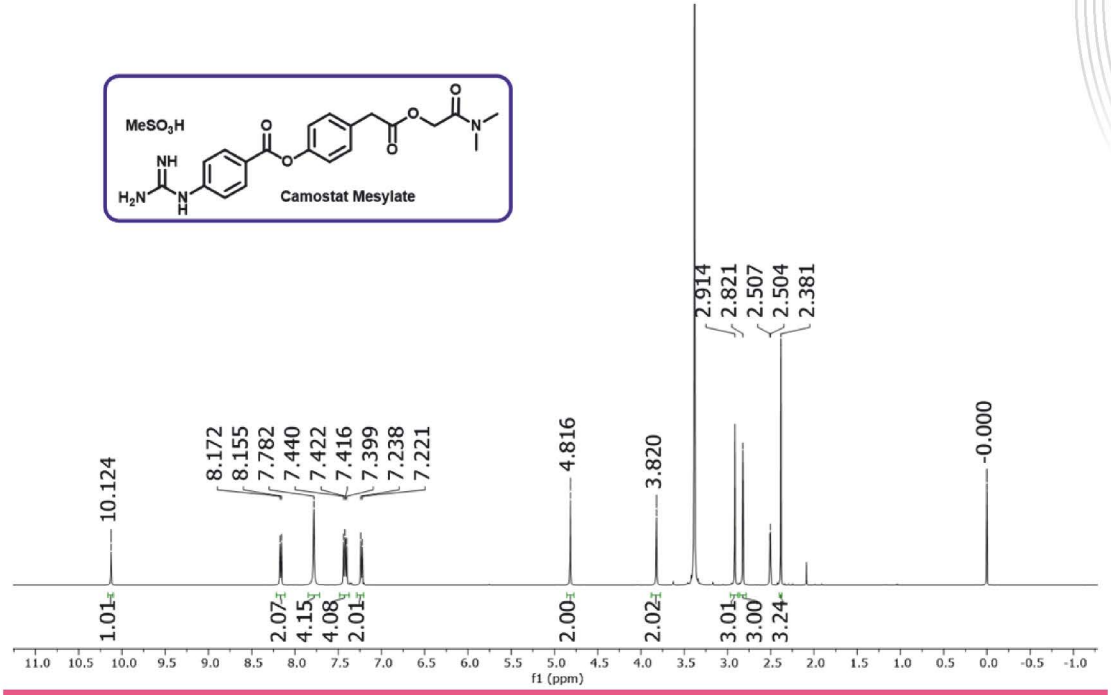


Techno-Economics
Sugars: Rs.50-200/kg
Sugar alcohols: Rs.150-600/kg
Methoxy phenols: Rs.100-300/kg
Lignin bio-oil: Rs.30-60/kg
Cyclohexanol: Rs.250-300/kg
Molecular hydrogen: Depending on the source (approx. Rs.250-500/kg)

Major Plant Equipment and Machinery Required:
- SS or Hastelloy high pressure reactor.
- Hydrogen supply line.
- Filtration assembly.
- Mass flow controller.

Technology Package:
Know-how for processes for hydrogenation of organic molecules using HRO; Demonstration of the processes; Equipment necessary for pilot scale; License fee, royalty and other financial details are available on request.

^{1}H NMR Spectra (500 MHz, DMSO-d_6)



Cost-efficient non-infringing process for camostat mesylate

Application/Uses/Problem being Addressed:

Camostat mesylate acts as a serine protease inhibitor, which is active against the enzyme transmembrane protease serine 2 (TMPRSS2) partially blocked SARS-CoV-2 S-driven entry into lungs cells and full inhibition was attained when camostat mesylate is used in combination with other drugs. Thus, this compound has an envisaged use as a repurposed drug for the treatment of COVID-19. Currently the drug is under Phase-II clinical trial for the treatment of COVID-19 patients.

Salient Technical Features including Competing Features/ Impact:

Synthesis of camostat mesylate through the synthesis of its key intermediates, namely 2-(Dimethylamino)-2-oxoethyl 2-(4-hydroxyphenyl) acetate (Int-I) and 4-Guanidinobenzoic acid hydrochloride (Int-II), starting from inexpensive and indigenously available raw materials.

The process is clean, giving excellent yield and purity of both the compounds, Int-I and Int-II. The synthesis of both Int-I and Int-II have been performed at 50 g batch and are ready at 100 g level with purity >99% each.

The coupling between Int-I and Int-II gives the tosylate salt of camostat which is subsequently converted into camostat mesylate. The synthesis of camostat mesylate in solid form with 96% purity (HPLC) has been achieved and reproduced in several 1 g batches. Currently efforts are ongoing to scale up the synthesis in up to 25 g batches.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Upon realization of 25g batches with pharmaceutically relevant purity, identification of industry partner shall be explored.

Environmental Considerations, if any:

Not done yet.

Status of Licensing: NA.

Status of Commercialization: NA.

Major Raw Materials Needed:

Chloroacetyl chloride, N,N-dimethyl amine hydrochloride, 4-hydroxyphenylacetic acid, sodium hydroxide, potassium hydroxide, 4-aminobenzoic acid, cyanamide, Dicyclohexyl-carbodiimide, p-toluenesulfonic acid, sodium bicarbonate, methanesulfonic acid.

Major Plant Equipment and Machinery Required:

Not yet figured out; process steps uses conventional reaction chemistry set up.

Technology Package:

Process for 2-(Dimethylamino)-2-oxoethyl 2-(4-hydroxyphenyl) acetate (KSM for camostat mesylate).

Process for 4-Guanidinobenzoic acid hydrochloride.

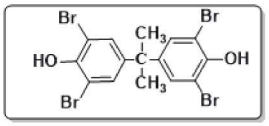
Process for camostat mesylate (API).

Techno-Economics

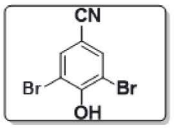
- A non-infringing process for camostat mesylate by utilising indigenously available raw materials
- Cost of the API production is proposed to be reduced by 20-30% of the existing process
- In Japan, the generic drug camostat mesylate costs 86,000 JPY/kg = ~ Rs.60,000/- per kg
- Our proposed cost for camostat mesylate is Rs.18,000-20,000/- per kg (~96% pure) [based on 1 kg production without considering any solvent/SM recovery. The cost will be further lowered when produced in a larger/industrial scale]

In India, both Int-I and Int-II are available at a price of ~Rs.26000/- and Rs.21,000/- respectively per 500g package. Gratifyingly, our proposed cost for Int-I is Rs.7500/- per kg and that for Int-II is ~Rs.3,000/- per kg

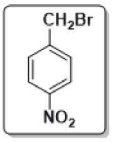
Preparation of industrially important organo-bromo compounds using brominating reagent



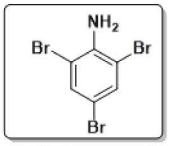
Tetrabromobisphenol-A
80-90 % Yield
95-98% Purity



Bromoxynil
99 % Yield;
>99 % Purity (GC)

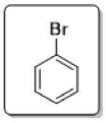


4-Nitrobenzyl Bromide
75-95 % Yield;
upto98 % Purity



2,4,6-Tribromoaniline
91%Yield;
Purity >99% by GC

N-Bromosuccinimide
81%Yield
m.p. 175 C



Bromobenzene
74%Yield;
Purity ~97% by GC

Application/Uses/Problem being Addressed:

CSMCRI/CSIR has developed a green brominating reagent (BR-S), an alternate to liquid bromine this reagent could be used for the preparation of various bromo-products such as 4-nitrobenzyl bromide PNBR (used as a protecting group in the synthesis of Penicillin and peptides), tetrabromobisphenol-A TBBP-A (widely used as a fire retardant), tri-bromoaniline TBA (dye intermediate), N-bromo-succinimide NBS (selective bromination source), bromobenzene (intermediate in the synthesis of various pharmaceuticals & fine chemicals) and bromoxynil (selective contact herbicide).

The use of BR-S, depends upon the number of bromide (Br) atoms to be substituted for a substrate, that many equivalents should be used. (Ex. For PNBR, TBBP-A, TBA, the BR-S required will be 1, 4, 3 equivalents respectively).

IPR Status & IPR Details
US 6,838,582 (2005);
US 6,365,786 (2002);
US 6,956,142 (2005);
Eur. 2,365,960 (2011).

TRL Level & Scale of Development
6

Salient Technical Features including Competing Features/Impact:

- Replacement of the corrosive elemental bromine.
- Safe, easy to handle & transport.
- Avoids the need of special equipment.
- Avoids need of catalyst.
- Maximum bromide atom efficiency.
- Operates under ambient reaction conditions.
- Easy to scale-up for the processes' development.
- No formation of hazardous by-products.

Status of Commercialization:

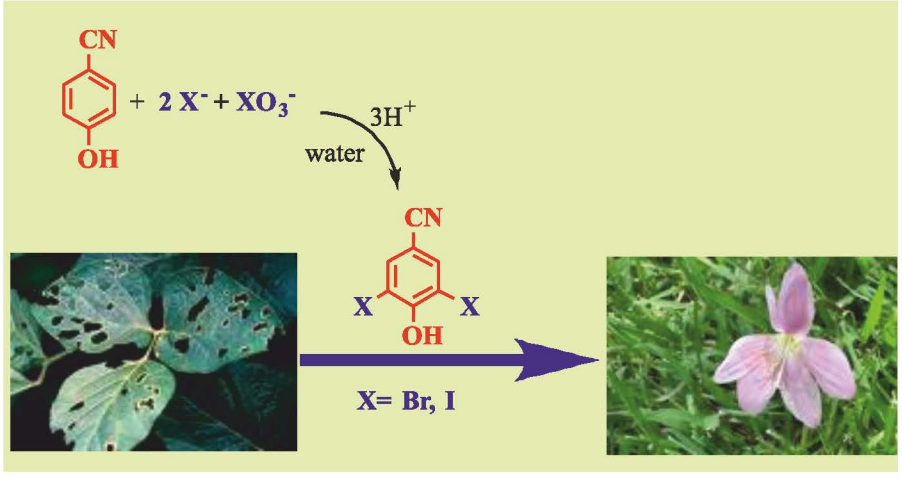
Not yet in commercial practice.

Major Raw Materials Needed:

Desired organic substrate, brominating reagent, mineral acid.

Major Plant Equipment and Machinery Required:

Glass reactor of desired size/ batch with re-fluxing and cooling facilities.



Technology Package:

Preparation of non-hazardous brominating reagent and its applications in the synthesis of organo-bromo derivatives.

Business Scope & Opportunity (in terms of scale, cost, market, etc.)

Bromo-compounds manufacturers, ready at batch scale demonstration.

Environmental Considerations, if any:

The process does not generate hazardous by-products. The effluent could be discharged after neutralization.

Status of Licensing:

Licensed to industry.

Techno-Economics

The cost varies based on the compound synthesized. The cost of the product would be roughly 1.2 - 2.6 times that of raw material cost

Catalytic process for the preparation of isolongifolene

IPR Status & Details :
US 7,132,582 B2, IN 195 683
KR 0674626, JP 4,468,891

Application/Uses/Problem being Addressed:

- Iso-longifolene ($C_{15}H_{24}$), an isomeric product of longifolene ($C_{15}H_{24}$), is extensively used in perfumery, fragrance, food and pharmaceutical industries due to its woody amber odor.
- The existing commercial method for the preparation of iso-longifolene from longifolene involves multi-step homogeneous catalytic process using corrosive liquid acid (e.g. sulfuric acid) that needs neutralization before waste disposal.
- We have prepared iso-longifolene from longifolene in a single step in presence of a solid acid catalyst, which is eco-friendly, easily separable and reusable.

Salient Technical Features including Competing Features/Impact:

- Single step, solvent free heterogeneous green catalytic synthesis of iso-longifolene resulting into 90-95% conversion of longifolene with ~100% selectivity of iso-longifolene.
- Use of an eco-friendly, separable and re-usable solid acid catalyst having excellent performance on re-cycling as an alternative to conventionally used homogeneous acid catalyst.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

- Reasonable cost.
- International market.
- Imported largely from China.

Environmental Considerations, if any:

The process is solvent free and environment friendly using an eco-friendly, easily separable and re-usable solid acid catalyst (and an endeavor to replace conventional liquid acid catalysts (e.g. sulfuric acid)).

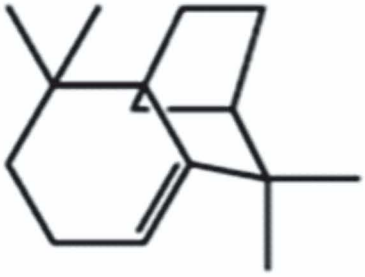
Status of Licensing:

Yet to be licensed.

Status of Commercialization:

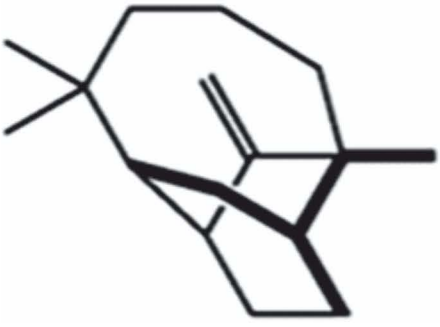
Not applicable.

TRL Level & Scale of Development
TRL is 3;
The reaction has been successfully scaled up to 1 kg in liquid phase batch reactor with similar as that of lab scale experiments (2 g)



ISOLONGIFOLENE

ISOMERIZATION



LONGIFOLENE

Major Raw Materials Needed:

Non-toxic solvents and reagents for catalyst synthesis and longifolene.

Major Plant Equipment and Machinery Required:

Stirred batch reactor, furnace and gas chromatograph (GC).

Technology Package:

Green catalytic process for the synthesis of isolongifolene perfumery chemical over eco-friendly, reusable solid acid catalyst.

Techno-Economics

The price of longifolene is ~Rs.130/- per kg
Isolongifolene is imported mainly from China companies (Zauba.com) with varied price ranging $2 to $120 per kg, probably based on purity on scale of shipment

Application/Uses/Problem being Addressed:

α-Hexyl cinnamaldehyde is found naturally in the essential oil of chamomile. It is an aroma substance and a common additive in perfume and cosmetic industry. Traditionally, it is manufactured from the reaction of benzaldehyde and n-octanal in presence of alkali metal hydroxide as a catalyst.

Limitations of the existing process:

1. Corrosive nature of strong base.
2. Separation difficulties.
3. Environmental challenges.

Advantages of the catalytic process:

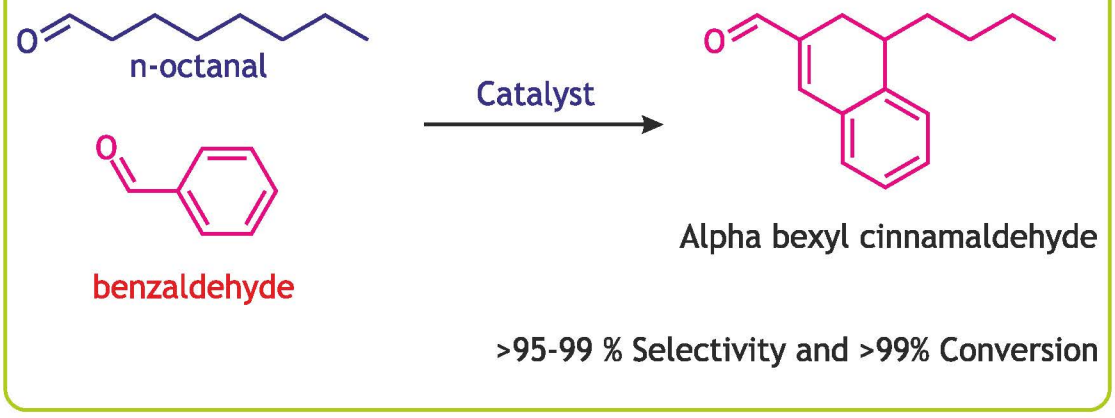
1. Solvent free condition.
2. Low catalyst loading.
3. Heterogeneous system.

Salient Technical Features including Competing Features/Impact:

The process for preparation of α-hexyl cinnamaldehyde involves catalytic cross aldol condensation between benzaldehyde and 1-octanal using a soft solid base catalyst, hydrotalcite.

IPR Status & Details : IN 201611009896

Technology for the production α-hexyl cinnamaldehyde via green catalytic route



TRL Level & Scale of Development
TRL-4; Scaled at 200 g with 99% conversion and >95% selectivity

- Good conversion (>99%) and selectivity (95-98%) are achievable using heterogeneous catalyst.
- Solvent free reaction condition.

- Organic or inorganic bases are not required for the preparation in the present process.
- Shorter reaction time that makes the process industrially attractive.
- Catalyst can be recovered by simple filtration after completion of reaction and effectively recycled several times (tested more than ten cycles) without any significant loss in activity and selectivity.

Techno-Economics

Techno-economically attractive as the product cost is roughly twice that of raw materials cost

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Being a perfumery chemical, α-hexyl cinnamaldehyde has potential market scope; One of the important perfumery chemicals used in Indian industry which is currently to a large extent imported from China.

Environmental Considerations, if any:

The process for α-hexyl cinnamaldehyde works in solvent-free condition making the process environmentally benign; Uses heterogeneous solid catalyst; no aqueous effluent generation.

Status of Licensing:

Yet to license the technology.

Status of Commercialization:

Not applicable.

Major Raw Materials Needed:

Benzaldehyde, n-octanal and hydrotalcite.

Major Plant Equipment and Machinery Required:

Reactor size depending upon plant capacity, distillation unit.

Technology Package:

Process know-how for α-hexyl cinnamaldehyde; Demonstration of the process at 500 g scale; License fee, royalty and other financial details are available on request.

A process for the preparation of iso-eugenol and iso-safrole from eugenol and safrole using recyclable heterogeneous solid base catalyst

Application/Uses/Problem being Addressed:

Traditionally, eugenol and safrole are extracted from plants; however, in recent times produced synthetically for fragrance application. The isomerized product iso-eugenol are used in different aroma industries, in perfumery, insect attractant formulations, UV absorbers, medicine (local antiseptic and analgesics) and for the production of vanillin and ferulic acid. Similarly iso-safrole, a major raw material in flavor industry to produce piperonal, ethyl vanillin, and vanillin with dense flavor (Catalysis Today, 141 (2009) 176 Applied Catalysis A General, 270 (2004) 227 Green Chemistry, 4 (2002) 607 Journal of Molecular Catalysis, 223 (2004) 225).

IPR Status & Details : Not filed

Salient Technical Features including Competing Features/Impact:

- Low-cost and easily synthesizable catalyst with non-precious metals (layered double hydroxides, LDHs).
- Highly active solid base catalysts are prepared from precursors by simple co-precipitation process.
- High yield was obtained by hydrotalcite (HT) with Mg/Al atomic ratio 4 (MgAl4-HT) for eugenol and MgAl6-HT for safrole.
- High boiling solvents such as DMF or DMSO showed high activity at 200 °C.
- Up to 98% conversion of eugenol and safrole was achieved with 85 to 95% selectivity of trans product, and importantly no by-products obtained.
- Both *cis* and *trans* isomers have similar perfumery notes in large number of cases and hence, are dispensable to separate.
- Catalyst is recyclable.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Isomerization of alkenyl aromatics used in perfumery has been practised commercially using alkalis such as KOH in alcoholic solutions (most often in higher alcohols) at high temperatures, homogeneous complex catalysts also require high quantity of alkali which are associated environmental issues. Heterogeneous catalyst used here can be separated easily and can be reused multiple times. Simple and scalable method is used for the preparation of low-cost catalyst precursors using water as synthesis medium. Catalyst is

TRL Level & Scale of Development

TRL - 3; Isomerization of eugenol has been scaled up at 50 g and achieved 90% conversion

Status of Licensing:

Yet to license the technology.

Status of Commercialization:

Not applicable.

Major Raw Materials Needed:

Eugenol and Safrole.

separated from the reaction mixture by simple filtration without using any further chemicals and are successfully recycled.

Techno-Economics

As the catalyst cost is inexpensive, the cost of product would be 1.5-2.0 times that of reactant cost; Available on request

Major Plant Equipment and Machinery Required:

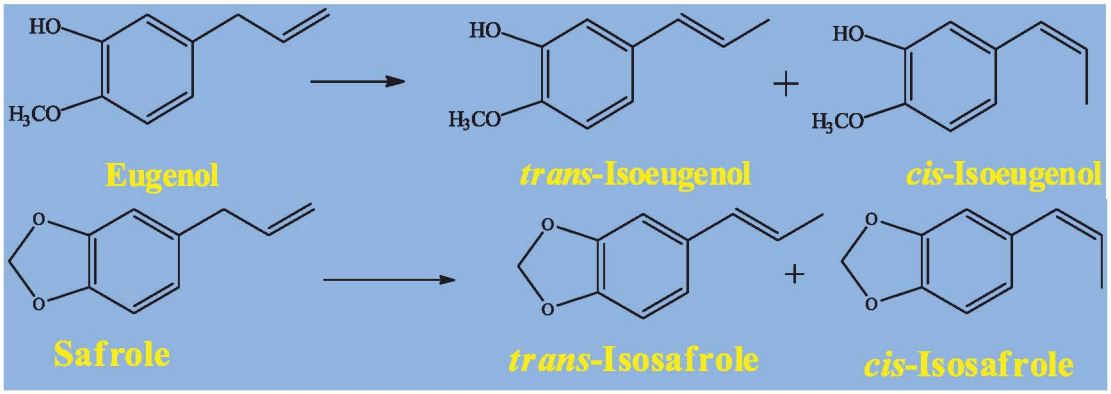
For reaction - Stirred tank reactor with water cooler system; Filtration assembly; Rotary evaporator to remove the solvent.

Environmental Considerations, if any:

Catalyst is easily recoverable (simple filtration) without any further addition of chemicals and reusable; No large aqueous alkaline/salt effluent is generated in the process.

Technology Package:

Know-how for process of isomerization of eugenol and safrole; Demonstration of the process; Equipment necessary for pilot scale; License fee, royalty and other financial details are available on request.



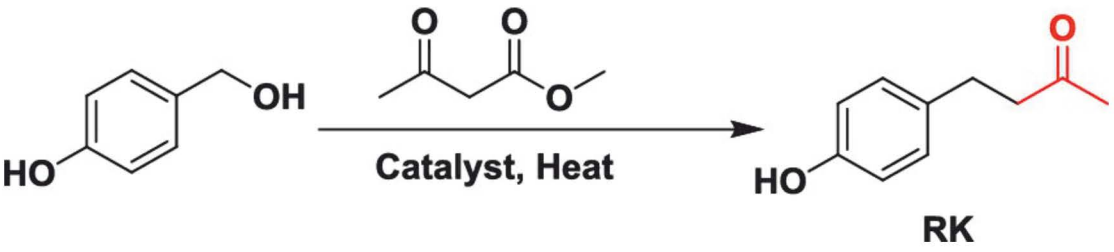
Application/Uses/Problem being Addressed:

Fruity berry-like odour; Raspberry ketones (RK) are found to be useful to burn subcutaneous fats, dietary supplements, promoting weight loss, in skin-lightening cosmetics anti-inflammatory and anti-oxidative activities.

market value (US$ 3000/kg). However, RK is mainly isolated from red raspberries fruits, and extractable concentration of RK is very low (1-4 mg/kg); Opportunity for "Make in India".

IPR Status & Details : IN 201911024665

Process for the preparation of flavouring ketones



Salient Technical Features including Competing Features/Impact:

- The present synthesis protocol reports aryl ketone using acetoacetic ester and substituted benzylic alcohols/halide using inexpensive indigenous commercially available solid acid catalyst provides convenient and efficient synthetic route of alkylation and decarboxylation.
- High conversion and excellent selectivity.
- Solvent free conditions are feasible.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

The market value for aryl ketones ranks second behind vanillin, with a total potential

Environmental Considerations, if any:

No effluent is generated in the process; Use of easily filterable solid catalyst; Scope to avoid solvents.

Status of Licensing:

Not yet licensed.

Status of Commercialization:

NA.

TRL Level & Scale of Development

TRL 3;
Process is carried out at 50 g scale

Techno-Economics

Techno-economically attractive as the reaction occurs in single pot using an inexpensive commercial catalyst

Major Raw Materials Needed:

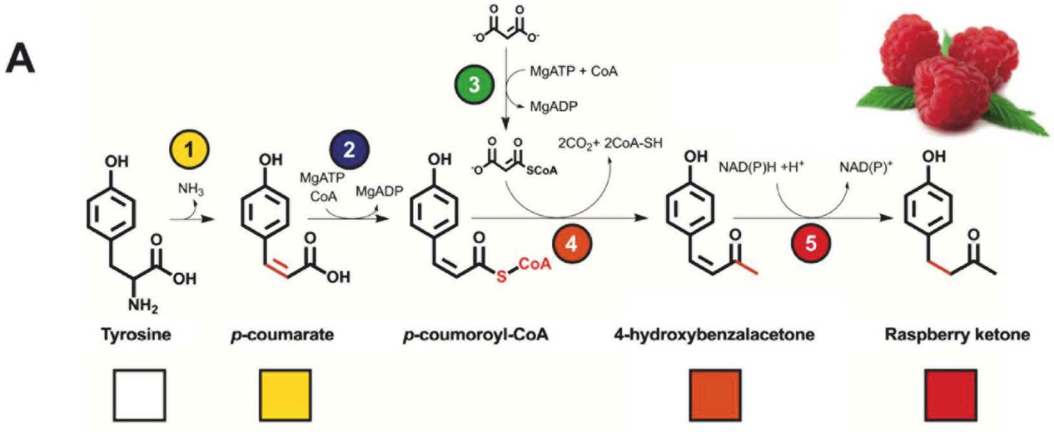
Benzylic alcohols, acetoacetic ester.

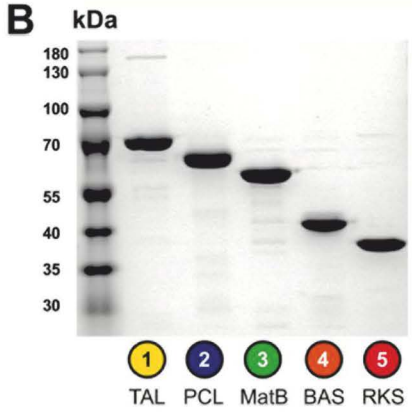
Major Plant Equipment and Machinery Required:

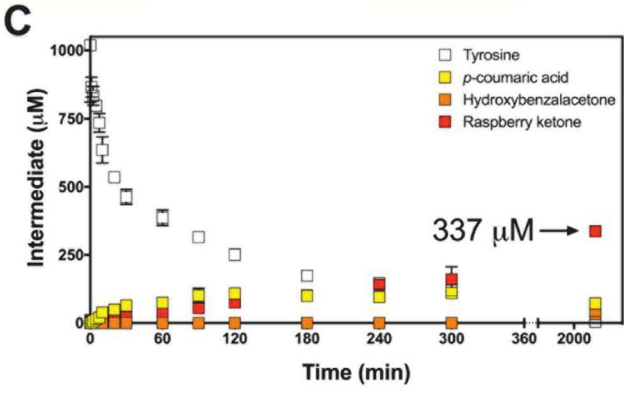
Process equipment like reaction vessel with agitating assembly, distillation set-up.

