




Compendium of Technologies

Developed under CSIR Fast Track Translation (FTT) Projects (1st Tranche)










Mission Directorate

Council of Scientific and Industrial Research

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Contents.....

Aerospace, Electronics, Instrumentation & Strategic Sector (AEISS) Theme

Aerospace, Electronics, Instrumentation and Strategic Sectors Theme

Cost Effective and Advanced Polymer Composite Processing Equipments

Expensive and energy intensive composite processes and repair equipments have to be imported in the country be it for academia, R&D or production realted to aereospace. Considering this, CSIR-NAL has developed indigenous advanced polymer composite processing equipment, such as Microwave autoclave, desktop autoclave and multi zone hot bonder to strengthen the eco-system related to aerospace sector in the country. Desktop Aerospace autoclave was developed for the first time in the country. These affordable products will boost R&D and production of composites at academia and small scale industries.

Desktop Autoclave

Micro Wave Hybrid Autoclave

Multi Zone Hot Bonder

Important Parameters Unique to the Development:

- Provides low cost and energy efficient products for addressing composite processes and repair requirements to strengthen the ecosystem related to aerospace sector;
- Desktop autoclave will enable R&D units and academia to carryout research and produce aerospace grade advanced composite materials and components at an affordable cost;
- Superior quality composite products can be realized using these reliable products;
- Multi zone hot bonder is an import substitution with enhanced features. This product will enable complex repair processes, apart from saving cost; and
- Significant advantages in processing time and energy consumption will occur through microwave autoclave.

Major Application(s):

- Processing of advanced composites for R&D and production;
- Low cost processing equipment for Industry, Academics and Research Institutions working on composites; and
- Repair of aircraft structures

Impact of the Technology: The products developed are low cost and energy efficient for addressing composite processes and repair requirements which would strengthen the esecosystem related to aerospace sector. Further, controlled and energy efficient processing of aerospace polymer composites would result in significant savings in process time, cost and energy consumption compared to the existing processing methods.

Commercialization Status:

(a) **Desktop Autoclave:** The technology has been licensed to three industries namely, M/s. Milvus Aero Solutions Pvt Ltd., Bengaluru, M/s. Datasol India Pvt Ltd., Bengaluru and M/s. Lakshmi Engineering Works, Chennai for marketing, production and commercialization of Desktop Autoclave on non-exclusive basis. One Desktop Autoclave is supplied to IIT Madras by M/s. Milvus Aero Solutions Pvt Ltd. Bengaluru. Also, two more orders, one from IIT Guwahati and another from DIAT, Pune are in pipeline. Several educational institutes have shown interest and have initiated procurement. The technology is available for licensing.

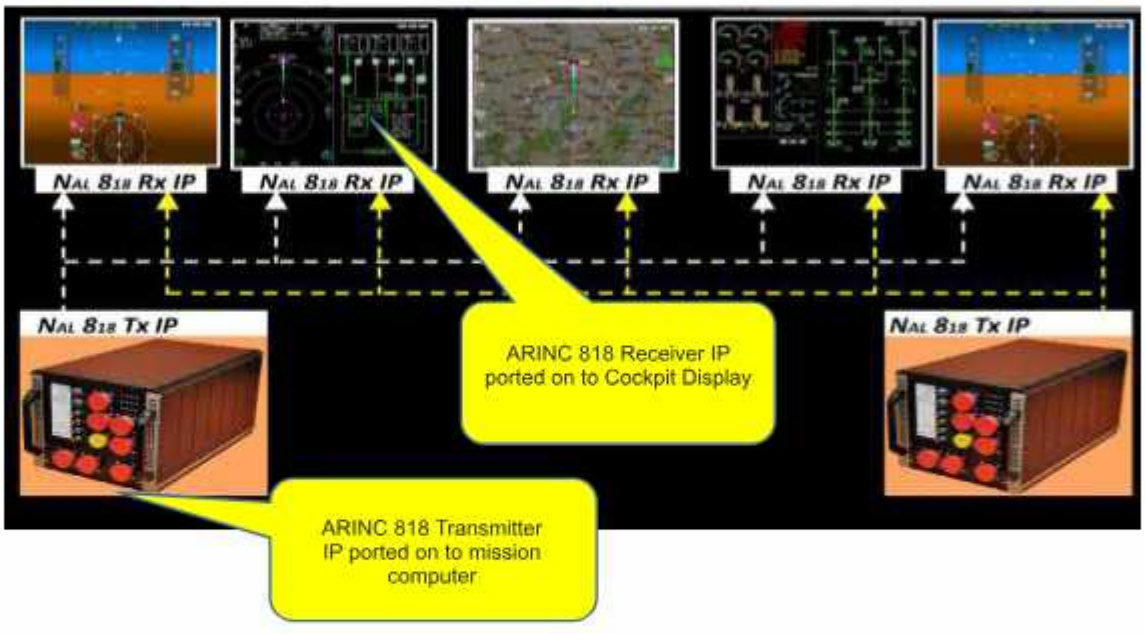
(b) **Microwave Hybrid Autoclave:** Design and development of the Microwave Hybrid Autoclave was successfully completed. One bar and two pressure assisted microwave curing of glass-epoxy prepreg laminates and MAV (PUSHPAK) airframe was successfully demonstrated. Hybrid curing (Autoclave + Microwave) of glass-epoxy prepreg composites at 1 bar & 2 bar pressure was also successfully completed. The technology is available for licensing.