Technology Package:

Process know-how for Raspberry ketone; Demonstration of the process at 100 g scale; License fee, royalty and other financial details are available on request.







Bio-based Fuels & Chemicals

Technology for the production of biodiesel from *Jatropha* seed

Application/Uses/ Problem being Addressed:

The biodiesel can be used either in blend or neat form in mobile and stationary diesel engines in place of fossil diesel without any engine modification. It can replace fossil diesel and it is alternative source of renewable energy.

IPR Status & IPR Details
US 7,666,234
PCT/IN 04 / 00329
IN 2056/DEL/2004

TRL Level & Scale of Development
6 ; On plant scale (1TPD)

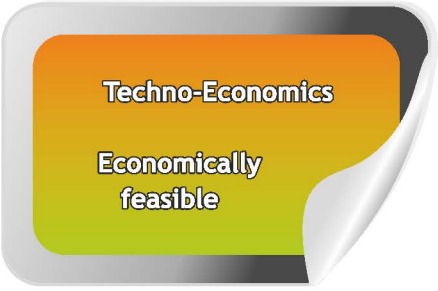
Salient Technical Features including Competing Features/Impact:

- *Jatropha* methyl ester (biodiesel) produced complies with the stringent EN14214 specifications.
- The biodiesel in neat form has been used successfully in mobile and stationary diesel engines without any engine modification and down to a temperature of +2°C.
- Mileage obtained with the neat biodiesel is comparable in most cases with that obtained with fossil diesel.
- Euro III emission norms have been met in studies.
- The process can handle variations in

Using this technology, a world class biodiesel can be produced with which it is possible to mitigate the environmental pollution by having low pollutants in the exhaust and carbon dioxide generated will be utilized by the vegetation for its growth.

Jatropha oil quality without compromising on biodiesel quality.

- The unit operations are simple to operate and maintain.
- All the operations in the core process are at ambient temperature making it an energy efficient process.
- The process is integrated all the way from whole seed to recovery of by-products.
- Zero effluent discharge through integration.
- The process is applicable to other vegetable oils besides *Jatropha*.



Business Scope & Opportunity (in terms of scale, cost, market, etc.):

In view of cleaner environment, in particular in terms of climate changes, huge opportunity exists for shift in bio-based fuels market.

Environmental Considerations, if any:

Zero effluent discharge as all by-products, including catalyst, are recovered in saleable form or recycled in integrated process.

Using this technology, a world class biodiesel can be produced with which it is possible to mitigate the environmental pollution by having low pollutants in the exhaust and carbon dioxide generated will be utilized by the vegetation for its growth.

Status of Licensing:

Licensed technology.

Status of Commercialization:

The institute has installed and commissioned 1000 liters per day & 750 Liters per day (3 shifts basis) capacity fully integrated zero effluent discharge *Jatropha* biodiesel plants on turnkey basis for DRDO at Military Farm, Secunderabad & Rajasthan State Mines & Minerals Limited, Udaipur respectively.

Major Raw Materials Needed:

Vegetable oil, Methanol.

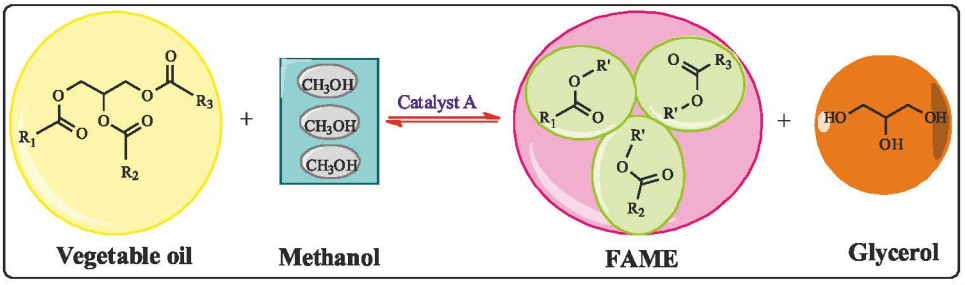
Major Plant Equipment and Machinery Required:

Oil Expeller, Vessels with Agitator, Centrifuges, Distillation Unit, Air Compressor, etc.

Technology Package:

Technology package is ready and would be provided to the party at the time of technology transfer.

TRL Level & Scale of Development: TRL-4; • For sunflower oil scaled up at 1 Kg scale. Successfully collected ~ 800 g (excluding handling loss) of FAME and ~ 85 g of glycerol with > 95 and > 97% purity respectively • At 25 g scale, *Jatropha*, pungai and karingatta oil results > 95% yield of FAME • At 25 g scale, even by using LR grade methanol that has high water content (0.05%) results > 90% yield of FAME



Preparation biodiesel (fatty acid methyl esters) from various vegetable oils using recyclable solid base catalyst

Application/Uses/Problem being Addressed:

- FAME (main-product) - Fuel, lubricants, surfactants, oleo-chemicals and polymers, etc.
- Glycerol (by-product) - Pharmaceuticals, cosmetics, food and plastic industries and as building block chemical, etc.

Salient Technical Features including Competing Features/Impact:

- Low-cost and easily synthesizable catalyst precursor (layered double hydroxides, LDHs).
- Highly active solid base catalyst (oxides) are prepared from precursors by simple calcination process.
- Basic nature of the catalyst was altered to achieve the maximum yield.
- Developed LDH derived oxides is very active for the FAME production from the non-edible oils that had very high acid values (Jatropha: 31 mg KOH/g).
- > 90% yield of FAME for various vegetable oils (edible, non-edible & used cooking oils) is obtained at 65 °C within 5 h using methanol:oil molar ratio of 5.6:1 (in few cases nearly 10:1) using developed solid catalyst.
- Even deliberate addition of water (up to 2%) showed only a marginal decrease in the yield of FAME.
- Transesterification of sunflower oil with alcohols such as ethanol, propanol and butanol results > 85% yield of fatty acid alkyl esters (FAAE) under reflux conditions.
- Catalyst was recycled up to 4 cycles (94% in the first cycle to 77% in the fourth cycle).

IPR Status & IPR Details

US 9029583B2, CN 103370405B, JP 5964327B2, EP 2675879B1, ES 2800023T3, IN 0371/DEL/2011, WO 2012111023A8, CA 2827063A1, KR 20140006030A, BR 112013020651A2, MY165640A

- Important physical properties of sunflower FAME match well with the standard DIN values.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

This process relates to the preparation of biodiesel from various vegetable oils which can probably replace to restricted available, depleting fossil source derived fuels. Simple and scalable method is used for the preparation of low-cost catalyst precursors by using only water as synthesis medium. Active catalyst is prepared from precursor by simple calcination process under static air condition that reduces the cost of inert gases which are generally required for the preparation of oxide catalysts. In this process, very less amount of methanol (nearly 2 stoichiometric ratio of oils) is used as alcohol source which makes this process more cost-effective. Catalyst is separated from the reaction mixture by simple filtration without using any further chemicals and are successfully recycled. By-product glycerol is separated from bio-diesel by phase-separation technique without using any further chemicals. Both FAME and glycerol have huge application potential and so the developed process provides scope to oleo-chemical industries.

Techno-Economics
Tentative Price:
Vegetable oils:
Approx. Rs.40-80/L.
Rates may be less (25-50%) in wholesale places.
Methanol:
Approx. Rs.20-30/L
Biodiesel:
Rs.100-120/L
Glycerol:
Rs.30-90/Kg
(local vendors)

Environmental Considerations, if any:

- Requires less amount of methanol (nearly 2 times of stoichiometric of oil - In most of the cases).
- Catalyst is easily recoverable (simple filtration) without any further addition of chemicals and reusable.

Status of Licensing:

Yet to license the technology.

Status of Commercialization:

Not applicable.

Major Raw Materials Needed:

- Various edible (9 sources), non-edible (7 sources) and waste cooking oils (3 sources) are used as vegetable oil source - Totally 19 different oil sources (mainly sunflower oil).
- LR grade methanol are used as alcohol source.

Major Plant Equipment and Machinery Required:

For reaction - Stirred tank reactor with water cooler syste m; Filtration assembly; Rotary evaporator to remove the unreacted alcohols; Phase separating unit for separation of FAME and glycerol.

Technology Package:

Know-how for process of FAME from vegetable oils; Demonstration of the process; Equipment necessary for pilot scale; License fee, royalty and other financial details are available on request.

Microalgal biodiesel

Application/Uses/Problem being Addressed:

- Engine worthy biodiesel as substitute to diesel.
- Food vs Fuel Debate: Possibility of utilizing unusable land of salt farm for cultivation.
- Cost-effectiveness: Utilizing solar energy for biomass production.
- Indigenous raw material: Related IPR for production of oil-bearing *Chlorella variabilis* EP 2619303A1; US Patent 8741628.
- Dry sea as a substitute for the nutrients of sea water media for marine cultures (PCT/IN2012/000857).

IPR Status & IPR Details : EP 2718453 A2
TRL Level & Scale of Development : TRL - 4; The process has been validated at pilot scale

Salient Technical Features including Competing Features/Impact:

- Low energy requirement.
- Raw materials indigenously available.
- Identified best strain of *Chlorella* (halo-tolerant (3-8 Be') and thermotolerant (25-45°C)).
- Harvesting auto-settled dry biomass of *Chlorella variabilis* for high energy efficiency.
- Biorefinery approach.
- Scope for further improvisation.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

The global advanced biofuel market is likely to grow to USD 44.6 billion by 2021, at a CAGR of close 44 percent by 2021.






Mass cultivation of *C. variabilis* (ATCC PTA 12198)

Environmental Considerations, if any:

- The process is eco-friendly.
- It can bring down CO_2 emissions.

Status of Licensing:

Not yet licensed.

Status of Commercialization:

Not applicable.

Major Raw Materials Needed:

Microalgae oil; Chemicals and Solvents.

Major Plant Equipment and Machinery Required:

Open ponds, Pilot centrifuge, Glass reactors, Soxhlet extraction system.

Technology Package:

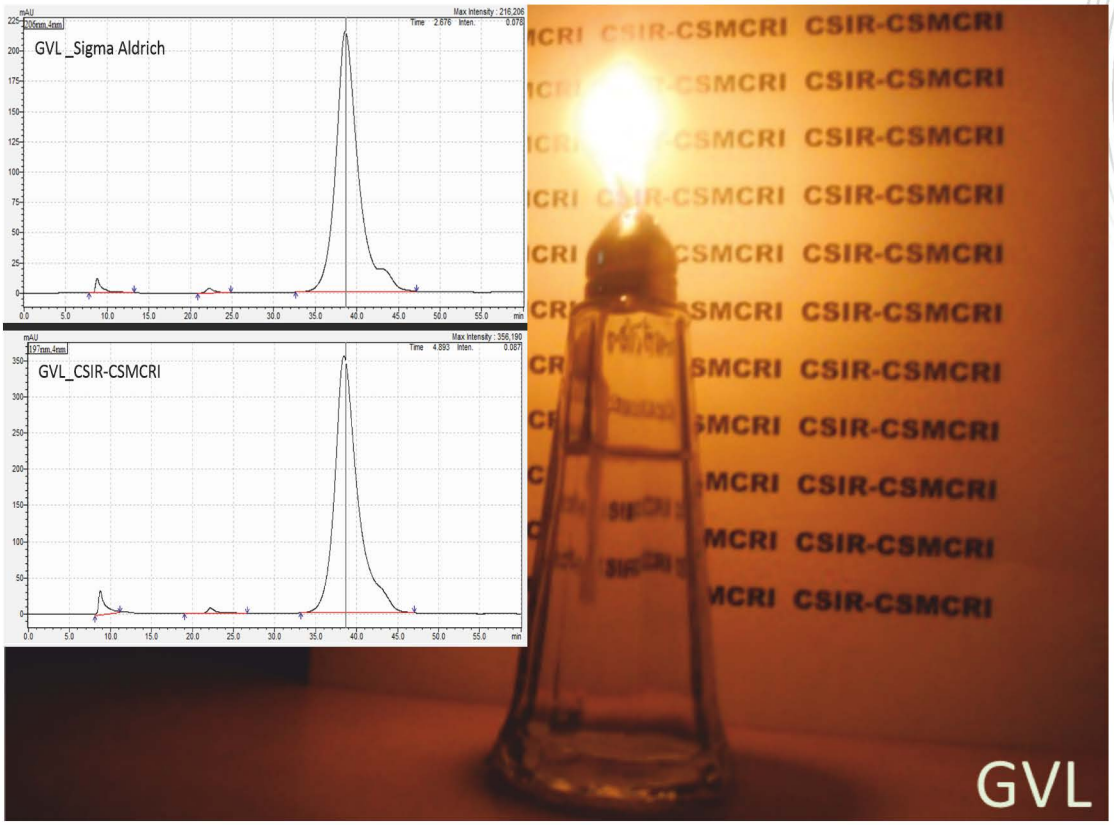
Available on request for "as is where is basis".

Techno-Economics
Tentative Price: Rs. 125/- per litre; Collaboration sought on further refinement

Mass cultivation of CCNM-*Chlorella variabilis* (ATCC PTA-12198)

Drying the auto-settled biomass

Heap of sundried auto-settled biomass



A process for the preparation of γ-valerolactone by catalytic hydrogenation of levulinic acid using Ru-based catalysts

Application/Uses/Problem being Addressed:

γ-valerolactone (Gvl), an attractive platform chemical, is used in the preparation of a variety of fuels, polymers and chemical intermediates and acts itself as a greener alternative solvent for various chemical transformations and is also reported as a good medium for the conversion of lignocellulose components.

Salient Technical Features including Competing Features/Impact:

- Reactions under mild conditions (50-100°C and 5-15 atm. H_2) using heterogeneous catalysts in aqueous medium.

IPR Status & IPR Details
IN 2866DEL2014, WO 2016/056030, EP 3204366A1, US 10221149B2

TRL Level & Scale of Development
TRL - 4; LA hydrogenation to Gvl has been tested at 200 g scale with 100% conversion/selectivity

- 100% conversion of LA with excellent selectivity for Gvl (100%).
- Shorter reaction time (2-30 min).
- Use of lesser weight % of Ru.
- No necessity of prior reduction of the active catalyst and is *in situ* generated.
- Active catalyst is recyclable.
- Requirement of nearly stoichiometric quantity of hydrogen thereby avoiding recycle operations.
- The active catalyst can be supported on inexpensive supports such as zeolites and LDHs for efficient recovery and reuse.

Techno-Economics

Tentative Price:
Levulinic acid:
Rs.300-350/- kg

Molecular hydrogen:
Depending on the source
(approx. Rs.250-500/kg)

γ-valerolactone:
Rs. Rs.500-550/- kg
(would be lesser if done on larger scale)

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

As Gvl is renewable bio-derived liquid, it has tremendous scope for its utility as green high boiling solvent and also has properties as that of fuel additive. The scope is high at least few tens of thousands of tons. The most critical factor is availability of levulinic acid at competitive rates that would enable replacement of fossil-derived solvent/additive by Gvl. This would be a new market opportunity.

Environmental Considerations, if any:

Gvl is renewable, easy and safe to store and move globally in large quantities.

The invention process is eco-friendly; used aqueous medium as reaction solvent and the invention catalyst is recyclable.

Status of Licensing:

Not yet licensed.

Status of Commercialization:

Not applicable.

Major Raw Materials Needed:

Levulinic acid and molecular hydrogen.

Major Plant Equipment and Machinery Required:

- Hastelloy high pressure reactor.
- Hydrogen supply line.
- Filtration assembly.

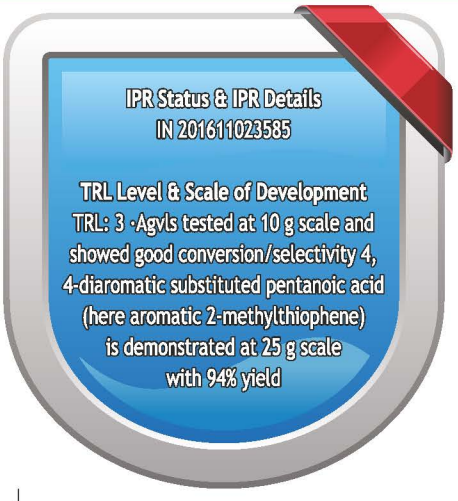
Technology Package:

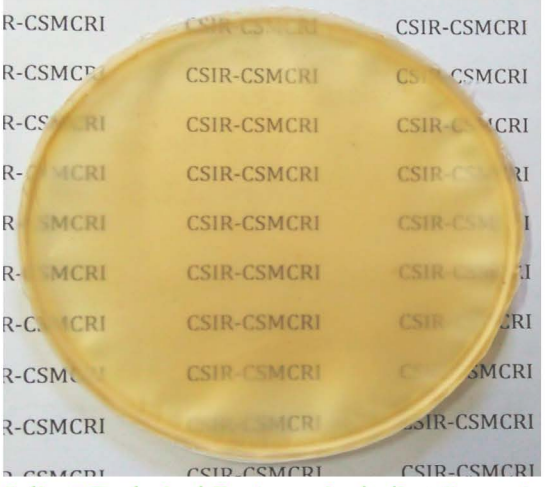
Know-how for process of GvL from LA; Demonstration of the process; Equipment necessary for pilot scale; License fee, royalty and other financial details are available on request.

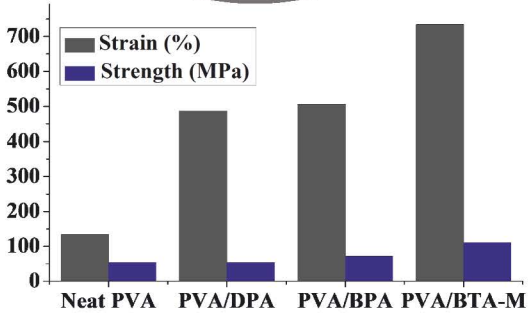
Arylated γ-valerolactones (Agvls), 4-keto esters and 4,4-diaromatic substituted pentanoic acid and its esters by catalytic organic transformations of levulinic acid with aromatics

Application/Uses/Problem being Addressed:

- Arylated γ-valerolactones (Agvls) moieties mainly used in agrochemical and pharmaceutical industry.
- 4-keto esters moieties act as a chemical intermediate for preparation of 1,4-dikotones.
- 4,4-diaromatic substituted pentanoic acid and its esters have excellent scope in polymer industry.







Salient Technical Features including Competing Features/Impact:

Various Agvls prepared from LA along with different aromatics such six membered (alkoxy/thio) and five membered (thiophene and 2-methylthiophene).

- 4-keto ester (phenyl 4-oxopentanoate) prepared from LA with phenol.
- 4,4-diaromatic substituted pentanoic acid and its esters prepared from LA and its esters with 2-methylthiophene.
- Mild reaction conditions (85-150 °C).
- Reactions under open atmosphere.
- Good conversion and yields.
- Use of recyclable heterogeneous catalysts.

Environmental Considerations, if any:

- The invention process is eco-friendly.
- All the reactions conducted under neat conditions.
- Excess used aromatics recycled/reused.

- Use of excess aromatic in the reaction medium that acts as solvent and enhance the kinetics of the reaction with excellent selectivity that could be recycled.
- Good chemo and regio-selectivity for the preparation of Agvls.
- Good selectivity (>95%) for the preparation of 4, 4-diaromatic substituted pentanoic acid along with total conversion of levulinic acid (LA).
- The prepared products of LA have structural accessibility to develop applications in the field of pharmaceuticals, agrochemicals and fuel industry.

Techno-Economics

LA:
Rs.350/kg;
Aromatics:
Rs.100-500/kg
Products:
Rs.1000-3000/kg
(depending on the usage/field)

Status of Licensing:

Not yet licensed .

Status of Commercialization:

Not applicable.

Major Raw Materials Needed:

Levulinic acid.

Aromatic compounds.

Major Plant Equipment and Machinery Required:

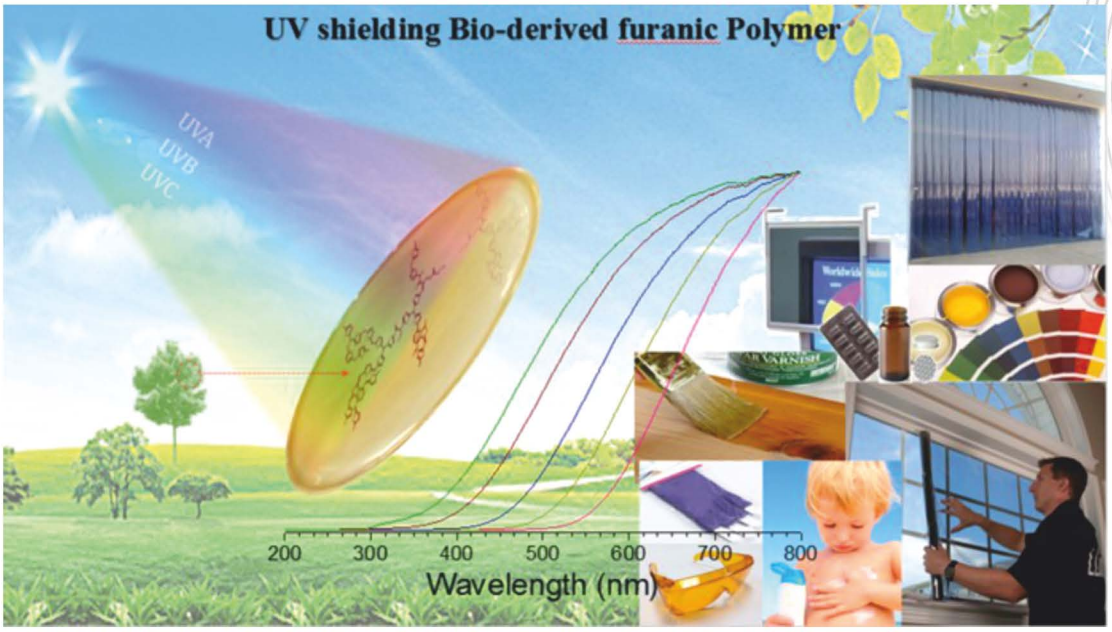
- Glass reactor with condensing assembly.
- Distillation assembly (for separation of the products) or preparative flash chromatography.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

4,4-diaromatic substituted pentanoic acid and its esters have excellent plasticizing ability and is potential alternative for commercially available DOP and BPA.

Technology Package:

Know-how for processes of arylated LA derivatives; Demonstration of the processes; Equipment necessary for pilot scale; License fee, royalty and other financial details are available on request.



IPR Status & Details

IN 201811003807, WO 2019150386A1, SG 11202005110XA, US 2020354558A1, EP 3746506A1, AU 2019213848B2

Application/Uses/ Problem being Addressed:

The humin-like furanic polymers can be used as both UV light shielding agent and as well as for improving mechanical strength in various products such as thin films, bottles, tablet strips for pharmaceutical uses, windows, display screens guard, sun protective glass, welding glass, vertical blind, cloths, paints, varnish, dispersant, sun-screen lotions and creams.

Salient Technical Features including Competing Features/Impact:

- Replacing the petroleum-derived products with biomass-derived products is an emerging area. Use of a biomass-derived

UV shielding bio-derived furanic polymers

TRL Level & Scale of Development:

TRL-4; Furanic polymer (BFP) has been prepared at 300 g per batch and BFP/PVA composite thin film is prepared at 1 meter length scale by a solvent casting method at CSIR-CSMCRI. BFP/PMMA composites prepared at 2.5 cm dia scale by micro compounding and compressing mould-casting method. BFP/LLDPE composite is prepared at few hundred meter scale by melt blowing method in CIPET, Ahmedabad. The approaches made guarantee that the BFP can be used at even larger scale through different methods

polymer as a UV-shielding agent with higher efficiency than petro-derived commercial polymers would be highly beneficial.

- Bio-derived furanic polymers (BFP) developed at CSIR-CSMCRI has better UV-shielding efficiency than many commercial compounds.
- It improves the mechanical strength of its composite materials.
- Further, it can be blended with many natural bio-polymers and their derivatives to make completely bio-based bio-degradable films/products.

Techno-Economics
Tentative Price: Rs.600-700/kg (without considering the other valuable products produced such as HMF)

BFP powder is not yet available as a commercial product

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

As BFP is biomass derived polymeric powder, it can be used as both UV shielding agent and as well as for improving mechanical strength in various products such as thin films, bottles, tablet strips for pharmaceutical uses, windows, display screens guard, sun protective glass, welding glass, vertical blind, cloths, paints, varnish, dispersant, sun-screen lotions and creams.

Environmental Considerations, if any:

This process is eco-friendly. No waste is generated.

Status of Licensing:

Yet to license the technology.

Status of Commercialization:

Not applicable.

Major Raw Materials Needed:

Polysaccharide and sugar sources for preparation of BFP (agarose chitosan, κ-carrageenan, cellulose, seaweed cellulose (Ulva), potassium alginate, starch, glucose, fructose, sucrose and xylose); Polymer (Polyvinyl chloride, Polyvinylidene fluoride, Poly(methyl methacrylate), Linear low-density polyethylene); Bio-polymer (κ-carrageenan, potassium alginate, Hydroxypropyl methylcellulose, Carboxy-methylcellulose, agarose, and agar); Solvent (Water, DMSO, Methanol).

Major Plant Equipment and Machinery Required:

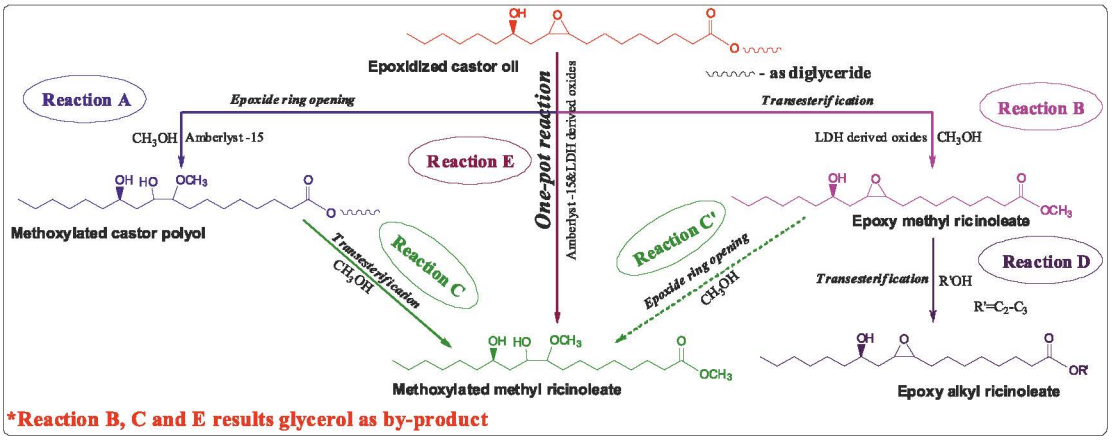
Reaction vessel; Centrifuge/filter assembly; Micro compounding; Melt mixture; Twin screw extruder; Melt blower; Dryer; Film making machines.

Technology Package:

Licensing of technology would include the know-how of BFP synthesis and BFP-polymer composite making and demonstrating its UV-shielding property; License fee, royalty and other financial details are available on request.

TRL Level & Scale of Development:
TRL-5;
- Methoxylated castor polyol (MCP) and isopropoxylated castor polyol (IPCP) - Scaled up at 100 g
- Epoxy methyl ricinoleate (EMR) - Scaled up at 50 g
- Methoxylated methyl ricinoleate (MMR) - Scaled up at 250 g
- Remaining all reactions - scaled up at 25 g

Preparation of functionalized castor oil derivatives from epoxidized castor oil using solid acid and base catalysts



*Reaction B, C and E results glycerol as by-product

Application/Uses/Problem being Addressed:

Lubricants, fuel additives, in automobile industries, in polymers, etc.

Salient Technical Features including Competing Features/Impact:

- Use of castor oil and its derivatives as raw material which are very cheap non-edible oil.
- Low-cost and commercially available catalysts are used as solid catalysts for the preparation of functionalized castor oil derivatives such as ring-opened glyceryl ricinoleates, epoxy alkyl ricinoleates and ring-opened alkyl ricinoleates.
- High yields of the products under benign reaction conditions.
- Reaction chemistry can be altered by choosing different catalysts.
- Catalysts are recyclable.
- Physical properties of the functionalized castor oil derivatives suggest the possibility of tailoring the values by

IPR Status & IPR Details

US 10260023 B2, CN106536494B, IN 2225/DEL/2014, WO 2016020941A3, BR 112017001289A2

suitably choosing the appropriate nucleophiles/reaction chemistry or by simple blending of them.

Techno-Economics

Tentative Price:
Epoxidized castor oil:
approx. Rs.100/kg
Methanol:
approx. Rs.20-30/L
Toluene:
approx. Rs.50-60/L
Functionalized castor oil products:
approx. Rs.250-500/kg
(Exact market value is not available because these are new molecules)

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

As India being a largest producer of castor oil, abundant scope is there to diversify different oleochemicals industry for several applications, such as lubricants, plasticizers, additives, etc.

Environmental Considerations, if any:

- Utilization of non-edible source castor oil for the preparation of value-added chemicals to overcome food vs fuel issues created by edible oils.
- Catalysts are easily recoverable (simple filtration) without any further addition of chemicals & are reusable.

Status of Licensing:

Yet to license the technology; Discussions with leading castor oil manufacturers.

Status of Commercialization:

Not applicable.

Major Raw Materials Needed:

Epoxidized castor oil (sourced from M/s Jayant Agro Organics Ltd., Mumbai).

Major Plant Equipment and Machinery Required:

For reaction - Stirred tank reactor with water cooler system; Filtration assembly; Rotary evaporator for purification of the product mixture (to remove the unreacted nucleophiles/alcohols and solvents).

Technology Package:

Know-how for process of several functionalized castor oil derivatives from ECO; Demonstration of the processes; Equipment necessary for pilot scale; License fee, royalty and other financial details are available on request.

Microbial synthesis of polyhydroxyalkanoate, a bio-polymer, utilizing *Jatropha* biodiesel by-products

IPR Status & IPR Details
US 8956836B2; EP2475754A1

TRL Level & Scale of Development
TRL- 4; Process has been validated at laboratory scale

Application/Uses/Problem being Addressed:

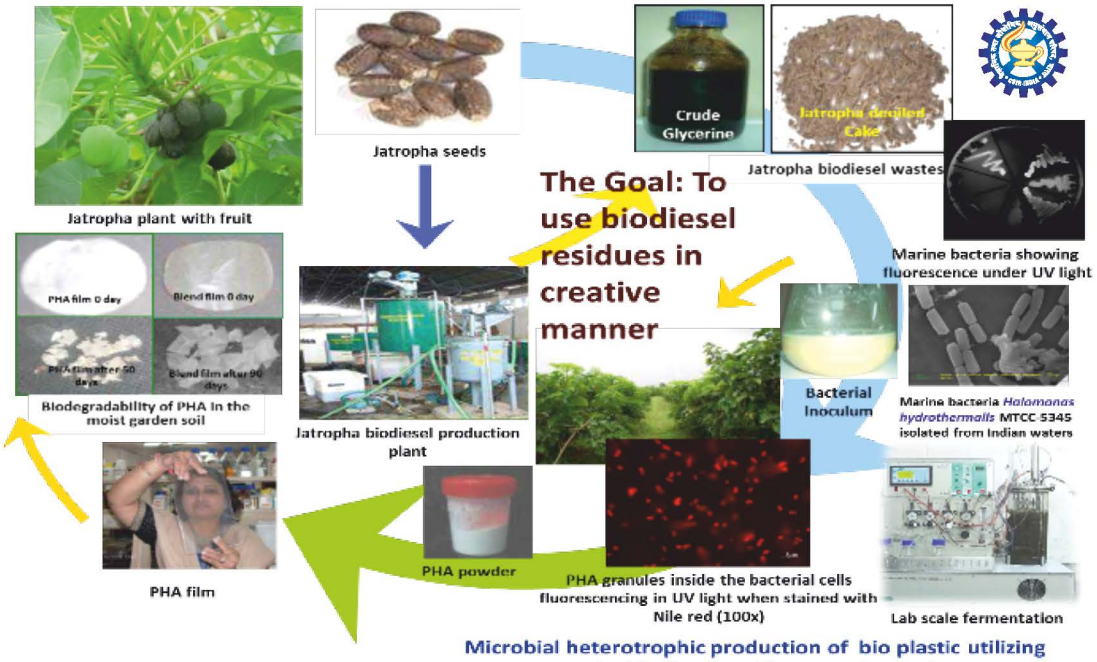
- Biodegradable bioplastics.
- Natural colorant in food and cosmetic industry.
- Functional food.

Salient Technical Features including Competing Features/Impact:

- Raw materials indigenously available.
- Competitive cost.
- Scope of further improvisation.
- Utilizing crude glycerol and hydrolysate of residual biomass.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Biodegradable plastics would have a significant demand in the coming days.



Microbial heterotrophic production of bio plastic utilizing Jatropha biodiesel residues as sole nutrients

Major Raw Materials Needed:

Chemicals and Solvents.

Major Plant Equipment and Machinery Required:

1 KL Fermenter, Glass reactors, Distillation unit..

Technology Package:

Collaboration sought to improve yield.

Environmental Considerations, if any:

- The process is eco-friendly.
- Replace fossil-based plastics.

Status of Licensing:

Not yet licensed.

Status of Commercialization:

Not applicable.

Membranes, Resins & Materials for Water Desalination, Water Purification and Separation Processes

IPR Status & Details

IN 244150; US 10384171B2; EP 2922617B1; WO 2014080426A1; EP 2833990A1

TRL Level & Scale of Developement

For brackish water desalination membrane: TRL9
For sea water desalination membrane: TRL5
For effluent biodegradation: TRL4

Flat sheet thin film composite (TFC) reverse osmosis membrane and spiral module making technology for brackish & seawater desalination including bio-degradation of organic effluent stream generated in the membrane process development

Application/Uses/Problem being Addressed:
Sea and brackish water desalination; treatment of wastewater containing aprotic polar solvents: DMF, DMAc and NMP.

Salient Technical Features including Competing Features/Impact:
High flux and high salt rejecting antifouling membrane.
Simple biodegradation of DMF (up to 30000 ppm within 48 h), DMAc and NMP (up to 10000 ppm within 96-120 h) contaminated water.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):
The BWRO membrane technology is commercialized.
The seawater membrane technology is ready for demonstration at 100 m^2 batch.
The effluent treatment technology is ready for demonstration at bench scale.

Environmental Considerations, if any:
Eco-friendly.

Status of Licensing:
BWRO membrane technology know-how transferred to-

- Uniqflux membranes LLP, Pune.
- OM TECH, Rajkot.
- Rinzai Hydratech Pvt. Ltd.

Status of Commercialization:
Commercialized.

Major Raw Materials to be Utilized:
Fabric, Polymer, Solvents, Water, Chemicals.

Major Plant Equipment and Machinery Required:
Membrane casting/coating machine; module rolling machines; membrane/ module testing plant.

Technology Package:
- Fabrication of ultrafiltration membrane.
- Fabrication of thin film composite RO membranes for brackish water and or seawater desalination.
- Effluent treatment (optional).
- Module making.

Techno-Economics

Depends on the proposed capacity

Figs. : (1,2) Demonstration facility in CSIR-CSMCRI (3) Products

IPR Status & Details :
IN 169550; IN 186522

Flat sheet ultra-filtration (UF) membrane and spiral module making technology for water purification and removal of pathogens

Application/Uses/Problem being Addressed:

For water disinfection to obtain potable water, water reclamation from effluents and as pre-filter of reverse osmosis.

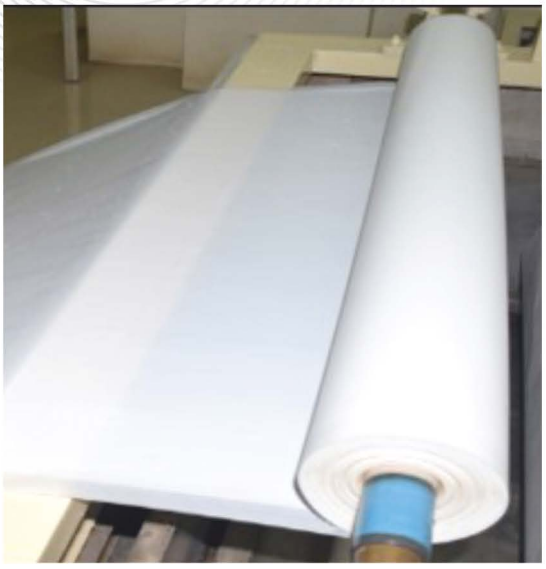
Salient Technical Features including Competing Features/Impact:

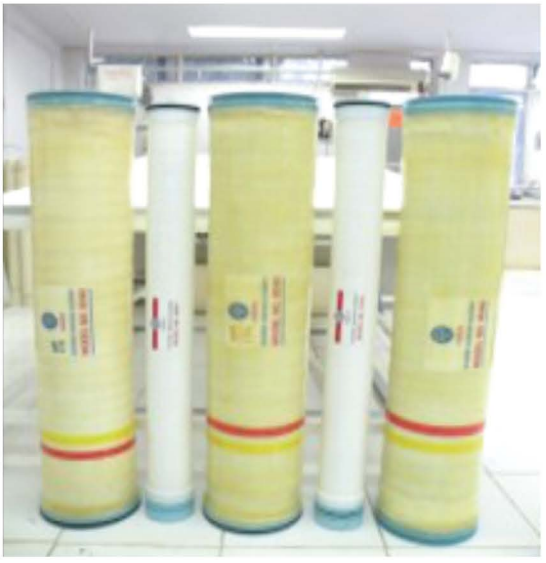
The membranes are suitable for the removal of bacteria (6 log reduction), virus (4 log reduction), turbidity and colloidal materials (NTU reduction ≥ 99%) from contaminated water and thus produce safe drinking water. The flux of 40 40 module is 700-1000 LPH at 50 psi operating pressure.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

The technology is ready for technology transfer and can be implemented on commercial scale. The UF flat sheet membrane is also part of RO membrane.

TRL Level & Scale of Developement : TRL-9





Major Plant Equipment and Machinery Required:

Membrane casting system and module fabrication system.

Environmental Considerations, if any:

Eco-friendly.

Technology Package:

Patented process for manufacture of the membrane shall be given. Process will be demonstrated at CSMCRI facility. License fee, process demonstration fee and annual recurring royalty (on ex-factory sale price) are payable and will be provided on request. Attractive discounts for MSME's/start-up's.

Status of Licensing:

Technology transferred to-

M/s Uniq Flux Membrane LLP, Pune, M/s Rinzai Hydratech Pvt. Ltd, Ahmedabad and M/s OM Tech, Rajkot.

Status of Commercialization:

Commercialized.

Techno-Economics

Depends on the proposed capacity

Major Raw Materials to be Utilized:

Polymer, solvent and other consumable items for module housing.

IPR Status
US 9364797, IN 2178DEL2010,
EP 2616168 (A1),
JP 5933557 (B2), WO 2012035402

TRL Level & Scale of Development : 9

Hollow fiber ultra-filtration membranes for water purification and removal of pathogens

Application/Uses/Problem being Addressed:
Water purification.

Salient Technical Features including Competing Features/Impact:
The hollow fibers were found suitable for the removal of bacteria (6 log reduction), virus (4 log reduction), turbidity and colloidal materials (NTU reduction ≥ 99%) from contaminated water and thus produce safe drinking water.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):
The technology is ready for technology transfer and can be implemented on commercial scale. The HF UF membrane is used as pre-treatment filter to RO membrane system.

Major Plant Equipment and Machinery Required:
Spinning system and module fabrication system.

Technology Package:
Patented process for manufacture of the membrane shall be given. Process will be demonstrated at CSMCRI facility. License fee, process demonstration fee and annual recurring royalty (on ex-factory sale price) are payable and will be provided on request. Attractive discounts for MSME's/start-up's.

Environmental Considerations, if any:
Eco-friendly.

Status of Licensing:
Technology transferred to-
M/s Uniq Flux Membrane LLP, Pune.

Status of Commercialization:
Commercialized. The performance of the fibers manufactured by M/s Uniqflux Membranes LLP was tested by Aqua Diagnostics, USA. Product is being exported by client.

Major Raw Materials to be Utilized:
Polymer, solvent and other consumable items for module housing.

Techno-Economics

Total investment cost of plant/machinery:
Rs.2.0 crore approx.
Raw material cost per year:
Rs.1.5 crore
(excluding land, man-power and recurring costs).
Total cost of production per year:
Rs.1.5 crore
(Rs.15,000/- as net cost of production and Rs.30,000/- as selling price for each module)
Sale price per units per year:
Rs.3.0 crores
per module units (Taking 5 modules/day making facility and 200 days operation of the unit)
Net profit per year:
Rs.1.5 crore per annum
Payback period:
Around 2 years

Hollow fibre domestic water filter of 1 LPM capacity operated under gravity without any electrical energy

TRL Level & Scale of Development : TRL-5
First customer trials at field and feedback, or prototype/ demonstration unit completed

Application/Uses/Problem being Addressed:

Water purification.

Salient Technical Features in-cluding Competing Features/Impact:

The unit is based on indigen-ously developed hollow fibre (HF) mem-branes of MWCO 90 - 100 kDa. The HF module is preceded by one micron and carbon filter to remove the suspended particles, odour and colour (if any) from the feed water. The filter equipped with a water level sensor works under gravitation (7-8 psi) without any electrical energy input. The HF exhibited > 6 log reduction in bacteria and needs simple backwash with water for every 1.5 months for dis-infection of supply tap water.

Environmental Considerations, if any:

Eco-friendly.

Status of Licensing:

Technology is ready for transfer.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

The technology is ready for technology transfer and can be implemented on commercial scale.

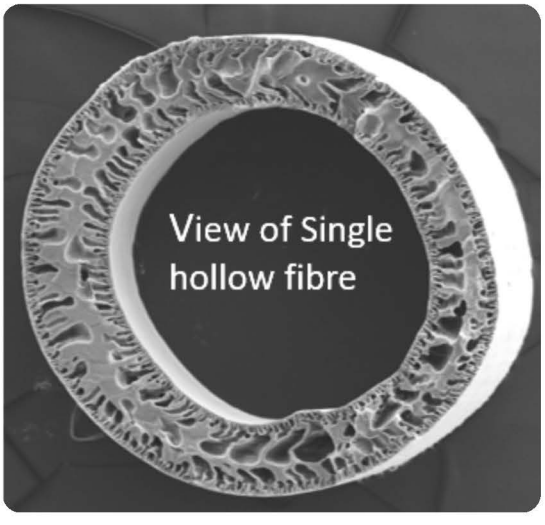
IPR Status & Details :
US 9364797, IN 2178DEL2010,
EP 2616168 (A1), JP 5933557 (B2),
WO 2012035402

INSIDE VIEW

Status of Commercialization:
Not applicable.

Major Raw Materials to be Utilized:
Polymer, solvent and other consumable items for module housing.

Major Plant Equipment and Machinery Required:
Spinning system and module fabrication system.



Technology Package:
Patented process for manufacture of the membrane shall be given. Process will be demonstrated at CSMCRI facility. License fee, process demonstration fee and annual recurring royalty (on ex-factory sale price) are payable and will be provided on request. Attractive discounts for MSME's/start-up's.

Techno-Economics

Depends on the scale of manufacturing; Will be available on request

Nanofiltration membrane for water softening by partial desalination, decontamination and disinfection

Application/Uses/Problem being Addressed:

Water purification by partial desalination, decontamination and disinfection.

Salient Technical Features including Competing Features/Impact:

Low pressure nanofiltration membrane process based on indigenously developed high-flux nanofiltration membrane. It is ultrathin-film composite membrane based on the cross-linked polyamide selective layer supported on a uniformly and highly porous support which exhibited the pure water permeability of 95-150 LMH at 150 psi, Na_2SO_4 rejection 99-99.5%, $MgSO_4$ 95-99 %, NaCl rejection 25±5%.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

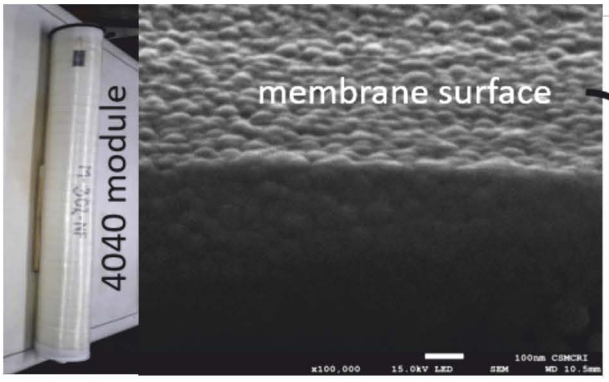
The technology is ready for technology transfer and can be implemented on commercial scale.

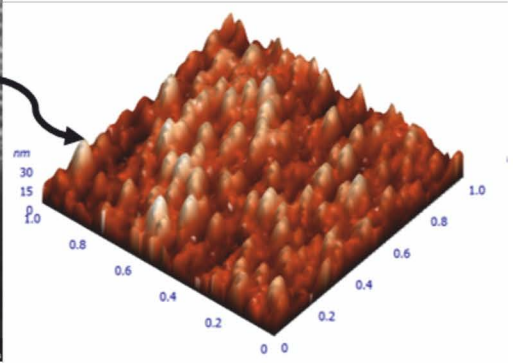
Environmental Considerations, if any:

Eco-friendly.

Status of Licensing:

Technology ready for transfer.





Status of Commercialization:

Not applicable.

Major Raw Materials to be Utilized:

Polymer, solvent and other consumable items for module housing.

IPR Status & IPR Details : IN 201811031932

TRL Level & Scale of Development

TRL-5- Prototype/ demonstration unit completed. Membrane preparation in the scale of 50 sq. m.; Spiral wound membrane modules of 4"×14" and 4"x 40"

Techno-Economics
Depends on the scale of manufacturing; Will be available on request

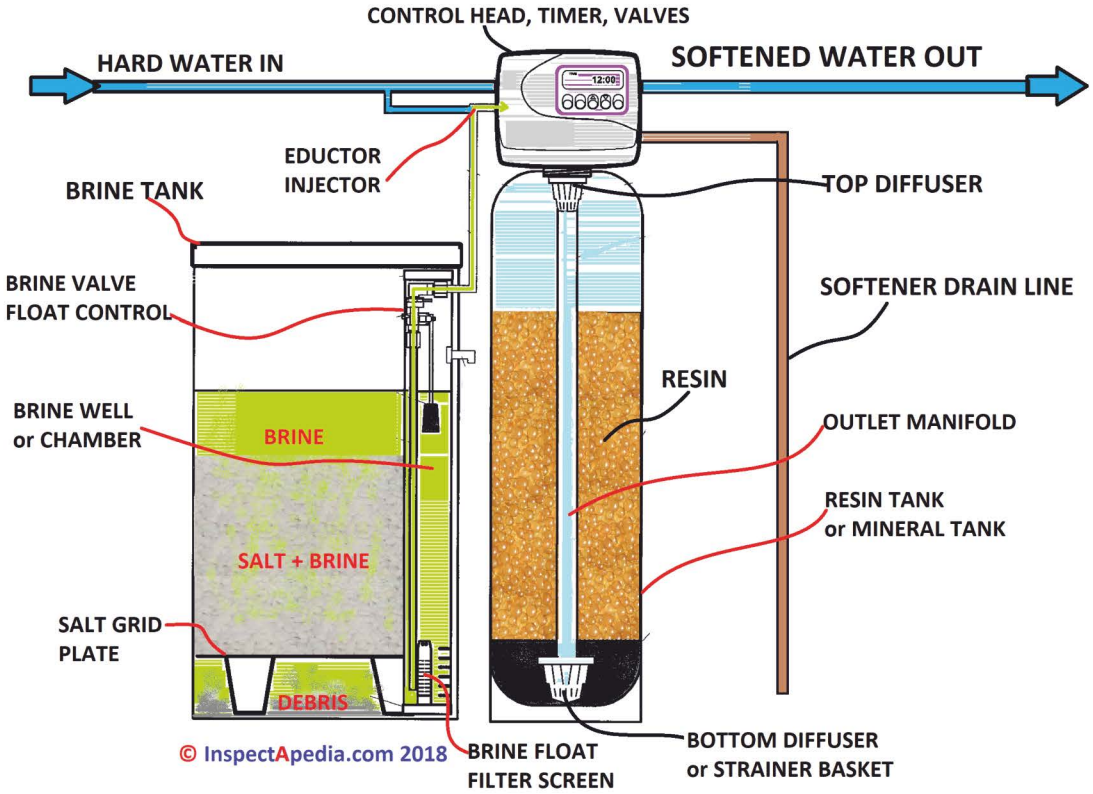
Major Plant Equipment and Machinery Required:

Spinning system and module fabrication system.

Technology Package:

Patented process for manufacture of the membrane shall be given. Process will be demonstrated at CSMCRI facility. License fee, process demonstration fee and annual recurring royalty (on ex-factory sale price) are payable and will be provided on request. Attractive discounts for MSME's/start-up's.

TYPICAL WATER SOFTENER COMPONENTS



Rejuvenation of the end-of-life seawater reverse osmosis membrane elements

IPR Status & IPR Details : Under filing

TRL Level & Scale of Development
TRL-5 (Pilot plant scale development and demonstration)

Application/Uses/Problem being Addressed:

Applications in desalination and water reuse plants for the same or alternate applications e.g. wastewater reuse, brackish water reverse osmosis, grey water treatment, etc.

Salient Technical Features including Competing Features/Impact:

We have converted the discarded membranes into useful membranes for following applications:

1. Low salinity brackish water desalination/ wastewater treatment and reuse.
2. Partial substitution of the original application by enhancing the flow rate but maintaining the salt rejection performance.
3. Conversion to ultrafiltration-like membrane elements by removal of polyamide barrier layer.

The second life of membrane will be a "waste to wealth" proposition.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

The technology is ready for technology transfer and can be implemented on commercial scale. The industry-specific customization may be required.

Environmental Considerations, if any:

It is very important from environment perspective to extend the life cycle of

membrane elements since membrane waste is a hazardous polymeric waste. Thus, it renders environment-friendly proposition. The treatment chemicals are neutralized before disposal.

Status of Licensing:
Not yet licensed; Discussions with industries are on with customer field trials.

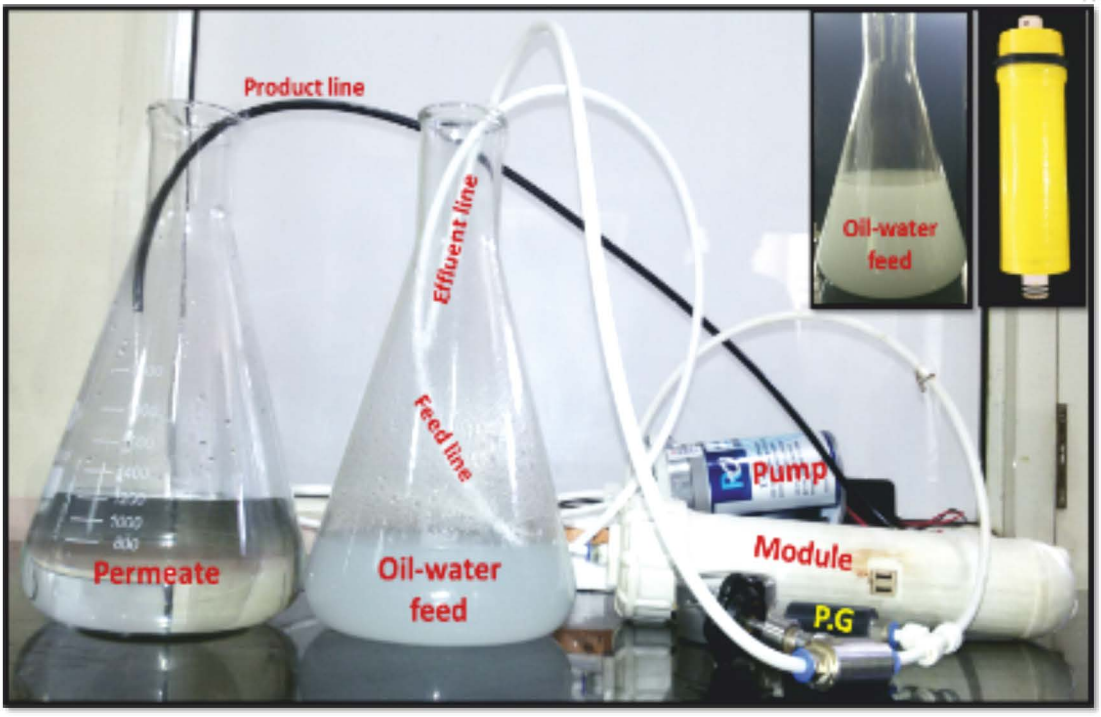
Status of Commercialization:
Not applicable.

Major Raw Materials to be Utilized:
Chemicals, alcohol, acid, surfactants.

Major Plant Equipment and Machinery Required:
Pumps, membrane test-rig, reactor, piping system, tanks, etc.

Technology Package:
Depends on the scale; Will be available on request.

Techno-Economics
The rejuvenated membrane cost will be about 15-20% of new membrane cost. It depends on the degree of fouling of membrane and desired use as the second life of membrane



Antifouling ultrafiltration membrane for separation of oil-in water emulsion

Application/Uses/Problem being Addressed:

Separation of oil-in water emulsion and removal of pathogens under low applied pressure (5 psi).

Salient Technical Features including Competing Features/Impact:

We have converted antifouling ultrafiltration membrane that can separate oil-in water emulsion such as soybean oil-in-water (>99%) and hexadecane-in-water emulsion (>40 nm to 20 micron droplet size) under low applied pressure (5 psi) and can be regenerated by washing with water.

Techno-Economics
Not computed as on date; Will be made available on request

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Water containing emulsified oil (bout 0.5-1%) could be separated under low applied pressure for further treatment with other membrane depending on feed composition. The process is scalable. Cost of per m^2 membrane=Rs. 600-700 (approximate).

Environmental Considerations, if any:

Generation of water containing DMF.

Status of Licensing:

Not yet licensed.

Status of Commercialization:

Not applicable.

IPR Status & IPR Details : IN DEL20161
TRL Level & Scale of Development : 4

Major Raw Materials to be Utilized:

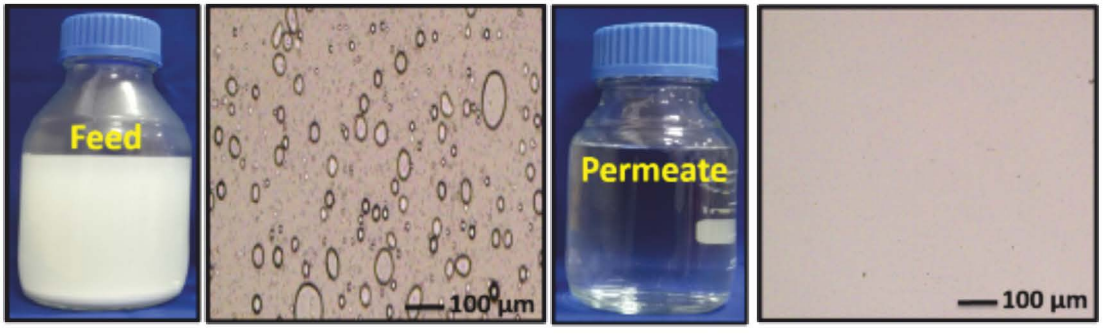
Polyvinylidenefluoride, poly(vinylpyrrolidone), 4-chloromethyl styrene, methylmethacrylate and polyethyleneimine.

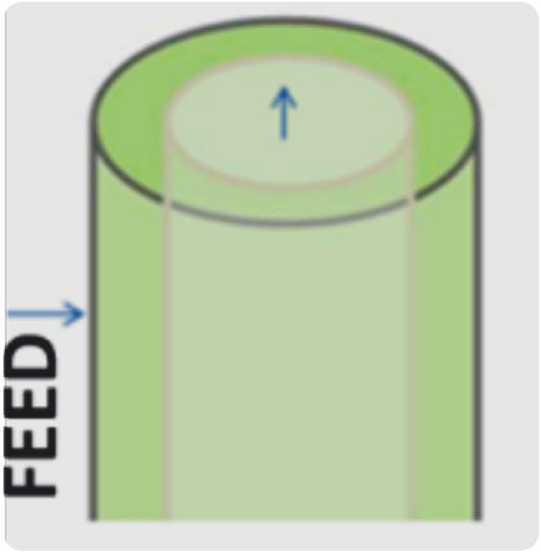
Major Plant Equipment and Machinery Required:

Membrane casting machine, module making machine and a tank for reaction.

Technology Package:

- Preparation of membrane which includes synthesis of copolymer, preparation of casting solution, preparation and post modification of the membrane.
- Assessment of membrane performance.
- Demonstration of separation of oil-in-water emulsion.
- Washing process for membrane regeneration.





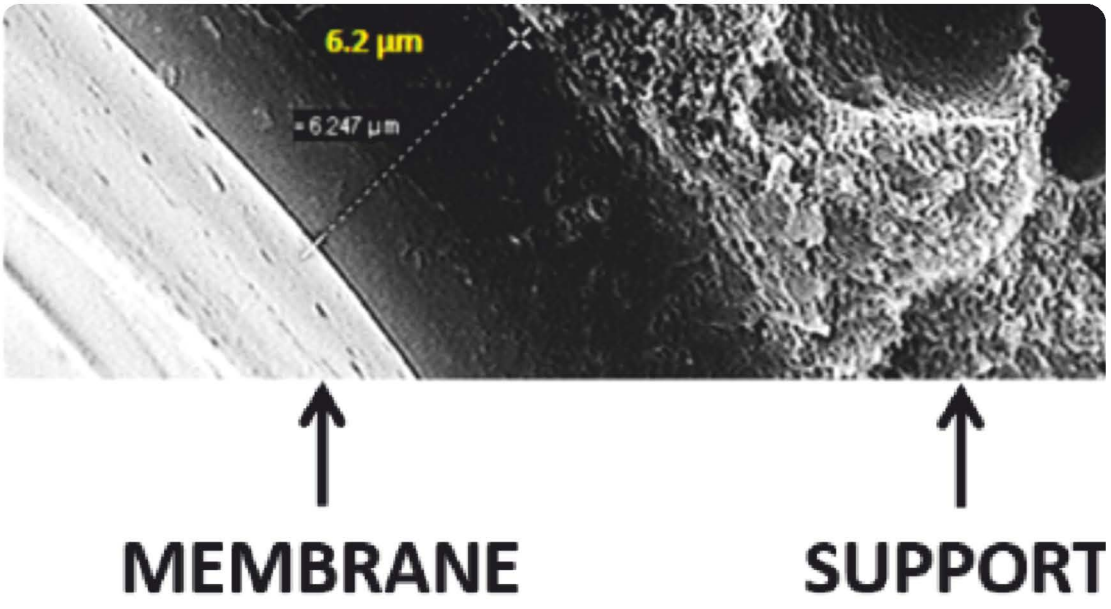
Composite hydrophilic pervaporation membrane for alcohol-water separation

Application/Uses/Problem being Addressed:

For production of absolute ethanol from ethanol-water azeotrope mixture while the hydrophobic membrane is for enrichment of alcohol concentration from water-alcohol mixture (0.1-10% alcohol).

Salient Technical Features including Competing Features/Impact:

- Permselective hollow fiber composite comprising of top hydrophilic layer and bottom support layer for production of fuel grade ethanol (> 99 %) from ethanol-water azeotrope mixture;
- Organophilic hollow fiber polymer membrane system with the top organic-selective layer and bottom porous support characterized by the selective alcohol permeate flux for enrichment of alcohol concentration from water-alcohol mixture.



Techno-Economics
Depends on the scale of manufacturing; Will be available on request

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

The technology is ready for technology transfer and can be implemented on commercial scale.

Environmental Considerations, if any:

Eco-friendly.

IPR Status & IPR Details :
IN 0357/DEL/2015; IN 201611010441
TRL Level & Scale of Development :
TRL-4; Prototype/ demonstration unit completed

Status of Licensing:

Not yet licensed.

Status of Commercialization:

Not applicable.

Major Raw Materials to be Utilized:

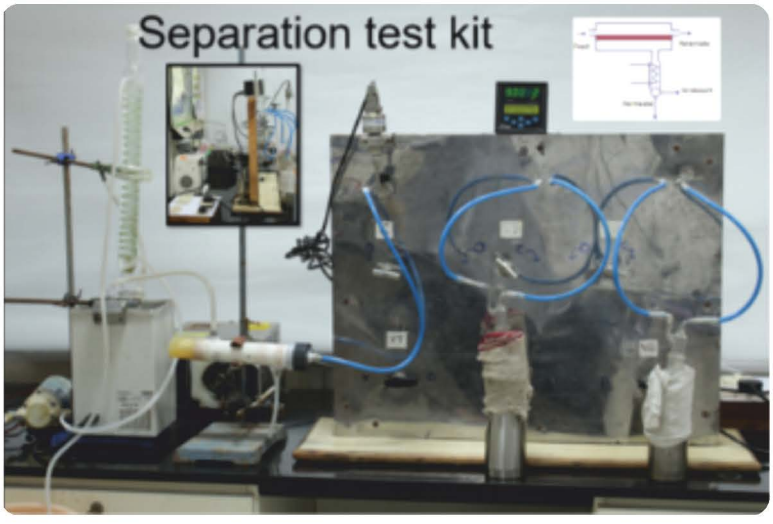
Polymer, solvent and other consumable items for module housing.

Major Plant Equipment and Machinery Required:

Spinning system and module fabrication system.

Technology Package:

Patented process for manufacture of the membrane shall be given. Process will be demonstrated at CSMCRI facility. License fee, process demonstration fee and annual recurring royalty (on ex-factory sale price) are payable and will be provided on request. Attractive discounts for MSME's/start-up's.



A high recovery ED-RO hybrid process for water purification/desalination with high water recovery

Application/Uses/Problem being Addressed:

Hybrid electrodialysis-reverse osmosis domestic desalination unit for high recovery of product water.

Salient Technical Features including Competing Features/Impact:

Reverse osmosis (RO) membrane-based domestic water desalination/purification units have gained wide acceptance even in India. Unfortunately, the recovery of product water from these units varies between 30 and 60% depending on total dissolved solid (TDS) of the feed water. Such low recovery of product water during desalination is a serious problem, in view of water scarcity. Further, the problem of tap water salinity is increasing owing to groundwater depletion. Alternatively, electrodialysis (ED)-RO hybrid process offers high recovery of product water from brackish water without compromising on water quality. In hybrid process, ED unit operates in high TDS region (low system resistance and thus high efficiency), and RO system operates in low TDS region, to reduce salinity load on membrane.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

The technology scalable with productivity of desalinated water from 10 LPH to 500 LPH, and suitable for domestic as well as societal uses. Cost of such units will vary with productivity and feed water quality.

Environmental Considerations, if any:

Eco-friendly.

Status of Licensing:

Yet to be licensed.

Status of Commercialization:

Not applicable.

Major Raw Materials to be Utilized:

Surface/ground water.

Major Plant Equipment and Machinery Required:

RO and electrodialysis units.

IPR Status & IPR Details :
IN 201001418-I1
TRL-5

Techno-Economics
Depends on the scale of manufacturing; Will be available on request

Technology Package:

Process configuration of ED and RO systems for desalination with higher water recovery efficiency (>60% cumulative).

Design of ED-RO hybrid domestic desalination unit.

Figs. : Hybrid ED-RO unit for water desalination/purification

Electro-dialytic desalination for production of mineral-balanced potable water

Application/Uses/Problem being Addressed:

Water desalination unit with improved protocols to produce mineral-balanced alkaline water.

Salient Technical Features including Competing Features/Impact:

Water desalination is a common practice to achieve the overarching goal of augmenting the goal for providing drinking water. Reverse osmosis (RO) has been practiced commercially. During desalination, the salinity is lowered - which is desired - but the concentrations of nutritious constituents are also be reduced excessively—which is undesirable. Specifications for ideal drinking water should be: total dissolved solid: 350-525 ppm; Na^{+}: 30-60 ppm; Mg^{2+}: 20-30 ppm; Ca^{2+}: 50-70 ppm; K^{+}: 5-15 ppm; Cl^{-}: 50-75 ppm; SO_4^{2-}: 100-150 ppm; and CO_3^{2-} / HCO_3^{-}: 100-125 ppm. In case of RO desalinated water product water contains low concentrations of nutritious minerals (Mg^{2+}, Ca^{2+} K^{+}, SO_4^{2-}, and CO_3^{2-}/HCO_3^{-}), while the relative

Fig. : ED u-nit for water desalination/purification
Energy requirement: 230V 50Hz

Techno-Economics
Depends on the scale of manufacturing; Will be available on request

proportions of Na^+ and Cl^- are very high. Remineralisation is one approach to correct the imbalance but this is not practiced always. In RO unit, TDS of the product water has been controlled by small amount by-pass of reject stream, in which NaCl is the major constituent. Thus, development of a methodology that enables desalination to be conducted with better retention of nutritious ions would be of considerable interest. We developed ED process for the separation of mono and bi-valent ions employing polyaniline (PANI)-modified interpolymer type of ion-exchange composite membranes. Due to sieving and hydrophobic effects, the PANI coating demonstrated to improve the retention of nutritious minerals in the desalinated water.

IPR Status & IPR Details :
WO 2014188450 A1; IN 2012DE3599 A
TRL Level & Scale of Development : TRL-6

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

The technology scalable with productivity of desalinated water from 10 LPH to 500 LPH, and suitable for domestic as well as societal uses. Cost of such electrodialysis units may vary from Rs. 30,000 to Rs. 15,00,000 depending on productivity.

Environmental Considerations, if any:

Eco-friendly.

Status of Licensing:

Yet to be licensed.

Status of Commercialization:

Not applicable.

Major Raw Materials to be Utilized:

Surface/ground water.

Major Plant Equipment and Machinery Required:

Ion exchange membrane making facilities.

Technology Package:

- Design for domestic ED unit for mineral-balanced potable water.
- Ion-exchange membranes preparations.

Process based on polymer-based ion-exchange resins for the removal of arsenic from ground water and arsenic detecting kit

Application/Uses/Problem being Addressed:

Resin: Removal of arsenic from water.

Arsenic detecting kit: A test kit to detect arsenic semi quantitatively in ground water up to 10 ppb.

Salient Technical Features including Competing Features/Impact:

1. Ion exchange resin technology for the removal of arsenic from ground water.
   - No electricity required.
   - No skill is required to operate.
   - Resin developed, efficiently removes both the forms of arsenic present in the water.
   - Reusable after regeneration.
   - Easily separable after use.

2. Economical and easy to use arsenic detection test kits to analyse the presence of arsenic in water.
   - Easy to use.
   - Colorimetric detection of arsenic in water.
   - Have shelf-life of ~2 years.

TRL Level & Scale of Development

TRL-7

Functionalization of resin can be achieved @20kg/batch in 100 litre RBF equipped with heating and cooling assembly. 65 domestic and 12 community scale unit capacity of 25LPH and 250LPH respectively were deployed at arsenic affected rural areas of 24-Parganas (N), West Bengal, to provide arsenic free water. Test kits were also supplied along with plant to analyze field water samples

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

The technology is ready for technology transfer and can be implemented on commercial scale. The product has high demand in water purification to provide arsenic free water.

The test kits are easy to use to analyse the presence of arsenic in water.

Techno-Economics

Depends on the scale of manufacturing; Will be available on request

Environmental Considerations, if any:

The process is quite economical; field tested and also clean in true sense.

IPR Status & Details : IN 287502

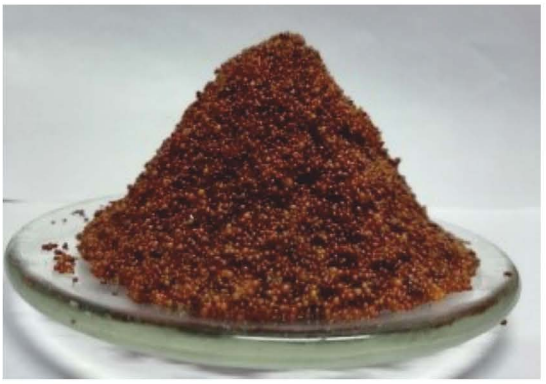


Fig. Arsenic selective resin

Status of Licensing:

Ready for the licensing.

Status of Commercialization:

Not applicable.

Figs. Domestic and community scale units

Major Raw Materials to be Utilized:

Resin: Monomers like methyl methacrylate, methacrylic acid, ethyleneglycol dimethacrylate, divinyl benzene, aliphatic amines, ferric chloride, hydrochloric acid and caustic alkali, etc.

Test Kit: Whatman filter paper, mercuric bromide, rosaline, nitric acid, ethanol, PVA, sulphamic acid, zinc metal dust, etc.

Major Plant Equipment and Machinery Required:

Resin Plant: Pumps, fittings, column, Overhead tanks and receiver tank, etc.

Test Kit: Glass bottle with lid, brown bottle to keep test strips.

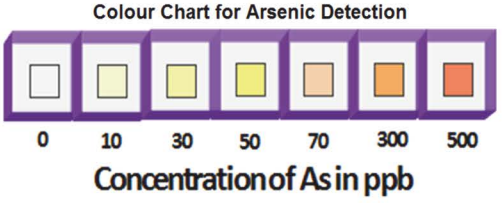


Fig. Colorimetric detection of Arsenic test kit

Technology Package:

Resin preparation and arsenic test kit making; Depends on the scale of manufacturing; Will be available on request.

Preparation of specific polymeric adsorbents for the removal of arsenic and fluoride from drinking water

Application/Uses/Problem being Addressed:

Removal of arsenic, arsenic & fluoride from water.

Salient Technical Features including Competing Features/Impact:

Polymeric adsorbent technology for the removal of arsenic, arsenic & fluoride from ground water.

- Single step preparation.
- No electricity required.
- No skill is required to operate.
- Efficiently removes fluoride and both the forms of arsenic & fluoride present in the water.
- Reusable after regeneration.
- Easily separable after use.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

The technology is ready for technology transfer and can be implemented on commercial scale. The product has high demand in the water sector for the removal of arsenic and fluoride.

Environmental Considerations, if any:

Eco-friendly.

Techno-Economics

Depends on the scale of manufacturing; Will be available on request

Status of Licensing:

Ready for the licensing.

Status of Commercialization:

Not applicable.

Major Raw Materials to be Utilized:

Vinyl monomer, methyl methacrylate, methacrylic acid, ethyleneglycol dimethacrylate, divinyl benzene, amines, ferric chloride, hydrochloric acid and caustic alkali, etc.

IPR Status & Details :
IN 201711008762; IN 0053NF2019
TRL Level & Scale of Development :
TRL-4, Laboratory scale @500g/batch

Major Plant Equipment and Machinery Required:

Material preparation equipment's such as RBF reactor equipped with over-head stirrer with heating and cooling assembly along with temperature sensor.

Materials for plant deployment such as pumps, fittings, FRP column, overhead tanks and receiver tank, etc.

Technology Package:

Material preparation, Demonstration.

IPR Status & Details :
WO 2014/080427A1; US 2015/0298116A1
TRL Level & Scale of Development :
TRL-8

Electro-deionization unit for producing ultrapure water

Application/Uses/Problem being Addressed:

Ultrapure water (resistivity: 18.2 MΩ cm; pH: 7.0) and 10-50 litre per hour using indigenously developed ion-exchange membranes for electronics, pharmaceuticals and other niche applications.

Salient Technical Features including Competing Features/Impact:

1. All components such as ion-exchange membranes, resins, electrodes are indigenously available.
2. Continuous regeneration of mixed bed resin.
3. Steady quality control for the product water (resistivity: 18.2 MΩ at 25 oC; TOC: 1 ppb; pH: 7.00 flow rate: 15 LPH).
4. Ground water or municipal water may be taken as feed water.
5. High percentage of water recovery.
6. Maintenance cost: negligible.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Use of ultrapure water is on continuous increase. Emphasis on indigenous production of such units, which are currently served from international players, provides opportunity for 'Atma Nirbhar Bharat'.

Environmental Considerations, if any:

Eco-friendly.

Status of Licensing:

Technology licensed.

Status of Commercialization:

Not yet commercialized.

Major Raw Materials to be Utilized:

Ground/surface water.

Major Plant Equipment and Machinery Required:

Membrane casting facilities and a workshop.

Technology Package:

- Design for electro-deionization unit for producing ultrapure water (resistivity: 18.2 MΩ cm).
- Process for ion-exchange membrane.
- Demonstration of the process.

Techno-Economics

Depends on the scale of manufacturing; Will be available on request

Process for inter-polymer membranes for the separation/concentration of value-added chemicals/salts from aqueous/organic medium

- Low water uptake 12-15%.
- High ion exchange capacity 1.30-1.45 meqg-1.
- Stability to pH window 1 to 14.

Application/Uses/Problem being Addressed:

For the separation/concentration of value-added chemicals/salts from aqueous/organic medium.

Salient Technical Features including Competing Features/Impact:

- High counter ion transport number >0.95.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

The technology is ready for technology transfer and can be implemented on commercial scale.

Environmental Considerations, if any:

Eco-friendly.

Status of Licensing:

Not yet licensed; Discussion for licensing is going on a client.

Status of Commercialization:

Not applicable.

IPR Status & Details : WO 2014080427 A1

TRL Level & Scale of Development : TRL-5

Major Raw Materials to be Utilized:

Polyethylene, styrene, 4-methyl styrene, benzoyl peroxide, trimethyl amine, chloro-sulfonic acid.

Major Plant Equipment and Machinery Required:

Polymer making mixtruder, blow film extruder, glass column.

Technology Package:

- Preparation of acid and alkali stable polyethylene polystyrene interpolymer based cation exchange membrane.
- Preparation of acid and alkali stable polyethylene poly 4-methyl styrene interpolymer based anion exchange membrane.
- Use of these membranes for the recovery and concentration of alkali.
- Use of these membranes for the separation/concentration of value added chemicals/salts from aqueous/organic medium.

Techno-Economics

The manufacturing cost of the membranes Rs.2000/m^2 while the commercial membranes price are around Rs.8000-15000/m^2

Figs.: Demonstration of the mobile van in (1,2) CSIR-CSMCRI (3) On field demonstration in villages of Gujarat (4) aftermath of cyclone "Tauktae"

Self-powered mobile van for water purification/desalination to provide safe potable water

Application/Uses/Problem being Addressed:

Mobile water desalination and purification plant, running on the engine power of the van itself. It can treat turbid / flood and contaminated water using indigenously developed membrane technology to make the water potable on spot during natural calamities.

Salient Technical Features including Competing Features/Impact:

Capacity to desalinate 2000 LPH brackish water & 500 LPH capacity two pass SWRO; Two different variants are available; The newer design is an improved version over the existing mobile van of dimensions of 11500 X 2500 X 3300 mm (LXBXH) to 2550 X 1750 keeping the

IPR Status & Details :
Design patent filing in progress
TRL Level & Scale of Development : TRL-6

overall power generation & desalination capacity similar & making it viable for reaching different terrain and remote locations smoothly. The indigenous TFC/UF membrane technology applied in the van makes it unique. No electricity requirements at site.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

The technology is ready for technology transfer and can be implemented on commercial scale. The product has high demand in various state governments and industrial sector. Ready to be placed in e-market. Mobile van is an important support system for potable water solution during the crisis like cyclone/floods/drought.

Techno-Economics
Depends on the scale of manufacturing; Will be available on request

Environmental Considerations, if any:

Eco-friendly.

Status of Licensing:

Not yet done; Under process.

Status of Commercialization:

Not applicable.

Major Raw Materials to be Utilized:

Compact Van of desired specifications, Membrane, desalination plant.

Major Plant Equipment and Machinery Required:

Transmission system, Gear box design, Generator/alternator, pumps, belt conveyors, body fabrication, pressure vessels, electrical panel, solar panel, etc.

Technology Package:

- Design, testing methods, installation & commissioning processes of mobile desalination plant.
- Demonstration of working of mobile desalination plant.

Conversion of low valued salt into high valued salt (KCl to K_2SO_4/KNO_3 or NH_4NO_3 to KNO_3 and similar cases) by ionic metathesis using electrodialysis

Application/Uses/Problem being Addressed:

CSIR-CSMCRI has developed electrodialysis technology for conversion of low valued salt into high valued salt using indigenously developed ion-exchange membranes by ionic metathesis.

Salient Technical Features including Competing Features/Impact:

1. All components such as ion-exchange membranes, electrodes are indigenously available.
2. Ground water or municipal water may be taken as feed water.
3. High rate of conversion.
4. Maintenance cost: negligible.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Electrochemical conversion of molecules is of significance in particular in fertilizer segment.

Environmental Considerations, if any:

Eco-friendly.

Status of Licensing:

Yet to licence.

Status of Commercialization:

Not applicable.

Major Raw Materials to be Utilized:

Low value salts and water.

Major Plant Equipment and Machinery Required:

Membrane casting facilities and a workshop.

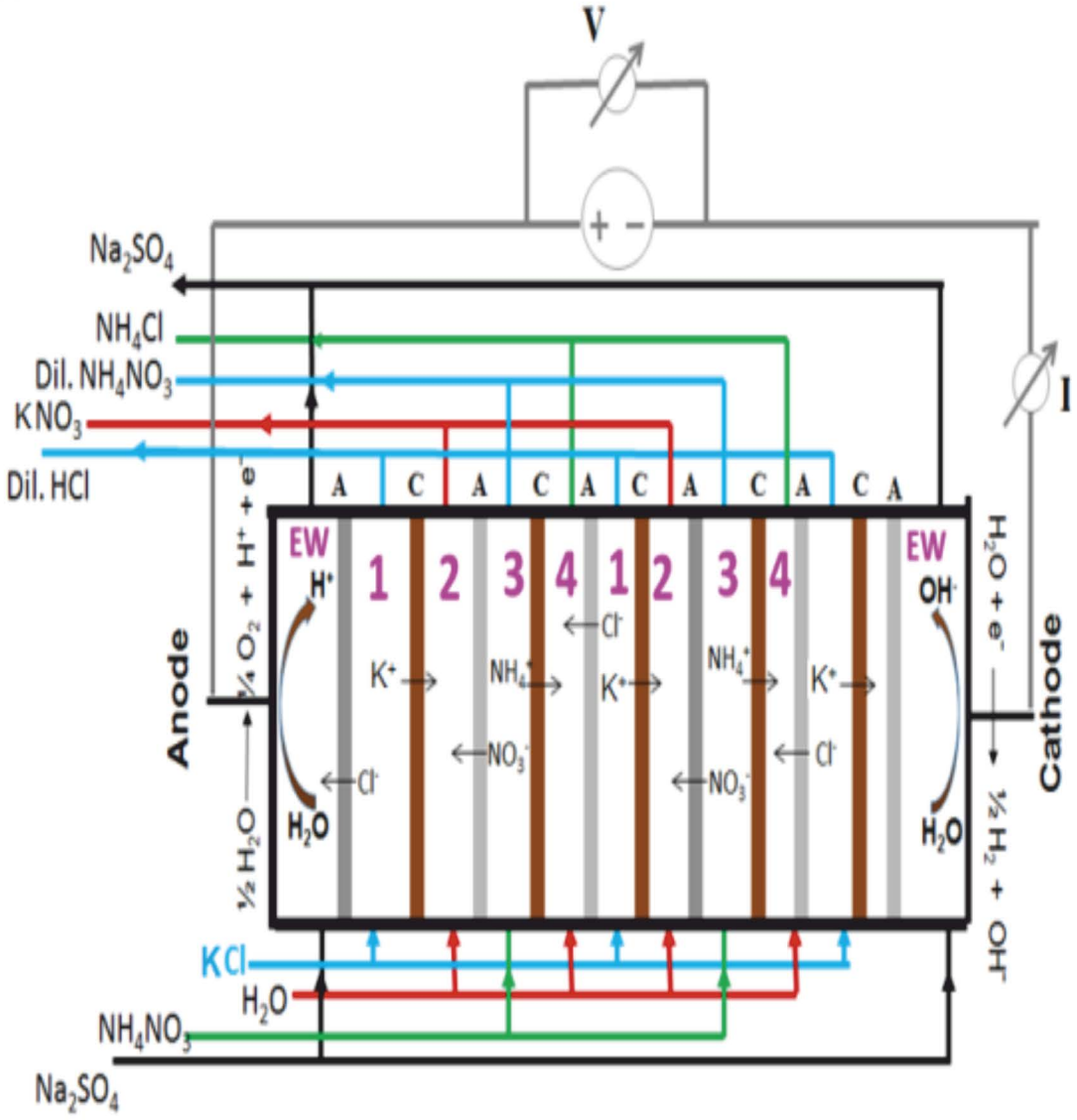
Technology Package:

- Electrodialysis unit for ionic metathesis.
- Demonstration of the process.

IPR Status & Details
NA
TRL Level & Scale of Development
TRL-4

Techno-Economics

Depends on the scale of manufacturing; Will be available on request



Acid and oxidative resistant cation exchange membrane based on fluorinated polymer (2 sq. m scale) for electrodialysis, electrolysis and other electrochemical processes

Application/Uses/Problem being Addressed:

Diversified electromembrane processes utilizing cation exchange membranes (CEMs) are expensive and require low electricity consumption due to its high conductive and stable nature even in strong acidic or oxidative environment. CEMs are membrane separator used in diversified electromembrane processes including: electrodialysis (water desalination, separation of inorganics from organic molecules, separation of specific inorganic ion, etc), electrolysis (used as separator for chlor-alkali process, production of HI by Bunsen reaction of iodine–sulfur (I–S) process, electrochemical catalytic water splitting), electro-electrodialysis for *in situ* ion exchange and ion substitution, electro-deionization for producing ultrapure water, and polymer electrolyte membrane for fuel cell applications.

Salient Technical Features including Competing Features/Impact:

We developed PVDF-co-HFP copolymer based polymeric cation exchange membranes for electrolysis, separation of inorganic salts in aqueous media by electrodialysis, water electrolysis, and also useful for other electro-membrane processes. The cation exchange membrane of this invention showed good stabilities (oxidative and acid), excellent conductivity, permselectivity, and other physicochemical properties such water content and ion exchange capacity, which are essential requirement for high performance during diversified electro-membrane applications in aqueous medium. The methods used to produce reported cation exchange membrane is quite simple and comparably less expensive, which contribute to the overall economy of the process using these ion exchange membranes.

IPR Status & IPR Details :
PCT 0016NF2018, IN 201811013972
TRL Level & Scale of Development : TRL-5

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

These acid and oxidative resistant cation exchange membranes have practical application in electrodialysis, electrolysis or any other electrochemical processes

Techno-Economics
Depends on the scale of manufacturing; Will be available on request

employing cation exchange membrane as a separator. Reported cation exchange membrane is a cost-effective substitute of costly Nafion® membrane.

Environmental Considerations, if any:

Eco-friendly.

Status of Licensing:

Not yet licensed.

Status of Commercialization:

Not applicable.

Major Raw Materials to be Utilized:

PVDF-co-HFP, 2-acryloamido-2-methyl-1-propansulfonic acid, (3-mercaptopropyl) trimethoxysilane, DMAc, NaOH, etc.

Major Plant Equipment and Machinery Required:

Membrane casting unit, stirrer, vessels, etc.

Technology Package:

Process for cation exchange membranes (CEMs).

Fig. : Indigenously developed 2-Acrylamido-2-methyl-1-propanesulfonic acid grafted PVDF-co-HFP (SCP-13) based cation-exchange membrane

Fast and safe defluoridation of water using alumina

IPR Status & Details : IN 2510DEL2014

TRL Level & Scale of Development
TRL 4
(Tested at laboratory for 150 L water batch. Patented and mechanism published)

Application/Uses/Problem being Addressed:

Removing fluoride from groundwater using alumina.

Environmental Considerations, if any:

NA. Process employs safer versions of earlier used chemicals.

Salient Technical Features including Competing Features/Impact:

Advantages over earlier attempts:

- Easy to setup: Setup involves flow under gravity from a height difference of 3 feet.
- Fast Process: Flow rate of water treated is 45 LPH for 1 kg alumina, ~15x.
- Safe Chemicals: Safe chemicals were used for all steps.
- Cyclic & Single Reactor: All the steps involved in 3 cycles i.e. pre-treatment of alumina, fluoride removal from water and regeneration of alumina were performed inside a single reactor.

Status of Licensing:

Not yet licensed.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

This process can be used to upgrade community level alumina based defluoridation plants.

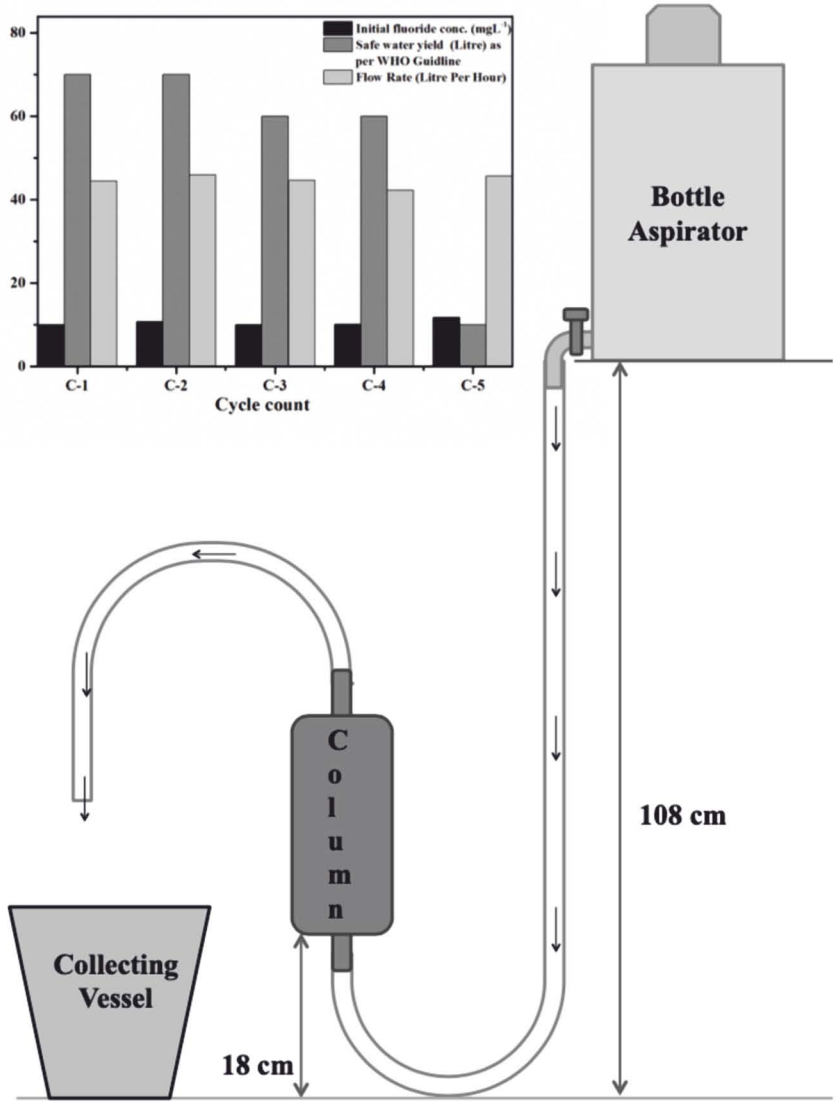
Techno-Economics

Costing estimated for 2000 L of treated water per day

- Total investment cost for alumina, overhand tank, pump, and pipes - Rs.13,000
- Raw material cost per day 2000 L- Rs.781
- Alumina to be used as procured (1 kg - Rs.100)
- Regeneration via acid/base, produce solution discarded
- Fluoride in treated water <1.5 ppm
- Regeneration capacity is ~ 100%

Technology Package:

Process for alumina suitable for deflouridation; Demonstration of the process; Know-how and license fee details can be obtained on request.



Status of Commercialization:

Not applicable.

Major Raw Materials to be Utilized:

Alumina (suitable for defluoridation).

Major Plant Equipment and Machinery Required:

Overhead or any other tank at 4 feet height and pump for filling water.

Seaweeds and their Downstream Processed Products

Kappaphycus alvarezii

Stacked SRC Sacs

Integrated processes for simultaneous production of sap and k-carrageenan from fresh seaweed

Application/Uses/Problem being Addressed:

India being agriculture country, there is considerable demand for developing low cost bio fertilizer that can affordable even by marginal farmers. The residue generated while producing liquid fertilizer can be used as a feedstock for making a number of commercially important products such as refined and semi refined k-carrageenan, biodegradable films, bio-ethanol, calorific applications, etc.

The integrated technology has already been commercialized and one of our licensees viz., M/s Aquagri Processing Pvt. Ltd., which has set up processing plants for sap (15000 LPH capacity), has been marketing the product itself under the brand Aquasap and through many large fertiliser companies, both for export and domestic markets. Aquasap is approved for sale in South Africa, Nigeria, Zimbabwe and is OMRI listed and CDFA approved in USA. IFFCO which started by marketing the product in their brand name Sagarika has now taken 50% equity in Aquagri and are working on making this affordable product available to the Indian farmers on a pan India basis.

Salient Technical Features including Competing Features/Impact:

The fresh seaweed as harvested from farm is liquefied to produce a sap which proven to be a promising low-cost bio fertilizer (foliar spray) from field trials on various crops and residue processed for recovery of κ-carrageenan which is used as an emulsifier, thickener and gelling agent in a wide range of commercial products.

- The integrated process as illustrated with *Kappaphycus alvarezii* allows both κ-carrageenan and liquid seaweed fertilizer to be recovered from fresh seaweed which would make cultivation of the seaweed more lucrative. For one-hectare area of cultivation, which conservatively yields 100 tons of fresh biomass per annum, 60-80 tons of liquid biofertilizer can be produced in addition to 2.5-4.5 tons of κ-carrageenan, depending on the grade.
- The sap, which has proven efficacy as biofertilizer, is obtained without thermo-chemical cycling and external addition of water. It may be marketed directly requiring no further processing other than addition of preservatives.

TRL Level & Scale of Development : 9

IPR Status IPR Details

US 6893479, IN 224938, CN 1324052(C), EP 1534757, ID 0019080, JP 2006504605(A), KR 100689982(B1), PH1-2005-500340, TZP /05/00082, WO 2004016656

- Simple equipment such as a grinder-cum-mixer and a press filter installed preferably near the site of harvesting may suffice for homo-genizing the fresh seaweed and allowing sap to be separated.
- As compared to the ca. 850-900 kg water that needs to be removed from one ton of fresh *Kappaphycus alvarezii* as per the conventional method of drying the whole plant, only the moisture in the wet residue, amounting to 100-200 kg per ton of fresh seaweed, needs to be removed as per the method of the invention thereby greatly reducing drying time and area.
- The free flowing, granular residue obtained from the fresh plant is superior to be dried whole plant as raw material for k-carrageenan since the former is less bulky, easy to transport, easy to store, easy to handle, contains very little colour, has a higher k-carrageenan content, and can even be used directly for gel formation in certain applications.

Techno-Economics

For one-hectare area of cultivation—which conservatively yields 100 tons of fresh biomass per annum—~60 tons of liquid biofertilizer can be produced in addition to 2.5-4.5 tons of κ-carrageenan, depending on the grade.

Tentative Price

Seaweed: Rs.15- 20/kg
Foliar Spray: Rs.150-200/L
Refined κ-carrageenan: Rs.700 -1000 /kg;
Semi-refined κ-carrageenan: Rs.250-300/kg

Business Scope & Opportunity (in terms of scale, cost, market, etc.):
India import large quantity of seaweed fertilizer that involves high foreign exchange exchequer (tentatively estimated at 800-1000 crore). Hence this technology has already been transferred to two industries for commercial production in India & revenue opportunity potential of licensee ~100=150 crore.

Environmental Considerations:
This is a eco-friendly process.

Status of Licensing:
Licensed.

Status of Commercialization:
Commercialised.

Major Raw Materials Needed:
Kappaphycus alvarezii (a red seaweed).

Major Plant Equipment and Machinery Required:
1. Liquid expeller 2. Jacketed open reactors with overhead mechanical stirring 3. Boiler 4. Autoclave 5. Centrifuge 6. Distillation unit for isopropyl alcohol.

Technology Package:
Demonstration of production of LSPB @ 100 L/batch; Demonstration of production of semi refined and refined κ-carrageenan; Technology transfer document (TTD) having information on product specification, competition, market, details of equipment required for pilot level installation, etc. along with demonstration certificate will be provided; Technical support till 6 months after know-how licensing; Know-how licensing fee details will be provided on request.

Preparation of refined k-carrageenan from *Kappaphycus alvarezii* granules via semi refined k-carrageenan

Application/Uses/Problem being Addressed:

It has wider applications in food, pharma, textile, dairy, ice cream, beverage industries.

Salient Technical Features including

Specifications	CSMCRI Refined Carrageenan	Specification-Carrageenan, E407
Moisture (% wt)	11.50	Max. 12.00
Solubility (% wt)	2.60	ca. 3.33
Ash (% wt)	18.19	15-40
Acid insoluble ash (% wt)	1.00	Max. 1.00
Sulphate (% wt)	17.20	15-40
Viscosity (cps)	240	Min. 5.00
Lead (%wt)	Nil	Max. 0.004

Competing Features/Impact:

- Solid seaweed residue obtained during liquefying, processed for the preparation of refined κ-carrageenan. Refined kappa-carrageenan is used as an emulsifier, thickener and gelling agent in a wide range of commercial products.
- The process is simple and produce k-carrageenan in high yield (25-30% w. r. to dry seaweed granules).

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

India imports large quantity of

k-carrageenan that involves foreign exchange exchequer. The technology has been transferred to an industry for commercial production in India & revenue opportunity potential of licensee is ~Rs. 50 Lakhs.

Techno-Economics

Tentative Price:

Seaweed:
Rs.50-80/kg

Refined κ-carrageenan production cost:
~ Rs.1000/kg

Major Raw Materials Needed:

Kappaphycus alvarezii (a red seaweed)

Major Plant Equipment and Machinery Required:

Liquid expeller to form granules from *Kappaphycus alvarezii*, Jacketed open reactors with overhead mechanical stirring, Jacketed closed reactors with overhead mechanical stirring, Boiler, Centrifuge, filtration unit, Distillation unit for isopropyl alcohol.

Environmental Considerations:

The solvent used in the process can be recovered by distillation and can be reused.

Status of Licensing:

Technology know how is transferred to an industry.

Status of Commercialization:

Commercial production of carrageenan is not started.

Technology Package:

Demonstration of production of refined carrageenan @ 2.5 Kg SRC/batch; Technology transfer document (TTD) having information on product specification, competition, market, details of equipment required for pilot level installation, etc. along with demonstration certificate will be provided; Technical support till 6 months after know-how licensing; Know-how licensing fee details will be provided on request.

TRL Level & Scale of Development : 6; (5 kg *Kappaphycus* granules/batch)

IPR Status IPR Details

US 6893479, IN 224938, CN 1324052(C), EP 1534757, ID 0019080, KR 100689982 (B1), PH1-2005-500340, TZP/05/00082, WO 2004016656. US 7067568B1

Kappahycus alvarezii elite seedling production through micropropagation of tissue cultured plants

Application/Uses/Problem being Addressed:

Kappaphycus alvarezii harvest yield in cultivation using conventional plant has declined significantly during the last few years due to loss in vigour after several successive generations. Elite seedlings with more vigour addressed this problem by achieving an average of 30% increase in biomass yield in cultivation.

Salient Technical Features including Competing Features/Impact:

K. alvarezii commercial cultivation was initiated in 2001 along the southeast coast of Tamil Nadu. Production increased significantly from 21 dry metric tons in 2001 to 1,490 dry metric tons in 2013. The number of seaweed growers in Tamil Nadu have risen from a mere 6 in 2001 to 950 in 2013. However, the production sharply declined in the subsequent years due to mass mortality. The production achieved till June 2019 was only 181 dry wt. Only few hundred farmers are involving in *K. alvarezii* cultivation. There is huge demand for seed material for continuing the cultivation. *K. alvarezii* commercial cultivation from isolated spores has been successfully developed in Indonesia to provide seed material to the farmers.

However reproductive material of *K. alvarezii* has not been recorded in India for the last 2 decades. Mass seedling production through micropropagation of shoot initiated plantlets in the lab, outdoor tanks and finally in the sea ensures consistent supply of seed materials to the farmers. It has been proven that micro propagated seedlings of *Kappaphycus* are more virulent and showed higher growth rate than farmed plants.

IPR Status & Details : Not Applicable

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Since an average of 30% increase in growth was observed in elite seedlings over farmed plants, there is huge opportunity for licensing this technology to the private entrepreneurs.

Techno-Economics

Farmers will get more biomass yield and subsequently earn more money than cultivating the conventional plants in their farms; Higher growth rate offers bet... economic gains

Environmental Considerations:

The seaweed farming does not required fertilizer, pesticide, irrigation, etc. that like of conventional land crops farming. Therefore, there is no environmental concerns.

Status of Licensing:

Not yet licensed.

Status of Commercialization:

Not applicable.

Major Raw Materials Needed:

Healthy vegetative fragments of *Kappaphycus alvarezii*. 80g fresh material will give 800 elite seedlings.

Major Plant Equipment and Machinery Required:

Tissue culture laboratory with controlled condition of temperature, light and aeration for elite seedling production.

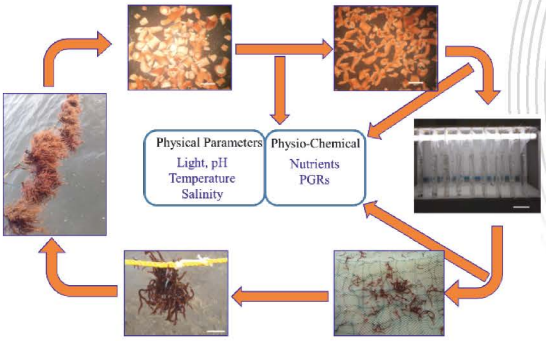
Outdoor FRP tanks for hardening the propagules.

Technology Package:

Know-how for micropropagation and growth protocols; Demonstration of the process; Seedling material; License fee and other financial details would be provided on request.

TRL Level & Scale of Development :
TRL-7; Technology was developed completely and about 400 kg seedlings were supplied to the farmers and the farmers confirmed the superior growth of elite seedlings

Process of production of seedlings in agarose yielding red seaweed *Gracilaria dura* for commercial exploitation



Application/Uses/Problem being Addressed:

Gracilaria dura is used as principal raw material source of agarose. The cost effective, green processing by surfactant-induced, coagulation of agarose from alkali-treated *G. dura* was patented by CSMCRI as an alternative to the traditional energy-intensive process of "freeze-thaw" cycles. The Council of Scientific and Industrial Research (CSIR), India has also obtained a trade mark for the agarose produced from *G. dura* (Sagarose: Number 2123313 dt. 30.03.2011, New Delhi, India). The experimental cultivation of *G. dura* employing net, pouch, bottom-net bag, hanging rope and raft technique, along the south-eastern coast of India, as well as using a raft method along Gujarat coast was attempted. The biomass availability of this species is poor and scanty distribution and seasonal occurrence hinders utilisation of this alga for industrial production of agarose. The seedling production technology that has been developed would cater need of commercial farming of this species in the country.

Salient Technical Features including Competing Features/Impact:

The technology has taken care of higher regeneration, survival and growth efficacy of non-apical and non-basal segments. It has demonstrated the use of minimum thallus tissue for utilization of maximum thallus tissue, to increase the number of seedlings per donor tissue. The weight to volume ratio has been standardized to achieve maximum survival and regeneration under controlled laboratory conditions. The various pre-treatments have been developed to get maximum survival and regeneration under controlled laboratory conditions. Besides, outdoor cultivation protocol has been established. The farming of this species has been adopted in the open sea along the Gujarat coast. The capacity building of 163 fishermen has been accomplished by providing hands on training, under National Fisheries Development Board, Hyderabad sponsored project. The buy-back agreement has been made with our agar-agarose producing industries. The adequate supply of seed material would certainly have bearing in augmenting the efforts to support farmers those are engaged in commercial cultivation of this species to make the livelihood lucrative and sustainable.

TRL Level & Scale of Development :
TRL - 4; Lab scale production @ 10,000 seedling in a batch has been achieved

of its cultivation, technology can be deployed in any of the Indian maritime states.

Status of Licensing:

This technology is not yet licensed; however, the process has been initiated to provide the know-how to Daman and Diu Administration.

IPR Status & Details : Not Applicable

Status of Commercialization:

Not yet done, though ready for deployment.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Since monsoon period seriously hampers the field cultivation, therefore this is the only method to supply the quality seedling material to seaweed growers. Scale and cost will vary depending on requirement of seedling material.

Techno-Economics

Starting with 2.5 Kg biomass, 1 ton seedling material can be produced in 180-200 days

Major Raw Materials Needed:

G. dura stock, seaweed tissue culture laboratory, seawater, tanks, shade and small farm to maintained adequate stock and acclimatized the newly generated seedling propagules.

Environmental Considerations:

The method follows non-polluting practices, does not require any harmful chemicals, etc. sometime use hormones and natural growth stimulant treatment. Since *G. dura* is indigenous, therefore depending on feasibility

Major Plant Equipment and Machinery Required:

Requires seaweed tissue culture laboratory kind of set up and seedling nursery kind of arrangements.

Technology Package:

Know-how for seedling generation and subsequent demonstration of cultivation for one cycle; Seedling material; License fee and other financial details would be provided on request.

Preparation of molecular biology grade agarose from Indian agarophytes with backward integration of farming

Application/Uses/Problem being Addressed:

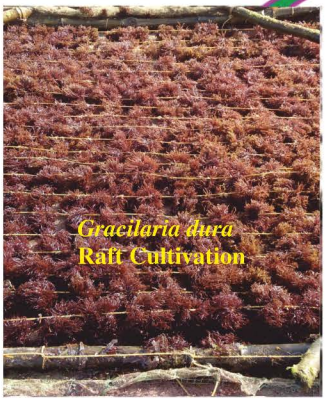
Till date, India mainly depens on the imported expensive (Rs.30,000-3,00,000/kg) agarose products. Given the rapid growth of the biotech Sector, demand for agarose is likely to increase substantially. There is a need for a low cost high quality product in India.

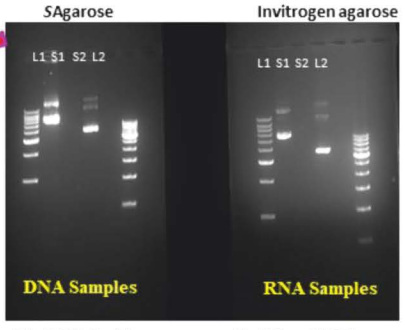
Salient Technical Features including Competing Features/Impact:

Gracilaria dura, a marine red alga, occurring sparsely in Indian waters, has been demonstrated to be cultivable in South east and West coast of India. A cost effective process was developed to obtain high quality agarose from this seaweed without involving any purification of agar done conventionally or involving any energy intensive freezing thawing process done conventionally to purify agar.

Cultivation: On Bamboo raft; Peak period: November to April.

Preparation of agarose: Through an energy-efficient room temperature isolation process that dispenses with the need for *"freeze-thaw"* cycles.





L1: 1 Kb Ladder
L2: 500bp Ladder
S1,2: plasmids

Cell lines RNA
1-A549; 2-Beas2b
3-Hela; 4-THP

Table : Benchmarking with commercial products

Properties	CSIR-CSMCRI *SAgarose* (Trade Mark No. 2123313)	Sigma (A0576)[b]	Sigma Agarose, Low EEO[a]
Gel strength	≥2000 g/cm^2	≥1800 g/cm^2	>1200 g/cm^2
Gel point (°C)	36 ± 1	36 ± 1.5	36 ± 1.5
Sulphate (%)	<0.20	<0.12	<0.20
EEO[c]	≤0.13	≤0.12	0.09-0.13

The yield of agarose is ca. 10% (based on dried alga quality as obtained from the field). Production cost is significantly low (Rs.5000-7000 per kg) compared to imported products (price of similar grade agarose available in the market is ca. Rs.30,000 to Rs 300,000 per kg).

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

India import reasonable quantity of agarose that involves foreign exchange exchequer. This indigenous technology has been transferred to an industry for commercial production in India & revenue opportunity potential of licensee (in the near term) ~1 crore (if production is started with suitable raw materials).

Environmental Considerations:

This process is eco-friendly.

Status of Licensing:

Technology know how transferred to an industry.

Status of Commercialization:

Commercial production of agarose is not started.

Techno-Economics

Tentative Price:

Tentative Price:
Raw material Seaweed:
Rs.100-120 /kg
Agarose production cost:
Rs.5000-7000/kg

Major Raw Materials Needed:

Red seaweeds *(Gracilaria dura)*.

Major Plant Equipment and Machinery Required:

Reactor (pressure vessel); Centrifuge; Filter Press; Mechanical Grinder; Evaporator; Boiler; Pumps.

Technology Package:

Demonstration of cultivation of *G. dura* and training with at least two Bamboo rafts. Demonstration of production of Agarose @ 2 Kg seaweed/batch. Demonstration certificate will be provided. Technology transfer document (TTD) having information on product specification, competition, market, details of equipment required for pilot level installation etc. will be provided. Technical support till 6 months after know-how licensing. Appropriate discount in license fee for small scale industries/startup will be provided. Cost of Technology know-how will be provided on request.

TRL Level & Scale of Development : 7

IPR Status & IPR Details

IN 2009DE567A; AU 2010227247, CA 2756520, CN 102439047 (B), EP 10715346.2, IDW 00201103393, JP 5642152, PH1-2011-501869, RU 2541635, WO 2010109289.

TRL Level & Scale of Development :
5, 5 kg seaweed as raw material / batch production of agar

Production of food grade agar from cultivated *Gracilaria edulis* / *G. debilis* with backward integration of farming

Application/Uses/Problem being Addressed:

Gracilaria edulis & *G. debilis* are utilized for more than three decades for food grade agar production in India. Many seaweed based industries in India are not producing agar to their full capacity due to shortage of raw material. A feasible cultivation method has been developed for sustainable production of biomass.

An improved process has been developed for extraction of superior quality agar from *G. edulis*, which may be useful for food, agriculture and biological applications.

IPR Status & Details : Not filed

Salient Technical Features including Competing Features/Impact:

G. edulis & *debilis* are utilized for more than three decades for food grade agar production in India. Many seaweed based industries in India are not producing agar to their installed capacity due to shortage of raw material. A feasible cultivation method has been developed for sustainable production of biomass for agar production using improved method.

J Appl Phycol 2008, 20:397-402; *J of Appl Phycology*, 2016, 28, 3479-3489; J *Appl Phycol* 2019, 31, 2609-2621, J Appl Phycol 2010, 22, 623-627.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

India is mostly depends on the imported agar products used as thickener and gelling agents in the food industry. Hence, CSIR-CSMCRI process technology will provide import substitute for expensive agar products.

Techno-Economics

Tentative Price:
Raw material Seaweed: Rs.40-60/kg
Agar: Rs.400-700/kg

Environmental Considerations:
This is almost zero liquid discharge process.

Status of Licensing:
Technology know-how for agar production from *Gracilaria edulis* is transferred to an NGO.

Status of Commercialization:
Not commercialized in market.

Major Plant Equipment and Machinery Required:
Reactor (pressure vessel); Centrifuge; Filtration unit; Mechanical Grinder; Evaporator; Boiler; Refrigerator (-15°C), Pumps.

Technology Package:
Cultivation methodology of *G. edulis* & *G. debilis* and training with at least two Bamboo rafts; Demonstration of the agar production @ 1 kg dry seaweed / batch; demonstration certificate and technology transfer document having information on market, completion, process, specification of products, optimized parameters of process, product evaluation details, equipment requirement details, designs etc., will be provided; Appropriate discount in license fee for small scale industries / startup will be provided.


A

Process for the production of bacteriological grade agar from *Gracilaria dura/Gelidiella acerosa* with backward integration of farming

IPR Status & Details :
US 2005/0267296 A1, WO 2005/118830 A1, IN 1189/DEL/2004, GB 2429209, AU 2004320343 A1, CA 2569495, CN 1993474 A, JP 2008501816 T, RU 2381276 CL, IN 201611002824

Application/Uses/Problem being Addressed:

Food & beverage industries, pharmaceutical, cosmetics, biological applications as media for bacteria culture, etc.

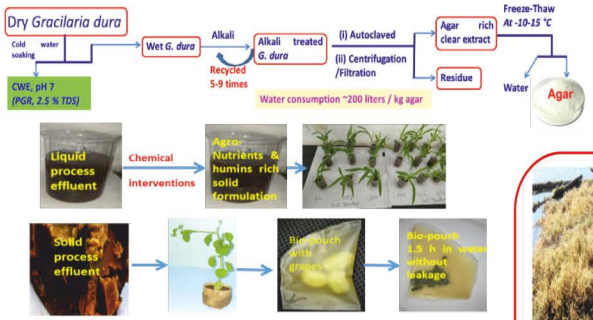
Process developed is devoid of any kind of effluent production and conventionally huge amount of effluent is produced during agar production.

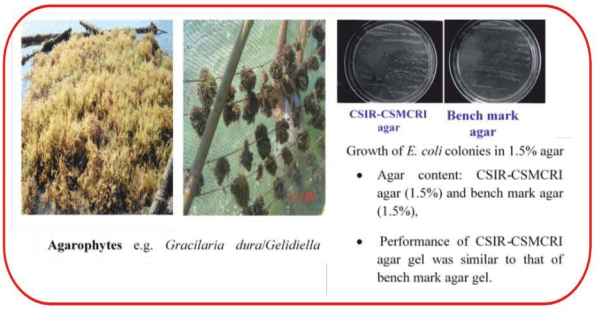
Salient Technical Features including Competing Features/Impact:

Due to the rapid growth of the food & beverage industries and biotech Sector, demand for agar is likely to expand substantially. There is a need for a low-cost high-quality product. At CSIR-CSMCRI, a new process for the extraction of food and bacteriological grade agars from Indian agarophytes such as *Gracilaria edulis*, *G. dura*, and *Gelidiella acerosa* which are abundant naturally in west and south east coasts of India and also being cultivated in the south east coast of India is developed and validated 3-4 kg dry seaweed level per batch in the pilot plant. The obtained agar samples with yield 15-20% (based on dried seaweed as obtained from the field) have shown high gel strength (700 to 2500 g cm^{-2}, in 1.5% gel), low metal and sulphate contents and found to be suitable for bacterial growth.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

India import large quantity of agar that involves high foreign exchange exchequer. For the first time, a zero-liquid discharge "ZLD" process is developed for the production of bacteriological grade agar from cultivated seaweed biomass such as *Gracilaria dura*, *Gelidiella acerosa*, etc.





TRL Level & Scale of Development :
500 g agar per batch (TRL 4)

Environmental Considerations:

Environmentally safe and benign as it is a zero liquid discharge process.

Status of Licensing:

No.

Status of Commercialization:

Not commercialised.

Major Raw Materials Needed:

Cultivated seaweed biomass.

Major Plant Equipment and Machinery Required:

Boiler, Open Jacketed Vessel, Closed Jacketed Vessel, filtration unit/centrifuge, Cold room are the major requirement for agar plant.

Technology Package:

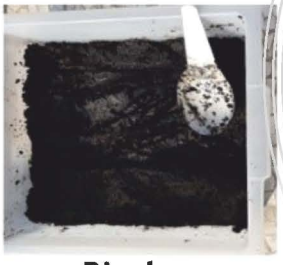
Demonstration of cultivation methodology of *Gracilaria dura* and training with at least two Bamboo rafts; demonstration of cultivation of *Gelidiella acerosa* with two cement blocks and training. Demonstration of production of agar @ 1.5 kg dry seaweed/batch; Technology transfer document (TTD) having information on product specification, competition, market, details of equipment required for pilot level installation etc. along with demonstration certificate will be provided; Technical support till 6 months after know-how licensing; Appropriate discount in license fee for small scale industries/startup will be provided; Know-how and licensing fee details will be provided on request.

Techno-Economics

Process is suitable to produce high quality agar product in eco-friendly manner, and production cost about Rs.700-800 per/kg agar.*[Similar quality commercial products are sold @ Rs.5000 to 25000 per kg]

Properties	CSMCRI *Agar*	Sigma Agar (A9668)	AgarGel	Marine Chemicals	Fluka (05070)
Gel strength (1.5% gel, g/cm²)	1200-2500	>1100	700-1000	900-1000	1400
Gel point (°C)	38 ± 1	36 ± 1.5	32 to 45	36-40	40-43
Sulphate (%)	0.35 ± 1	<0.30	-----	----	≤0.50
Moisture (%)	10 ± 0.5	≤10	Max 18	15	
Ash (%)	1 ± 0.1	≤1.5	NR	NR	≤1.0
pH	7.0 ± 0.2	NR	NR	8.2	NR
Remarks	Essential properties are identical & CSMCRI agar exhibits Greater gel strength compared to commercial agars	----	http://www.agargel.com.br/agar-tec-en.html	http://www.marineagar.net/specification-of-agar-agar.htm	-----


Sargassum spp.


Biochar


Cellulose


Fermented Solid Soil Nutrient


ALginate


Solid Soil Nutrient

TRL Level & Scale of Development : 9
IPR Status & Details : IN 201811029622

Process for preparation of liquid seaweed plant bio-stimulant (LSPB) from brown algae-*Sargassum*

Application/Uses/Problem being Addressed:

India being agriculture country, there is considerable demand for developing low cost bio fertilizer that can affordable even by marginal farmers for enhancement of crop yields & quality. The residue generated while producing liquid fertilizer can be used as a feedstock for making a commercially important products such as cellulose, carbon materials, for desired applications, etc. It is tested for enhancing the crop yield & quality. LSPB and its solid formulations shows excellent enhancement in crop yields from 13 to 28%.

Salient Technical Features including Competing Features/Impact:

- The fresh/dry seaweed biomass is liquefied to produce a seaweed liquid fertilizer which proven to be a promising low-cost bio fertilizer (foliar spray as well

as soil applications) and residue processed for recovery of cellulosic and carbon materials which may be used for suitable applications.

- Raw material (brown seaweeds) used are abundant in nature and easy to harvest.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

India import large quantity of seaweed fertilizer that involves high foreign exchange exchequer (tentatively estimated at 800-1000 crore). The technology has already been transferred to 10 industries for commercial production in India & revenue opportunity potential of licensee (in the near term) -~Rs.20 crore.

Environmental Considerations:

This is an eco-friendly process with zero liquid discharge.

Raw material (brown seaweeds) used are abundant in nature and easy to harvest

Tentative Price:
Seaweed:
Rs.15-30/kg
Seaweed liquid fertilizer:
Rs.150-200/L

Status of Licensing:

Technology know-how is transferred to 10 industries.

Status of Commercialization:

Commercialised.

Major Raw Materials Needed:

Brown seaweeds *(Sargassum spp.)*.

Major Plant Equipment and Machinery Required:

1. Mechanical grinder.
2. Jacketed open reactors with overhead mechanical stirring.
3. Boiler.
4. Autoclave.
5. Centrifuge, etc.

Technology Package:

Demonstration of production of LSPB @ 200 L/batch; Technology transfer document (TTD) having information on product specification, competition, market, details of equip-ment required for pilot level installation etc. along with demonstra-tion certificate will be provided; Technical support till 6 months after know-how licensing; Appropriate discount in license fee for small scale industries/startup will be provided; Know-how and licensing fee details will be provided on request.

A zero liquid discharge process for the production of alginic acid and its derivatives from alginophytes

Application/Uses/Problem being Addressed:

Alginic acid in the form of sodium, ammonium and polypropylene glycol alginate (PGA) is used in various applications in the food, beverage and pharmaceutical industries. Due to use of excessive acids and alkali in the processing of the alginophytes, it produces large volume of effluents with very high BOD and COD, which are difficult to dispose. The problem, addressed in the process developed, is valorizing the effluent into value added products and reduce the water requirement substantially.

Salient Technical Features including Competing Features/Impact:

The dry seaweed biomass is treated with alkali and acids to produce respective alginates. The effluents produced during soaking of the seaweeds were reused in the next batch of seaweed treatment. The neutralized effluents were converted to soil nutrients.

Raw material (brown seaweeds) used are abundant in nature and easy to harvest.

- Sodium, potassium and ammonium alginate can be produced (25-30% Yield).
- No solid and liquid waste produced.
- Process suitable for all types of alginophytes.
- PGA alginate is produced.
- High viscosity of the biopolymer aqueous solutions.
- Water input reduced by 25% in comparison to conventional process of extraction.
- Effluents produced is converted to values added products.

TRL Level & Scale of Development : 5
IPR Status & Details : IN 201711025753

Sargassum spp.

Sodium Alginate

Propylene Glycol Alginate

Solid Residue

Crude cellulose

Liquid Effluent

Plant Bio stimulant

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

During 2017-20, India imported large quantity of alginates that involves high foreign exchange exchequer (tentatively estimated at Rs.50-70 crore) and only 35% of the total domestic demand of alginates is fulfilled by the alginate products produced in the country. This technology has already been transferred to an industry for commercial production in India & revenue opportunity potential of licensee (in the near term) - ~Rs.50 lakhs.

Techno-Economics

Raw material (brown seaweeds) used are abundant in nature and easy to harvest

Tentative Price:

Seaweed: Rs.15-30/kg
Sodium alginate: Rs.180-250/kg;
Ammonium alginate: Rs.280-350/kg

Environmental Considerations:

This is an eco-friendly process with zero liquid discharge.

Status of Licensing:

Technology know-how is transferred to an industry.

Status of Commercialization:

Commercialisation of the product not yet done.

Major Raw Materials Needed:

Brown seaweeds *(Sargassum spp.)*.

Major Plant Equipment and Machinery Required:

1. Mechanical grinder.
2. Jacketed open reactors with overhead mechanical stirring.
3. Boiler.
4. Autoclave.
5. Centrifuge, etc.

Technology Package:

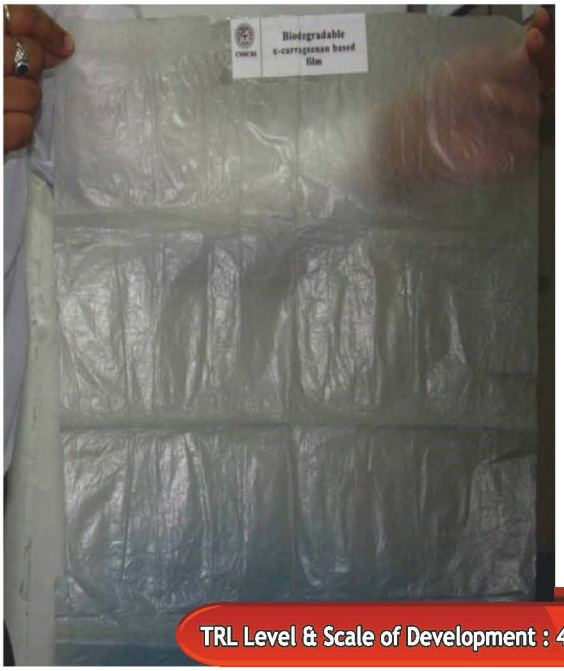
Demonstration of production of alginates @ 2 kg seaweed/batch; Technology transfer document (TTD) having information on product specification, competition, market, details of equipment required for pilot level installation, etc. along with demonstration certificate will be provided; Technical support till 6 months after know-how licensing; Know-how licensing fee details will be provided on request. Appropriate discount in license fee for small scale industries/startup will be provided.

Application/Uses/Problem being Addressed:
As biodegradable and eco-friendly packaging material for solid food items such as fruits, vegetables, perishable items, etc.

3) These films are suitable to store solid food items.
4) These films disintegrate in cold and hot water.
5) The films are completely biodegradable.

Preparation of biodegradable thin films for food storage applications from phycocolloids obtained from seaweeds

Fig. : Biodegradable k-carrageenan films



TRL Level & Scale of Development : 4

Salient Technical Features including Competing Features/Impact:
The specification of the film: Tensile Strength; 10-14 MPa, Water vapour permeability: 0.0085 $g/cm^2.h^{-1}.bar$; Moisture content = 8-10%.

1) The films are stable at ambient condition for 1-2 years without any degradation and moisture accumulation.
2) These films are odourless and can be heat-sealed and pouches to store non-aqueous solvents can be prepared.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):
In recent times, synthetic & non-biodegradable packaging materials are the big source of environmental pollution in the world. They (synthetic) require long time to degrade in the environment and produce toxins to organism. Hence, CSIR-CSMCRI has developed an optimized seaweed-based formulation for the preparation of bio-degradable packaging materials in the form of thin films. These developed thin films are suitable for packaging non-aqueous and solid

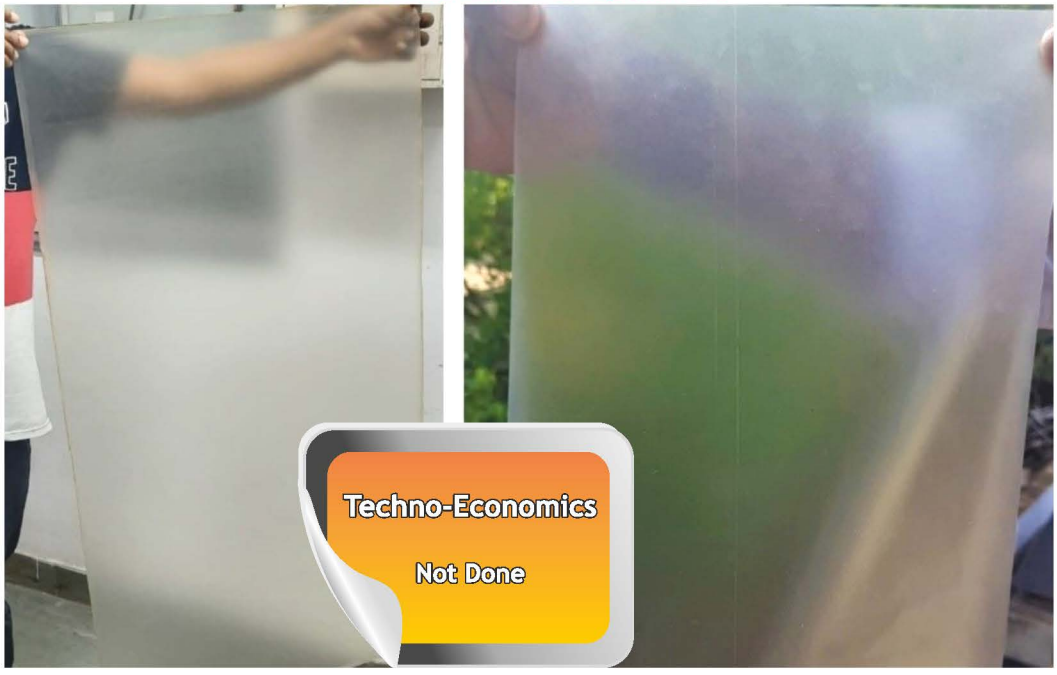
food items for long time. The process developed will reduce the demand of synthetic packaging materials in the food industries, which help to reduce environmental pollution in future. This invention has huge business opportunity in future.

TRL Level & Scale of Development : US 7,067,568, WO 2006059180 A3, AU 2004325362 A1, GB 2435768 A, CN 101316865 A ; IN 1280/DEL/2005

Major Plant Equipment and Machinery Required:
Jacketed open vessel, Closed pressure vessel, Boiler, Centrifuge/filter bed, Alcohol distillation unit, Thin film casting machine.

Technology Package:
Demonstration of preparation of films by mold casting method and using prototype casting machine of dimension 2'x3.5'/batch; Technology transfer document (TTD) having information on product specification, competition, market, details of equipment required for pilot level installation, etc. along with demonstration certificate will be provided; Technical support till 6 months after know-how licensing; Appropriate discount in license fee for small scale industries/startup will be provided; Know-how and licensing fee details will be provided on request.

Fig. : Biodegradable k-carrageenan films



Environmental Considerations:
This process is almost effluent free.

Status of Licensing: Not licensed.

Status of Commercialization: Not applicable.

Major Raw Materials Needed:
Refined & semi-refined k-carrageenan & alginates.

Preparation of capsule shells from seaweed phycocolloids

Application/Uses/Problem being Addressed:

It is a substitute of gelatin capsule shells, and could be used in wider areas including foods, pharmaceuticals, biological applications, etc.

Salient Technical Features including Competing Features/Impact:

Due to the well-established multiple problems associated with currently used gelatin-based capsule shells, there is a global demand for the technology on biocompatible, non-gelatin, and veg capsule shells. Further, due to the outbreak of 'mad cow disease' in Europe in 1992, gelatin, the main ingredient of edible capsule shells was removed from GRAS category of FDA. To address the issue and to develop non-animal gelatin capsule shells, CSIR-CSMCRI has developed a technology to produce these items from phycocolloids. Further, the capsule shells can be used by pharmaceutical companies for making capsules of non-animal gelatin source. The physico-chemical properties of the capsule shells are at par to that of their gelatin counterparts.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

In the world, most of the pharmaceutical industries are using gelatin based capsule shells for filling/packing the active drug ingredients. These gelatin capsule shells have several health issues as mentioned above. Hence, this technology developed by CSIR-CSMCRI has huge business scope & opportunity in future.

TRL Level & Scale of Development :
3 (Laboratory scale production of 100 capsule/batch)

Environmental Considerations:

Process is almost zero liquid discharge.

Fig. : Hard capsule shells

Techno-Economics
Tentative Price:
Raw material:
Rs.250 to 450 /kg
Capsule shell cost:
Rs.0.02 to 0.04
per capsule shell

Status of Licensing:

Not licensed.

Status of Commercialization:

Not applicable.

Fig. : Filled soft capsule shells

Major Raw Materials Needed:

Refined k-carrageenan and alginates.

Major Plant Equipment and Machinery Required:

Boiler, Closed Jacketed Vessel, capsule making machines, dryer for capsule shells are the major requirement for agar plant.

IPR Status & Details : US 7067568 B1

Technology Package:

Demonstration of preparation of capsule shells by mold casting method @ 60 capsule/batch; Technology transfer document (TTD) having information on product specification, competition, market, details of equipment required for pilot level installation, etc. along with demonstration certificate will be provided; Technical support till 6 months after know-how licensing; Appropriate discount in license fee for small scale industries/startup will be provided.

Know-how and licensing fee details will be provided on request.

Seaweed based new animal feed additive formulations for improving productivity and health

Application/Uses/Problem being Addressed:

- Improve performance of poultry and cattle.
- Better Immuno-responsiveness (cellular mediated and HA titer) in poultry and cattle.
- Gut health (microbial & structural) in poultry.
- Higher egg production and advancement in egg laying age.
- Higher calcium and iron content in milk.
- Reduced methane emission and higher energy use efficiency.
- Higher daily growth rate in cross bred calves.

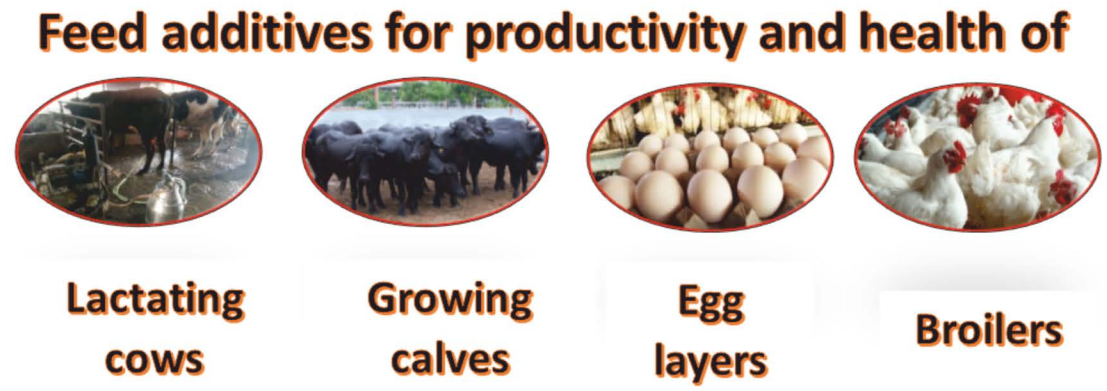
TRL Level & Scale of Development : TRL: 5
- The formulations have been tested and validated by different ICAR institutes working on animals (IVRI, NDRI) and poultry (CARI)
- Toxicology studies of specific formulation are available

Salient Technical Features including Competing Features/Impact:

- Low energy requirement.
- Raw materials indigenously available.
- Competitive cost.
- Idea of toxicological profile and active constituents.
- Palatable to animals.
- Can be offered as feed additive to animals in different forms including powder and cattle lick.
- Good health benefits in cattle and poultry.
- Higher productivity and quality of produce.
- Scope of further improvisation.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Animal feed additive market - by 2022 is projected at USD 1.853 billion and growing CAGR@ 8.1 %, and thus offers tremendous scope.



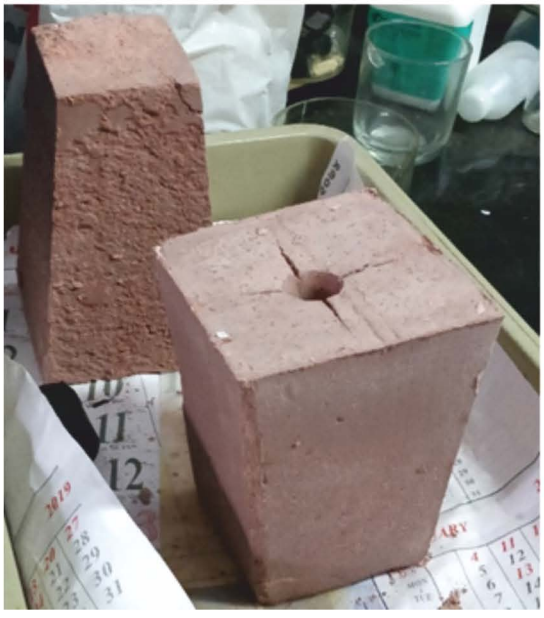


Fig. : Seaweed based cattle lick

IPR Status & Details : Invented products and rocesses are under IPR filing

Environmental Considerations:

- The invention process is eco-friendly.
- It can bring down methane emissions.

Status of Licensing:

Licensed the technology to a company. New products/formulations are intended to be developed in collaboration with interested stakeholders.

Status of Commercialization:

Commercialization is under progress.

Techno-Economics

Tentative Price:

Tentative Price:
Rs.150 per kg
- depending on the formulation and process

Major Raw Materials Needed:

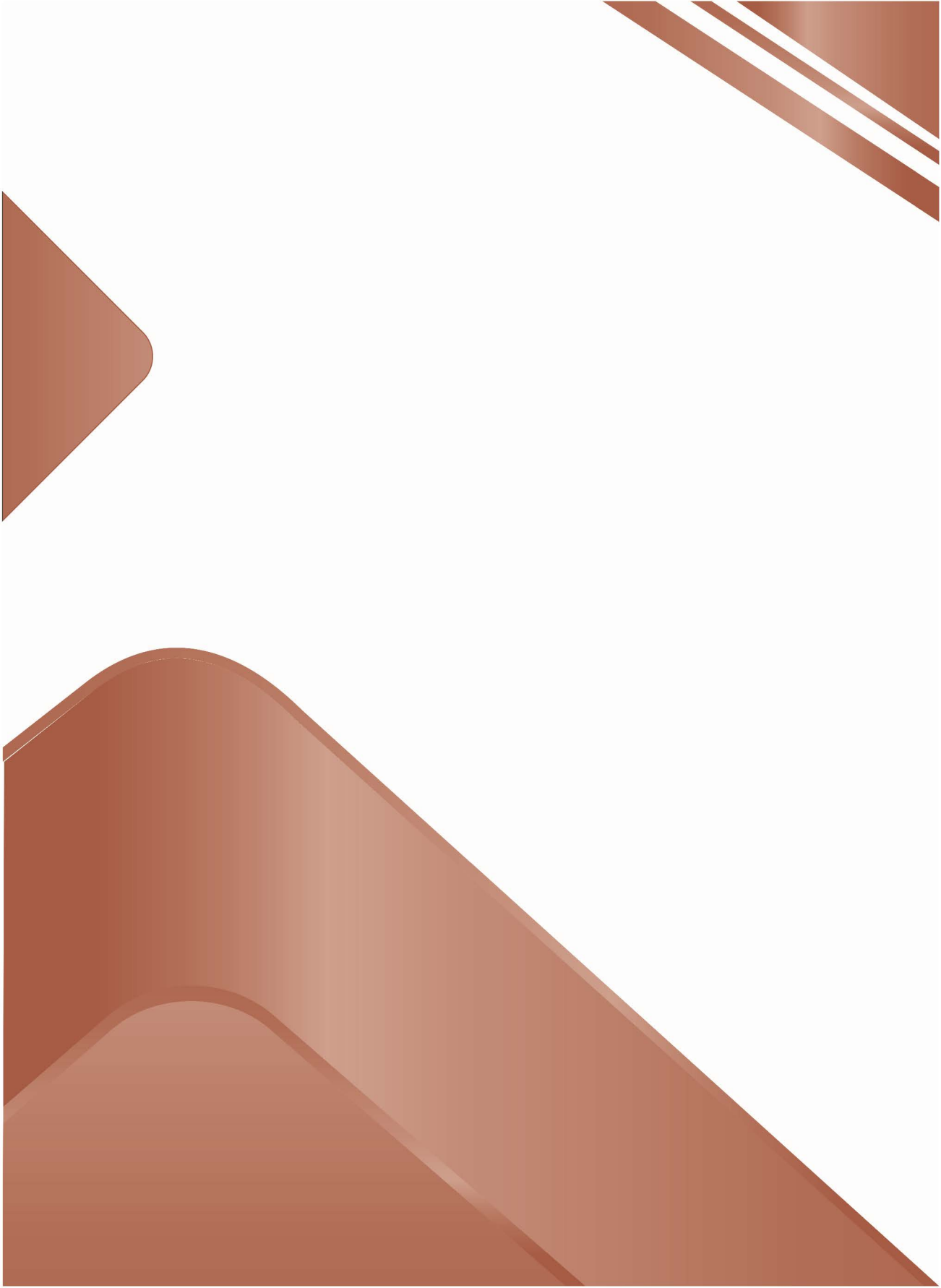
Select seaweeds.

Major Plant Equipment and Machinery Required:

Seaweed cultivation or collection mechanism, expeller, dryer, pulveriser and reaction vessels.

Technology Package:

Know-how of formulation; Demonstration through field validated data; License fee and other financial details would be provided on request.



Waste to Value

A ZLD management of molasses-based alcohol distilleries effluent (spent wash) with value-added products - potash & organics

Application/Uses/Problem being Addressed:

Effluent from sugarcane molasses-based distilleries (spent wash) pose serious environmental threat for contamination of groundwater & waterbodies. This is the single biggest impediment for ethanol capacity expansion in Indian context. This ZLD compliant spent wash management technology allows distilleries to produce various value-added marketable products (viz. FCO grade potash fertilizer, cattle feed binder, etc.) from spent wash.

TRL - 7; Commercial plant

IPR Status & IPR Details

IN 318659; US 10683211;
US 10793480; IDP 000072069
US Patent no. 9,540,282 (2017)

Salient Technical Features including Competing Features:

- Process involves recovery of FCO grade potash fertilizer, organics (binder in cattle feed formulation), activated carbon & water, using spent wash as resource.
- Indigenous potash fertilizer - import substitution.
- De-linked from sugar mill - more alcohol from same distillery.
- ZLD + Sustainable environment.
- Ethanol capacity expansion - enabling scope to achieve fuel blending target.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Potential client base:

India: >350 distilleries.

SE Asia, Africa, Brazil, etc.

Environmental Considerations, if any:

The process is ZLD compliant and all solid streams are saleable product - environmentally safe & benign process; Implementation of the process would lead to better environment in particular for land/water bodies around the distilleries.

Status of Licensing:

The technology has been licensed to M/s Aurangabad Distillery Limited (ADL).

Status of Commercialization:

The unit, attached to ADL's 60-klpd distillery at Walchandnagar, Maharashtra, is operational.

Major Raw Materials Needed:

Distillery spent wash, lime, magnesia, nitric acid, sulphuric acid, etc.

Major Plant Equipment and Machinery Required:

Generic equipment required in chemical plant, viz. reactors, settlers, filter press, dryers, etc.

Technology Package:

Know-how transfer of the process; License fee and other financial details would be made available on specific request.

Techno-Economics

Broadly, for a 60 KLD distillery, Rs.25-30 crore would be the initial investment towards plant and machinery with a payback period of < 3 years

Processes for the utilization of kimberlite waste for the manufacture of sodium silicate, detergent grade zeolite A and precipitated silica

IPR Status & IPR Details

US 7037476 B1; US 7335 342 B2; US 7560093 B2, IN 01290DELNP2005, CA 2592499, CN 101090864 (B), WO 2006070399 (A1), ZA 2007/05224, IN 253874, CA 2629083, CN101296865 (B), WO 2007054955, ZA2008/02284, IN 246306, CA 2592518, CN 101094808B , WO 2006070400 (A1), ZA 2007/05227

Application/Uses/Problem being Addressed:

Huge quantity of kimberlite waste is available in Panna (~0.9 million ton of kimberlite waste annually), major constituents of this mineral waste is magnesium silicate mineral of serpentine group. The conversion of the waste to value added products make diamond mining more environmentally friendly.

Utilization of kimberlite tailing for producing value added products like sodium silicate, precipitated silica and zeolite-A.

Precipitated silica is used in rubber, tooth-paste, paint and paper industries and Zeolite-A as an environmentally friendly builder in detergent replacing phosphate.

Salient Technical Features including Competing Features:

This is the first time that such technology has been developed for the utilization of kimberlite tailing for producing value added products like sodium silicate, precipitated silica and zeolite-A and other value added by product like magnesia, pigment grade iron and titania. Developed process offers an alternative raw material for sodium silicate which is based on utilization of industrial waste. This is ecologically better option than using natural occurring sand mines.

TRL Level & Scale of Development
TRL-4; Pilot Scale

A process for the utilization of kimberlite waste for the preparation of sodium silicate on ~ 50 kg/batch has been developed. Processes for the preparation of detergent grade zeolite-A (10 kg/batch) and precipitated silica (5 kg/batch) have been developed using the sodium silicate prepared from kimberlite waste.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

As India and other specific countries has huge kimberlite tailing (in the diamond mines), there exists huge opportunity and business potential to valorise into many useful products. There is a scope of preparation of magnesia and titania base products also.

Techno-Economics

Cost of precipitated silica is projected to be under Rs.50 per kg; Cost of detergent grade Zeolites-A is projected to be Rs.30 per kg; Will be provided on specific request

Environmental Considerations, if any:
Waste utilization from diamond mining into valued added products. It is pertinent to look for value addition of this waste not only to make diamond mining more economic but also to make diamond production environmentally friendly.

Status of Licensing: Not applicable.

Status of Commercialization: Not yet licensed.

Major Raw Materials Needed:
Kimberlite tailing (diamond mining waste), caustic soda, sulphuric acid and hydrochloric acid.

Major Plant Equipment and Machinery Required:
General chemical process equipment like reactors, filter, boiler, dryer, pulverizer, etc.

Technology Package:
Will be provided on specific request.

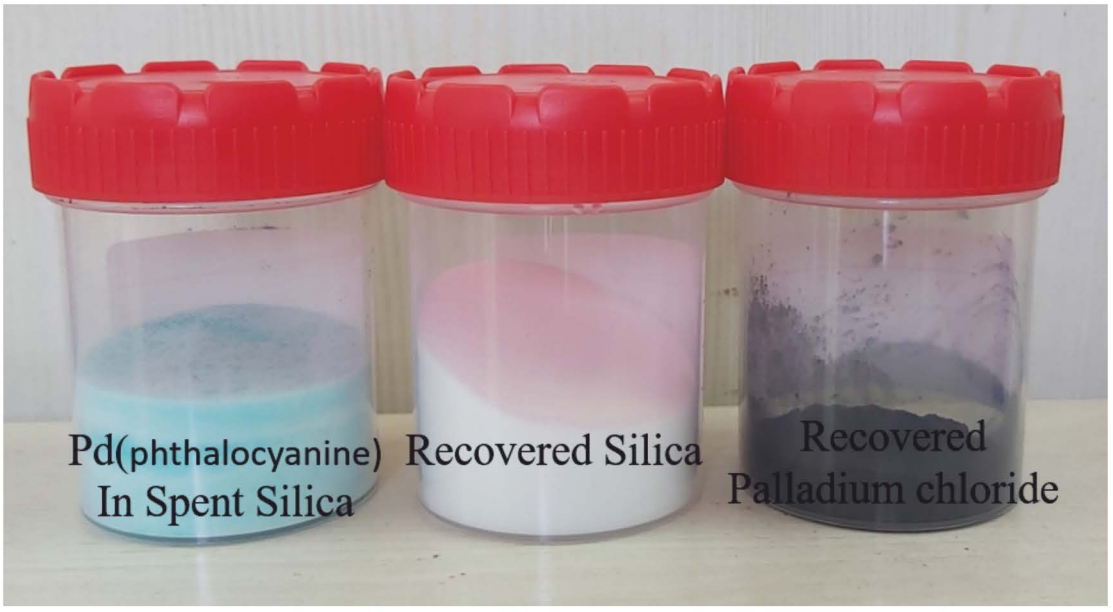
Table : Comparison of the properties and specification requiere for the rubber grade precipitated silica and detergent grade Zeolite A

Precipitated Silica (Rubber Grade)	Required	Achieved
Bulk density (g/cc) After taping	0.10 to 0.12	0.1
Oil absorption value (g/100g)	225-245	225
Moisture at 105°C (%)	5 to 6	5.4
Loss on ignition (%)	5 to 6	6.5
Silica (SiO_2 % min)	87	87
Particle size (% min) (-325 BS mesh)	99	99
Detergent Grade Zeolite A	Required	Achieved
Calcium Binding Capacity (mg Cao/g)	160	163
Particle size (µM) $d_{0.5}$	2-4	4.8
Particle size (µM) $d_{1.0}$	≤ 25	< 25
Whiteness Index, (%)	> 97	98
Crystallinity, (%) (compared to BDH 4A)	95	97

Palladium recovery from spent catalysts/materials

IPR Status

US 7108839 B2, IN 252378, CA 2508237, CN 1306048 (C), EP 1576200, JP 4384989, KR 10-0792639, WO 2004050926 US 7473406, IN 232461, CN 100336923(C), EP 1636393(B1), JP 4417907, KR 10-2005-7022957, WO 2004106563 (A1)



TRL Level & Scale of Development :
TRL 4; Up to 1 kg of spent catalyst

Application/Uses/Problem being Addressed:

Precious transition metal irons and their coordination complexes such as palladium, silver, platinum find industrial applications as supported catalysts for oxidation, hydrogenation and dehydrogenation reactions and performance chemicals in fine chemicals industries. Various polymeric materials modified silica, zeolite or various clay materials are used as support for these metals. It is important to recover the precious metals from the support, from ore or scrap including spent catalysts or from subsequent reaction effluent which may comprise of various remnants to the maximum extent possible once the catalyst is deactivated.

Salient Technical Features including Competing Features:

Demonstrated for one of spent catalysts of an industry that used Pd/C catalyst for hydrogenation.

Recovery of Pd from spent catalyst @ nearly 100% with greater than 99% purity.

Recovery could be possible for Pd concentration >0.1%.

Techno-Economics

It depends on the palladium content in the spent catalyst

Developed process tolerated the presence of moisture in the range 60-80% and organics <6%, carbon support in the range 15-25%.

The process for Pd recovery from used silica is demonstrated successfully at 10 kg calcined silica batch.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Palladium supported catalyst are used in many chemical reactions in the industry.

Environmental Considerations, if any:

Mild conditions were used for the recovery of palladium from spent catalyst as palladium chloride.

Status of Licensing:

Licensed to Strides Arcolab Ltd., Bangalore.

Status of Commercialization:

Not yet put in commercial practice.

Major Raw Materials Needed:

Spent catalyst having palladium, mineral acid and caustic.

Major Plant Equipment and Machinery Required:

Furnace with vertical column facility, leaching unit, filtration set up.

Technology Package:

Available on request and inputs from the client; Calculated based on the scale and operational process, impurities and palladium content in the spent catalyst.

A process of conversion and separation of sodium carbonate, potassium carbonate and KOH from spent water of isobutyl benzene (IBB) plant as (a) potassium nitrate, sodium nitrate and potassium perchlorate, potassium chlorate or potassium bitartrate, sodium carbonate or (b) potassium carbonate as value added products

IPR Status & Details : Patent filing under process

TRL Level & Scale of Development

4 (for potassium nitrate, sodium nitrate and potassium perchlorate, potassium chlorate or potassium bitartrate; 9 (for sodium carbonate and potassium carbonate); Commercial plant is operating at 2500 TPA K_2CO_3 and 500 TPA Na_2CO_3 plant capacity

Application/Uses/Problem being Addressed:

Potassium nitrate is one of the largest sources of non-chloride potassium fertilizer. It is more soluble than potassium sulphate and its use as a fully soluble fertilizer in applications such as fertigation. Potassium chlorate is a strong oxidizing agent that has a wide variety of uses. It has been a component of explosives, fireworks, safety matches, and disinfectants. Potassium perchlorate is used in explosives, flares, rocket propellants, photography, as a medication, and as an agent in automobile safety air bag. Sodium perchlorate is gene-rally used in pyrotechnics. Potassium bitartrate is used as an additive, stabilizer, pH control agent, antimicrobial agent, processing aid or thickener in various food product. Potassium carbonate and sodium carbonate are most important inorganic compounds used in industry.

Salient Technical Features including Competing Features:

Cost effective and simple process for various applica-tions from waste generated during produc-tion of isobutyl benzene (IBB).

The advantages are:

- Conservation of water.
- Production of value-added products depend-ing on the market demand.
- Elimination of polluting stream.

Techno-Economics

Economically feasible

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Potassium chemicals are imported or produced using imported chemicals. Demand for potassium carbonate has remained in the range of 25,000-tonnes to 30,000-tonnes (2014). Considering the double-digit growth in the pharmaceutical industry and growth in the other segments, annual growth of 7% is anticipated.

Environmental Considerations, if any:

Environmentally friendly and cost-effective process from the effluent generated during production of (IBB). IBB manufacturing process results in formation of aqueous stream containing sodium and potassium carbonate/hydroxide mixture due to catalyst destruction step. This stream is evaporated by industry where mixed salt of carbonates are sold or dumped at site. The process is an important tool for generating wealth from the waste with simultaneously abating pollution problems to bring benign environment.

Status of Licensing:

Licenced (separation of potassium carbonate and sodium carbonate).

Status of Commercialization:

Commercialized; (separation of potassium carbonate and sodium carbonate). Commercial plant is operational.

Major Raw Materials Needed:

Nitric acid, perchloric acid, tartaric acid, etc. for potassium chemicals.

Major Plant Equipment and Machinery Required:

General Process equipment like reactors, filter press, dryer, etc.

Technology Package:

Technology package is ready and would be provided to the party at the time of technology transfer. License fee and other financial details are available on request.

Application/Uses/Problem being Addressed:

During the process of recovery of lac from the stick lac, the stick lac is scraped and washed with hot alkali solution to get a refined product known as seedlac. During this process, two by-products lac dye and wax may dissolve and goes into the aqueous effluent (filtrate). To recover these by-products in the pure form

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Shellac/lac manufacturers, ready at lab scale demonstration.

Environmental Considerations, if any:

Yes, it reduces the environmental pollution by recovery the lac from the aqueous effluent.

Process of selective extraction of pure lac resin from the aqueous effluent

for commercial applications, many difficulties are faced by shellac industries. These industries are dumping this effluent into the environment due to the lack of innovative technology to recover the dissolved lac resin. The present invention not only evade the environmental pollution, but also an economical process for the recovery of value-added products from the aqueous effluent.

Status of Licensing:

Licensed to an industry.

Status of Commercialization:

Customer is producing the lac resin with the present technology.

Major Raw Materials Needed:

Stick lac / any lac source.

Salient Technical Features including Competing Features:

Cost-effective process for the recovery of lac resin from aqueous effluent of shellac industry. Reduces the environmental pollution meanwhile enhance the economics to the shellac manufacturers.

IPR Status & Details : IN 202111001134

TRL Level & Scale of Development
8; Tested at field @ m^3 scale

Major Plant Equipment and Machinery Required:

As desired by the customer for their production.

Technology Package:

Demonstration of extraction of lac resin @ 1 L effluent/batch; Technology transfer document (TTD) having information on product specification, methodology, market, details of equipment required etc. along with demonstration certificate will be provided; Technical support till 6 months after know-how licensing; Know-how licensing fee details will be provided on request.

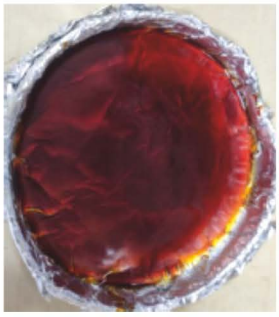
Techno-Economics

- The process is the first of its kind for the recovery of lac resin from the aqueous effluent of shellac industry
- As informed by the customer, the product (lac resin) recovered from the aq. effluent is useful for commercial applications

Shellac Aqueous Effluent

CSIR-CSMCRI Technology

Recovered lac from the aqueous effluent for commercial applications



IPR Status & Details : IN 301912
TRL Level & Scale of Development : 4; Pilot Scale

Preparation of ammonium bicarbonate from waste effluent of dyes/dyes intermediate industries containing ammonium carbonate

Application/Uses/Problem being Addressed:

The main uses of the product are: Nitrogenous fertilizer (India is still importing nitrogenous fertilizer), livening agent, blowing-agent for rubber foam products, ingredient for fire extinguisher, de-greasing of textiles, cooling baths, ceramic industry and light weight brick production, catalyst manufacture, smelling salt, pharmaceutical industry, etc. It is used as a foaming agent in elaboration of plastics and rubber.

It is also used as a component in the manufacture of fungicides and cleaning products.

Salient Technical Features including Competing Features:

Cost effective and simple process to produce ammonium bicarbonate with purity greater than 99% that meets the specifications for various applications from the organic pigment effluent. The advantages are: Conservation of water, production of value-added product, elimination of polluting stream.

Techno-Economics
Economically feasible

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

The ammonium bicarbonate industry is driven by the rising food industry, where it is employed as an active baking agent in the production of baked goods like biscuits, cookies, among others. Further, the growing population and urban development are strengthening the demand for food, which is likely to have a positive impact in the forecast period as well. In addition to this, the product is also finding extensive use in the end-use industries, such as rubber and leather industry, among others. The sustainable growth of these industries is predicted to aid the ammonium bicarbonate industry positively.

Environmental Considerations, if any:

Environmentally friendly and cost-effective process from the effluent generated in organic pigment industry.

This effluent of pigment industry is either discharged in water bodies such as sea or sea creeks or used by magnesium carbonate manufacturers who dispose ammonium salt containing effluent resulting in death of birds and aquacultures. The process will be an important tool for generating wealth from the waste with simultaneously abating pollution problems to bring about benign environment.

Status of Licensing:

Not licensed.

Status of Commercialization:

Not applicable.

Major Raw Materials Needed:

Ammonium carbonate containing effluent of pigment industry.

Major Plant Equipment and Machinery Required:

General process equipment like reactors, filter press, dryer, etc.

Technology Package:

Technology package is ready and would be provided to the party at the time of technology transfer.

Recovery of industrial grade sodium chloride and sodium sulphate using waste effluent of tannery & textile dyeing industries

TRL Level & Scale of Development
6, Pilot scale (tannery);
9, commercial scale
(6 KLPH plant is in operation using textile effluent

IPR Status & Details :
IN 232395; IN 202011009669

Application/Uses/Problem being Addressed:

Due to these unresolved environmental issues, both of these sectors faced severe sanctions, including closure notice, from legal as well statutory bodies. This cost-effective and simple technology is useful for recovery of salt (>98.5% w/w NaCl) and sodium sulphate (>98.5% w/w Na_2SO_4) from solid waste of textile and leather industries. The recovered salt is suitable as raw material for various industrial applications such as soda ash, alkali, pulp and paper industry, textiles, deicing and detergents, etc.

Salient Technical Features including Competing Features:

- The solid waste from textile/leather industries mainly contains sodium chloride and sodium sulphate along with minor

organic and trace metal impurities. Sodium chloride and sodium sulphate have overlapping solubility and are difficult to separate by chemical or physical methods.

- The process involves mechanical washing of solid waste with saturated brine followed by crystallization of sodium sulfate and recycling of left out saturated brine for upgradation of subsequent batches of solid waste.

Techno-Economics
Economically feasible

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Through the process sodium chloride >98.5 wt% and sodium sulphate > 98.5 wt% purity are recovered in a cost effective manner. Both the products have good commercial value. Adoption of this technology will enable value recovery through sale of by-products and also mitigate increasingly critical issues, viz., environment, storage & space constraints. For both RO reject & solid waste, with minor site-specific variations, can be employed in conjunction with upcoming ZLD facilities to achieve complete waste management regime in tannery & textile dyeing sector, with improved economics. Generally, this type of proposed plant will be a waste disposal plant. Capital cost/Project cost may be partially funded by different agencies.

Environmental Considerations, if any:

For both the effluent, post primary & secondary treatment stages, sodium chloride and sodium sulphate are the major contaminants along with minor content of calcium & magnesium salts and soluble organics. Due to high pollutant loading, these effluents are not suitable for direct discharge & requires downstream treatment/processing.

Status of Licensing:

Licenced.

Status of Commercialization:

Commercially operational in one of the textiles CETPs; shortly would be operational for tannery CETPs.

Major Raw Materials Needed:

Settling agents/additives, activated carbon, etc.

Major Plant Equipment and Machinery Required:

Belt conveyor, screw conveyor/washer, chilling unit, Nutsche filter, crystallizer centrifuge, packing machine, mini loader, etc.

Technology Package:

Technology package is ready and would be provided to the party at the time of technology transfer. License fee and other financial details are available on request.

A zero-discharge hydrometallurgy-based process for the recovery of valuable metals from spent lithium ion batteries

Application/Uses/Problem being Addressed:

Recycling of used lithium-ion batteries (LIBs).
Recovery of metals for economic benefits.
Recovery of excess lixiviant & by-product.
Preventing environmental pollution.

Salient Technical Features including Competing Features:

- A complete process for recycling of cathode of used LIBs.
- The hydrometallurgical process involves environmentally benign lixiviant (acetic acid) for leaching of metals, which are subsequently separated through sequential precipitation method with recovery of excess lixiviant and by-product.
- Room temperature leaching (no external heating), as compared to high temperature leaching in most of the reports.
- Recovery of individual metallic components in pure form by precipitation methods only (most of the reports use solvent extraction method for recovery of Co & Ni).
- The process does not include any solvent extraction step, avoiding possible fire hazard, which is very prone for recycler industries.
- Excess lixiviant (acetic acid) is recovered, which is rarely reported.
- The by-product (sodium acetate) was recovered at the end without any left-out liquor, claiming a zero-discharge process, rarely reported.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

We are in touch with few recycling companies who have shown interest. After the patent is filed, we will go for process demonstration. This may not be a very profitable business but considering the scarcity lithium and cobalt in our country and to prevent environmental hazard, there is a great scope.

IPR Status & Details : Applied for filing

TRL Level & Scale of Development : TRL 4, 1 kg cathode powder scale

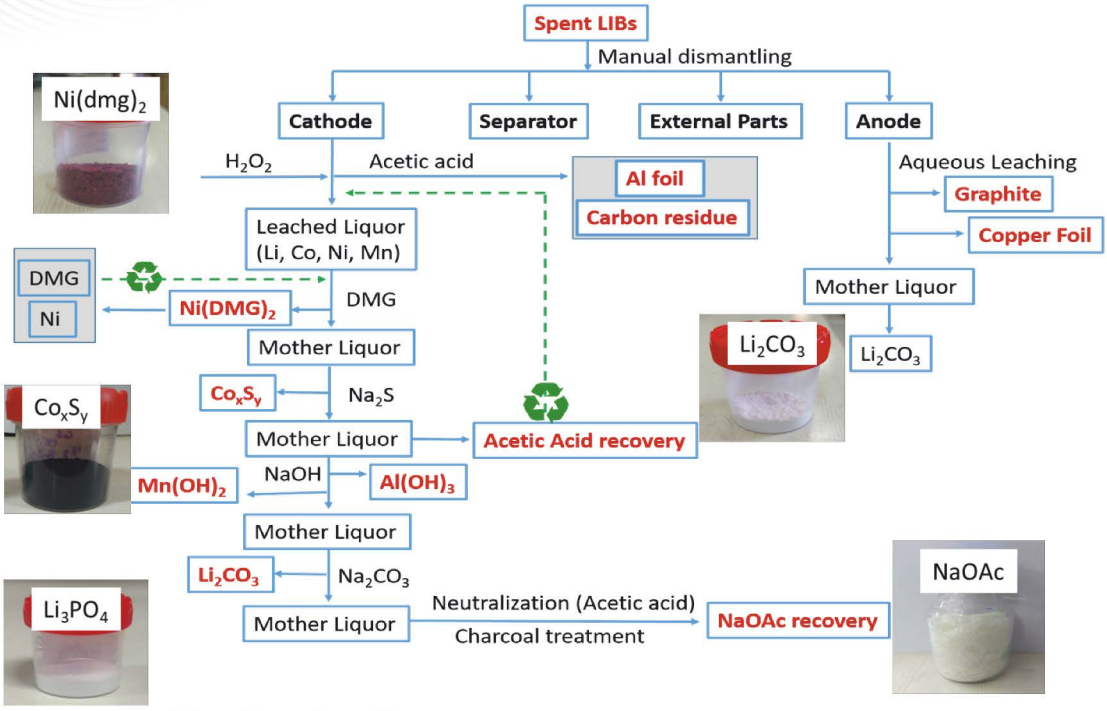
Techno-Economics

Depends on types of cathode material. For a particular type of battery easy to do. For mixed batteries the techno-economics depend on the composition of the cathode material; Computed and would be made available on request based on the used battery study

sodium sulphide, dimethylglyoxime, sodium hydroxide.

Major Plant Equipment and Machinery Required:

Dismantling unit (shredder, crusher, grinder, separator & dust collector), Hastelloy/Glass reactor, Basket centrifuge, Nutsche filter, dryer, etc.



Environmental Considerations, if any:

The process is environmentally benign with a zero-discharge process.

Status of Licensing:

Not licensed so far.

Status of Commercialization:

Not applicable.

Major Raw Materials Needed:

Used LIBs, acetic acid, hydrogen peroxide,

Technology Package:

Know-how of hydrometallurgical process for sequential separation; Demonstration of the process; Generic process equipment needed for pilot scale can be given; Technical specification for battery dismantling unit can be provided though not in our work or demo scope.

Devices & Sensors

Low-cost fluorimeter

TRL Level & Scale of Development
TRL 4;
Manufacturing fully tested, validated and qualified / System complete and qualified (test and demonstration)

IPR Status & Details : NA

Application/Uses/Problem being Addressed:

The device provides emission measurements at preset excitation wavelength by laser diode, displays sample emission counts and concentration reading post calibration.

Salient Technical Features including Competing Features/Impact:

It has four operation modes:

- Calibration: offers 5-point calibration for user defined analyte concentration and preset calibration data.
- Measurement: display of emission counts of sample and concentration reading (in µM) of unknown samples post calibration.
- Time Scan: offers 30 min trend of emission counts vs. time.

- System: displays system health parameters like CPU voltage, Laser Diode operating current, temperature, and Laser Diode ON/OFF status/ control.
- Limit of Detection: 0.01 µM of Fluorescein.
- The device has facility for sample excitation at 405 nm, 450 nm, 488 nm, 520 nm by swap of laser diode; although other wavelengths can also be provided.
- The device operates with 12Vdc power supply, hence 12V battery can directly be used for powering the device.
- Device can be tailored for specific applications.

Techno-Economics

Costing estimated for 50 nos. per year

- Total investment cost of plant /machinery - Rs.5,00,000
- Raw material cost per year - Rs.20,00,000
- Total cost of production per year - Rs.40,00,000
- Sale price per unit - Rs.1,00,000
- Gross profit from sale of a unit per year - Rs.20,000
- Net profit per yea r- Rs.10,00,000
- Benefit cost ratio (BCR) - 25%
- Return on investment (ROI) - > 150-200%
- Payback period- within 1 year

Business Scope & Opportu-nity (in terms of scale, cost, market, etc.):

Substitute to commercially available costly scanning fluorimeters for diverse range of applications related to medical, biological, food, drug, agro, colleges, etc.

Environmental Considerations, if any:

NA.

Status of Licensing:

Ready for licensing.

Status of Commercialization:

Not applicable.

Major Raw Materials Needed:

Active / Passive electronic components, optoelectronics, LCD, plastics, aluminum.

Major Plant Equipment and Machinery Required:

None.

Technology Package:

Know-how related to product design, assembly, testing and validation.

Plastic chip electrode (PCE)

IPR Status & Details
GB 2539862,
JP 6779863.
WO 2015170344 A1.
2014DE01254A

TRL Level & Scale of Development
6; Electrodes are made at several inches scale

Application/Uses/Problem being Addressed:

Multipurpose electrode platform.

The electrode has been successfully used in electrochemical sensing, electrocatalysis and electrometallurgy by ours as well as other collaborative groups. The electrode is multipurpose in nature and can be used in any electrochemical application in aqueous media in a wide pH window. Although the electrode is not fit for non-aqueous medium.

Electrode in glucometer, sensors, fuel cell, etc. after specific application modifications.

Salient Technical Features including Competing Features/Impact:

- The screen-printed electrode (SPE) are manufactured by printing different types of ink on plastic or ceramic substrates and conveniently used in miniaturized laboratory as well as commercial electrochemical sensing devices. There are several bottlenecks for SPE such as delamination of conducting layer, cannot be used in high current applications, requires high level of expertise, difficulty in scaling-up, etc.
- We have developed a general-purpose electrode the "Plastic Chip Electrode" (PCE). PCE is a bulk conducting, self-standing, composite electrode of carbon (graphite) and polymer (PMMA). The fabrication process in fully spontaneous and hence is highly simple fabrication process as well as highly cost-effective. It can sustain as high current density - 500 mA/cm^2.
- Demonstrated in: voltammetry's (CV, ASV, DPV), impedometry, electro catalysis,

electrometallurgy current collector in supercapacitor, platform for solid-state reference electrode.

- Lightweight, bulk conducting, moderately stable thermally & mechanically, bio-degradable (if prepared using bio-degradable polymer).

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

No similar product available in the global market to the best of our information. PCE is going to be at least 100 times cheaper compare to the existing products having common applications, mostly due to lower material cost, easy fabrication steps and having extremely high shelf-life.

Environmental Considerations, if any:

NA.

Status of Licensing:

Not yet licensed.

Status of Commercialization:

Not applicable.

Techno-Economics

Available on request

PCE (6"x6")

Major Raw Materials Needed:

Graphite powder and PMMA and solvent.

Major Plant Equipment and Machinery Required:

Glass mould.

Technology Package:

Know-how for preparation of PCE; Demonstration of PCE for electrochemical applications; License fee and other financial details are available on request.

Optical liquid switch (OLS)

Application/Uses/Problem being Addressed:

Optical liquid switch is useful for detection of either absence or presence of water (clear or turbid) or detect water level.

Applications include:

- Over-flow detection in tanks / reservoirs / pans / dams.
- Low-level or high-level monitoring with warning/control in tanks and salt farms.
- Empty pipe/blockage detection in water / drainage pipelines.
- Water level warning on vehicles.
- Alarm in events of water flow over bridge / road or under-pass for traffic management and safety.
- Water-level monitoring and alarm in open canal/stream/open drainage for vicinal population safety.
- Warning of high tides in coastal areas.
- Telecom outdoor stations, electrical substation, tunnels, basements for rainwater ingress alarm.
- Domestic appliances based on water application.

Salient Technical Features including Competing Features/Impact:

Optical liquid switch is suited for use in any process directory employing water service. The change in state from presence to absence of water or *vice-a-versa*, triggers inbuilt relay (250Vac/220Vdc @ 2A) which can be used for switching applications and/or for annunciating audio or visual alarm, or signaling process controllers. Features include:

- Low cost.
- Low power demand.
- Compact design.
- No calibration / adjustment required.
- Pipe end-connection.
- Water proof.
- Easy installation.
- Suitable for various applications.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Owing to growing awareness for water conservation, OLS market is huge and it is cost effective for deployment.

Environmental Considerations, if any:

NA.

Status of Licensing:

Ready for licensing.

Status of Commercialization:

Not applicable.

Major Raw Materials Needed:

Active / Passive electronic components, plastic for molding.

Major Plant Equipment and Machinery Required:

Molding outsourced Rs.10 per pc.

Technology Package:

Know-how related to product design, assembly, testing and validation.

Techno-Economics

Costing estimated for 1000 nos. per year.

- Total investment cost of plant / machinery- Rs.5,00,000
- Raw material cost per year - Rs.2,50,000
- Total cost of production per year - Rs.5,00,000
- Sale price per unit- Rs.600
- Gross profit from sale of item/unit per year Rs.60
- Net profit per year- Rs. 60,000
- Benefit cost ratio (BCR) - > 10%
- Return on investment (ROI) - >12%
- Payback period - 8 years

Bacterial detection kit

Application/Uses/Problem being Addressed:

1. Simple method for bacterial detection from any type of water.
2. No need of any instrument, laboratory assistance.
3. Anyone can perform without any skill.

Salient Technical Features including Competing Features/Impact:

This is a simple kit; bacterial detection can be made by observing color change. Time taken to change the color will determine the bacterial load.

TRL Level & Scale of Development
TRL: 4,
The product has already been developed.
Not verified so far in the commercial/customer operating environment

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Aquaculture (shrimp) farms have started using this kit in the farm and also in the hatcheries. There is also business scope in the domestic user market.

Environmental Considerations, if any:

The process does not involve any discharge; only 5×5 cm modified PVDF membrane will be generated after each testing. The Eppendorf tube can be washed, sterilize and reused.

Status of Licensing:

Licensed to an MSME.

Status of Commercialization:

Trial for commercialization is in progress.

IPR Status & Detail : IN 201711024804

Major Raw Materials Needed:

PVDF membrane and some non-hazardous chemicals.

Major Plant Equipment and Machinery Required:

Membrane manufacturing machine.

Technology Package:

Know-how for preparation of functionalized PVDF membrane for bacterial detection and demonstration; Color chart for the extent of bacterial presence.

Techno-Economics

Cost for large production: 1000 membrane strip cost Rs. 5,000
For home segment: 30 numbers of strip cost Rs.300
(for monthly regular monitoring/family)

TRL Level & Scale of Development

TRL: 4,

The product has already been developed. Not verified so far in the commercial/customer operating environment

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Utility oriented for both domestic and commercial segment; Scope for enhancement into other innovative products are possible like probiotic curd etc.; Incubation Venture Center, NCL Innovation Park, Pune has approached for discussion and exploring further for commercialization scope.

Curd strip for consistent quality curd preparation

Application/Uses/Problem being Addressed:

Inoculum based curd preparation which is generally in practice does not guarantee consistent quality curd. Inoculum (old curd) is also not readily available all time at home. Using the membrane-based strip, consistent quality of curd can be prepared. By changing the size of membrane, any quantity of curd can be prepared.

Salient Technical Features including Competing Features/Impact:

- It is a simple membrane-based strip, which can be used for consistent quality curd preparation.
- The strip can be stored in normal refrigerated condition form more than 3 months (shelf life).
- By changing the size of membrane, varied quantity of curd can be prepared.
- By changing the attached bacterial type, probiotic curd can be also prepared at home.

IPR Status & Detail :
IN 201711024804

Environmental Considerations, if any:

Preparation method of curd strip does not generate any waste discharge. After use, the strip/membrane may be cleaned and reused.

Status of Licensing:

Not licensed so far.

Status of Commercialization:

Not applicable.

Major Raw Materials Needed:

PVDF membrane and bacterial inoculum.

Techno-Economics

Production cost of the strip will be around Rs.5

Major Plant Equipment and Machinery Required:

Liophylizer; size based on production requirement.

Techno-Economics:

Production cost of the strip will be around Rs.5.

Technology Package:

There will be single membrane pack as well as 5 membrane/pack as per the requirement of commercial requirement.

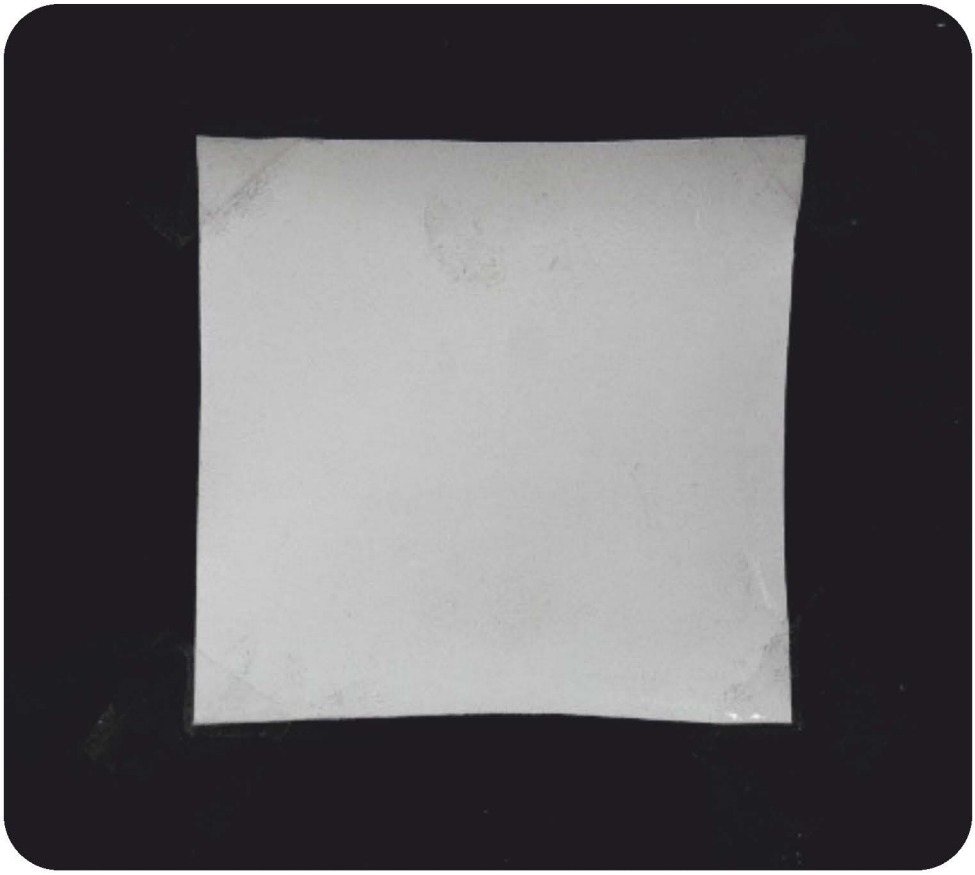
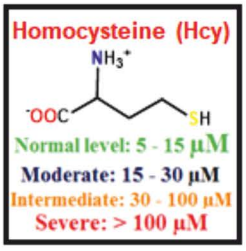
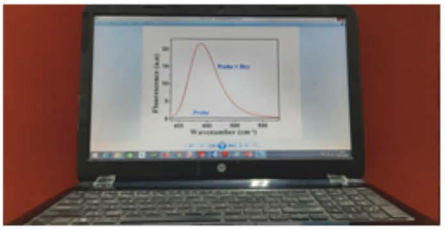


Fig. : Curd strip for consistent quality curd preparation

Diagnostik kit for quantification of homocysteine

Under UV lamp @364 nm





Step 1: Take 1.5 mg of probe in 100 mL HEPES solution.

Step 2: Add 1 mL of probe in 1 mL sample containing Hcy.

Step 3: Quantify Hcy by exciting the sample at 370 nm.

Homocysteine specific optical sensor for diagnostic use

Application/Uses/Problem being Addressed:

Direct measurement (fluorimetric) of cardiovascular disease marker homocysteine in human blood plasma.

Salient Technical Features including Competing Features/Impact:

- Optical sensor for measuring homocysteine directly and selectively in human plasma.
- Proof-of-concept has been established with spiked human blood samples.
- Clinical validation of the optical sensor has been performed with cardiac patient samples.

- Cell-line based bio-imaging and toxicity (MTT) data available.
- Gold standard validation of the developed sensors for sensitivity and specificity.

IPR Status & Details :
IN 202011038506

Techno-Economics
Available on request

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Measurement of homocysteine concentration in human blood functions as the single largest risk marker for heart diseases and strokes. Indian market is desperately looking for indigenous point-of-care assay for measuring plasma homocysteine with extreme specificity. No indigenous kit is available in India to measure homocysteine directly in human plasma. All available kits are imported and can only perform indirect measurement. We, at CSIR-CSMCRI, have developed a sensor that can measure homocysteine with absolute specificity in human plasma directly.

Environmental Considerations, if any:

Not applicable.

Status of Licensing:

Not yet licensed.

Status of Commercialization:

Not applicable.

Major Raw Materials Needed:

Hydroxycoumarin, hexamine, acetic acid, diethyl ether, substituted diamine, copper nitrate and methanol.

Major Plant Equipment and Machinery Required:

None.

Technology Package:

Know-how for homocysteine specific optical sensor; Demonstration of the synthesis of probe and diagnostic process; License fee and other financial details are available on request.

Decentralized solar thermal dryer for hygienic drying of food products

Application/Uses/Problem being Addressed:

Solar dryer technology is simple and therefore easily adoptable by the household, community and food processing sector. Mixed mode type of solar dryers have been 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. at CSIR-CSMCRI, Bhavnagar. The capacity of the dryers can be varied from 5-20 kg of raw material per batch, however it depends on the nature of the food to be dried. The drying of various food products can be achieved in about half the time duration taken for open sun drying. Based on the small-scale design, a 0.6 T/batch dryer was installed at Sagar Island for drying of freshly caught fish.

Benefits of solar thermal dryer include:

a) Since the food is enclosed it is therefore protected from dust, insects, birds, flies and wandering animals.

b) Higher temperature reduces the risk of spoilage due to microorganisms.

Fig. : Fish being dried inside the constructed solar thermal dryer at Sagar island

c) The unit is waterproof and thus the product need not be moved when it rains or at night.

d) The unit can be constructed form the locally available materials.

e) Sometimes in open sun drying color of the product changes because of direct sun light exposure. In a solar dryer, the color of the product is retained as the product is not directly exposed to sunlight.

f) Less risk of spoilage because of the speed of drying, as because, slow drying has tendency to result in fermentation and spoilage.

g) The quality of the product is better in terms of nutrients and hygiene.

Salient Technical Features including Competing Features/Impact:

The innovative features of CSIR-CSMCRI solar thermal dryer are:

- Operation entirely on solar thermal energy and solar photovoltaic (PV) power and hence suitable for off-grid and remote locations.
- Solar PV powered de-humidifier installed inside the unit maintains desired temperature and relative humidity (RH) at night, in order to prevent reabsorption of moisture and finish drying of a batch in shorter time.
- 85-90 % solar UV cut-off, so that better colour retention is obtained and better price fetched.
- Solar PV operated heaters for inclement weather conditions.
- Renewable energy-based technology.

Techno-Economics

As a demonstration project, 0.6T / batch solar thermal dryer (0.3 Tx2) was installed at Sagar Island in for coastal fishing community which enhanced their profit by ca. 2.7 times

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Predominantly societal. Proliferation anticipated through licensee.

Environmental Considerations, if any:

Clean and green technology.

Status of Licensing:

Technology not yet licensed.

Status of Commercialization:

Not yet commercialized; Installed 0.6 T/batch capacity in a location and at 5-10 kg/batch capacity as demonstration units in two locations.

Major Raw Materials Needed:

Hardware material like plastic sheet, metallic sheets, anodized aluminum sheet, rods, pipes, PV panels, battery inverters, etc.

Major Plant Equipment and Machinery Required:

Modular units are needed to be fabricated in workshop.

Technology Package:

Available on request.

Fig. : Demo unit at a fishing village at Talaja, Gujarat

Improved solar still

Application/Uses/Problem being Addressed:

- Scarcity of potable water for drinking and cooking is a challenge confronting people in remote locations like coastal areas and small islands.
- Seawater desalination through techniques such as RO and ED are costly propositions, difficult to scale down to individual household levels, and grid power is unreliable in many locations.
- Many of these locations are blessed with abundant sunshine.
- There is merit in low-tech solutions such as desalination in a solar still, a device that enables evaporation and subsequent condensation of water in an enclosed unit assisted by solar thermal radiation.

Salient Technical Features including Competing Features/Impact:

- Maximum output of 5.0 litres/m^2/day.
- Incorporate reflectors in V-trough alignment along the North-South edges of the still, which is the simplest of concentrating technologies to enhance solar intensity on collector.
- Incorporating steps or partitions in the basin. The steps (i) allowed the water to be held in the tilted position, thus maximizing the absorption of solar beam radiation by the suitably tilted absorber surface, (ii) triangular exposure area, avoiding shadow effect as generally reported in literature for stepped solar stills, (iii) reduction in the free space thereby maximizing the partial pressure of water vapour and (iv) enhanced the contact area between water and heated basin surface.

Techno-Economics

Considering a $3m^2$ solar still unit
Water output (average) : 12 LPD
300 days in year and 5-year service life:
18000 L
Cost of water/L:
Rs.4.5/L
Bottling cost:
Rs.3/L
Selling price:
Rs.15/L
Profit:
Rs.7.5/L
Profit/year:
Rs.27000
Payback:
~3 years

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

Predominantly societal application. Proliferation anticipated through licensee.

Environmental Considerations, if any:

Clean and green technology.

Status of Licensing:

Technology licensed to ThermoSep, Ahmedabad.

Status of Commercialization:

Not yet commercialized.

Major Raw Materials Needed:

Hardware material like metallic sheets, anodized aluminium sheet, rods, pipes, etc.

Saline water of any TDS can be used as feedwater.

Major Plant Equipment and Machinery Required:

Modular units are needed to be fabricated in workshop.

Technology Package: Available on request.

Fig. : Solar distillation units in experimental salt farm of CSIR-CSMCRI

Fig. : 3m^2 solar distillation system at Kavaratti

Differential depth water sampler (DDWS) - A device for collecting water to concentrate diversified bacteria at different depths

Application/Uses/Problem being Addressed:

This is an innovative vertical water sampler which can collect water from different depth without any cross contamination from other layer.

Salient Technical Features including Competing Features/Impact:

- DDWS is the improved version of Niskin sampler, which is used for vertical water sampling from long past throughout the world.
- DDWS can dip to the desired depth and from boat with a rope the lid can be open for filling of water.
- Water filling can be checked from boat by observing the bubble which comes to the surface of water.
- After filling of water, bubble formation stops and it can be assumed that the sampler is filled with water. After that the lid can be closed from boat by using another rope.
- Such monitoring process is not available in case of Niskin sampler which go to the desired depth in open condition, which increase the chance of cross contamination from other layer. Further Niskin sampler work based on messenger and therefore in the area where undercurrent is very strong, false operation is very common in case of Niskin sampler.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):

We are in contact with companies who are involved in coastal/ marine sampling.

Environmental Considerations, if any:

This instrument is made up of steel or other metal which are heavy and less chance of rusting. During operation no waste products are generated.

Status of Licensing:

Not licensed so far.

Status of Commercialization:

Not applicable.

Major Raw Materials Needed:

Steel or other metal which are heavy and with less chance of rusting.

Major Plant Equipment and Machinery Required:

Engineering firms that manufacture different steel products.

Technology Package:

Unit sampler.

Techno-Economics

Production cost of unit sampler will be around Rs.40000-50000

Miscellaneous

Application/Uses/Problem being Addressed:
Aqueous Hand Sanitizer.

Status of Licensing:
Licensed to two MSMEs.

IPR Status & Details : IN 202011030085

TRL Level & Scale of Development
TRL-9;
Commercially manufactured

Novel silver nano-based aqueous sanitizer against pathogens

Salient Technical Features including Competing Features/Impact:

- Kills 99.9% SARS Cov-2 virus along with other virus & bacteria [*Klebsiella pneumoniae* (SC-1, 9023, 19114, 16280), E.coli, *Pseudomonas aeruginosa*, *Staphylococcus aureus*].
- Water based hand sanitizer.
- Completely non-toxic to skin layer.
- Enhanced with moisturizer.
- Non-flammable.
- Free from hydrogen peroxide.

Business Scope & Opportunity (in terms of scale, cost, market, etc.):
Scalable; Health and hygiene will be getting prominence post pandemic provides huge opportunity for sanitizer market.

Environmental Considerations, if any: Zero waste.

Status of Commercialization:

Commercialized.

Major Raw Materials Needed:

Silver nitrate, SDS, sodium boro-hydride, glutathione, sodium meta silicate.

Major Plant Equipment and Machinery Required:

Mechanical stirrer assembly, large flask or vessel.

Techno-Economics

Rs.3,500/- for 100 litres (approx.)

Technology Package:

Know-how for preparation of aqueous hand sanitizer; Demonstration of the preparation; Batch wise quality assessment; License fee and other details are available on request.

A decentralized multistage constructed wetland system for sewage treatment

Application/Uses/Problem being Addressed:

1. The technology can be used in following sectors: Municipalities, urban development units, real estate, small to medium scale residential communities, apartments for sewage/grey water treatment; and agricultural & storm water treatment.
2. Reusing the treated wastewater for gardening, aquifers recharging, etc.
3. Reducing dependency on fresh water resources.
4. Protecting the environment from contamination due to untreated discharge of sewage.

Salient Technical Features including Competing Features/Impact:

- The system is free from clogging.
- An antibacterial device filled with antibacterial granules is used finally to kill the residual bacteria from the treated wastewater.
- Running life: >15 years.
- Minimal electrical/mechanical inputs.
- Pulling carbon out of the atmosphere.
- Treated water quality follows CPCB standards.

Business Scope & Opportunity (in terms of scale, cost, market, etc.)

The technology can be used in following sectors: Municipalities, urban development

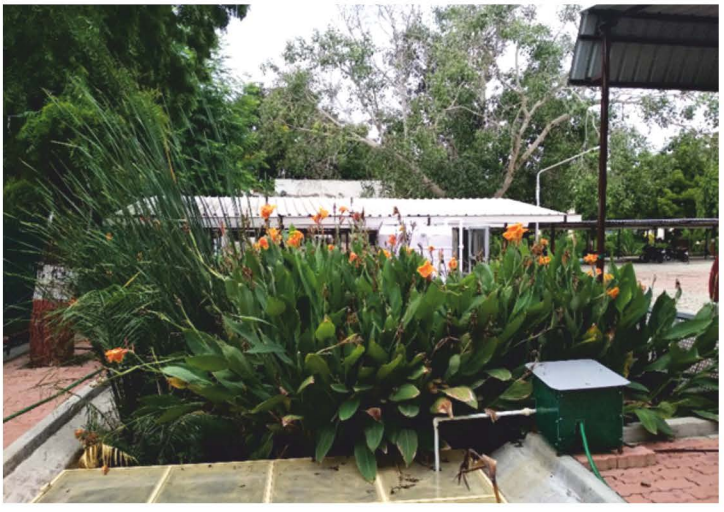


Fig. : System at CSIR-CSMCRI, office premises

IPR Status & Details : IN 202111001294

Techno-Economics
Approximate cost:
3-6 KLD = Rs. 3 lakhs; cost will be reduced for larger ones

units, real estate, small to medium scale residential communities, apartments for sewage/grey water treatment; and agri-cultural & storm water.

Capability: CSMCRI can design for small to medium scale i.e. 2 to 100 KLD plants.

Market: The system design is made based on Indian climatic conditions, therefore, it can be installed in any part of India, which are facing water scarcity problems.

Environmental Considerations, if any:

Protecting the environment from conta-mination due to untreated discharge of sewage, grey water, etc.

Fig. : System at Ramakrishna Ashram, Rajkot

Status of Licensing:

Not yet licensed.

Status of Commercialization:

Not applicable.

Major Raw Materials Needed:

Specific plants species, media / substrate, etc.

Major Plant Equipment and Machinery Required:

Civil works.

Technology Package:

Construction, media and plants species etc. for 3-6 KLD system; antibacterial granules.

नोट / NOTES

OUR SOME ESTEEMED PARTNERS

निदेशक

सीएसआईआर - केन्द्रीय नमक व समुद्री रसायन अनुसंधान संस्थान

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