(c) **Multi Zone Hot Bonder:** The technology has been licensed to two industries namely, M/s. san process Automation, Bengaluru and M/s Ajay Sensors and Instruments, Bengaluru for marketing, production and commercialization of Multi Zone Hot Bonder on non-exclusive basis. Licensee has submitted offers in response to the tender from HAL. Quotes have been submitted to IAF and other private companies The technology is available for licensing.

Contact: The Director, CSIR-National Aerospace Laboratories, HAL Airport Road, Bengaluru - 560017; Tel.- 080 - 25270584; Email: director@nal.res.in

Design, Development and Certification of Avionics Video and Data FPGA based IP Core

In an aerospace domain, there are plenty of technology development around the world, in specific to avionics system, many of the systems are migrating to modular functionalities with configurable interfaces features. In near feature, these modular configuration of avionics architecture demands all avionics display system to handle high bandwidth (3.18Gbps) video and data interface. ARINC 818 is the standard for avionics display video protocol interface. Almost every aircraft demands for video interface with ARINC 818 standard. CSIR-NAL completed the design & development of ARINC818 IP-Core and has received the certification from CEMILAC (Centre for Military Airworthiness & Certification) for the developed IP-Core. The Prototype has been developed and demonstrated. With this development, CSIR-NAL now can contribute to all strategic and / or national programs of the country with the certifiable IP cores.



Typical End Application of ARINC 818 IP core

Important Parameters Unique to the Development:

- Developed the expertise in FPGA based design and development in avionics domain;
- DO254 expertise in the country with full life cycle data generation required for certification of FPGA based IP Core design as DO254 process guidelines;
- Unique design of ARINC 818 based IP core fully indigenous, first time in the country; and
- Established the library for certified FPGA IP cores for all national programs.

Major Application(s):

- Military and civil Aircraft Avionics Display applications (with ARINC 818 interface)
- Current day state of the art Integrated Modular Avionics (IMA) processing computers with ARINC 818 interface;
- Ground based integration rigs;
- Any aircraft LRU which are to be interfaced to the ARINC 818 based system; and
- Applicable to Military Unmanned Aerial Vehicles (UAV), Ground based vehicles, Missiles etc. where high bandwidth requirement is needed.

Impact of Technology:

- It is first of its kind IP core in India for aerospace application with DO 254 DAL A clearances. The available product abroad has many limitations for use in India;
- The development is very useful for the strategic sector for next 3 decades at least;
- The technology reduces the number of voluminous bundles of wires used for communication reducing them all into couple of fibre channel interfaces;
- Fibre channel based FPGA IP core will be available to the Indian aerospace industry at affordable price for use without any restrictions on deployment against too many restrictions from foreign OEM at a high acquisition cost;
- The technology is an enabling technology for high bandwidth communication channel interface across various applications on day to day basis to improve the quality of life; and
- With CSIR NAL's technology, Indian requirement is met without any restrictions and also at affordable cost. The same product / technology can be used across the programs and in the process, the DO 254 process. Know-How is available in India for all Indian users freely.

Commercial Status: CSIR-NAL successfully licensed ARINC 818 IP Core for design and development of an avionics display with ARINC 818 interface (using CSIR-NAL's ARINC 818 IP Core) to M/s. Paras Defence and Space Technologies Limited on non-exclusive basis. Further, discussions initiated with Astronautics Corporation of America (ACA) to certify this IP core internationally with FAA Certification to meet the international market demand. The technology is available for further licensing.

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Fully Autonomous Fixed Wing Mini UAVs Under 5.0 kg Class

CSIR-NAL has designed and developed an all composite, light weight, modular mini UAV named 'SUCHAN'. It is designed to operate from sea level altitude to 5000 m above sea level. Being indigenously designed and developed this mini-UAV is a far more cost effective solution than other UAVs with similar payload capabilities.

SUCHAN Mini UAV

This modular UAV with high percentage of in-house developed components has an advantage in terms of support and services. This mini UAV has an endurance of about 90 minutes and can fly for a range of 10 km Line of sight. SUCHAN UAV carries an interchangeable gimbaled Daylight or IR Camera weighing around 500 grams. It can be programmed for autonomous missions or operated manually utilizing the advanced avionics and precise GPS navigation. It comes with a retractable 2-axis stabilized gimbal, which delivers real-time colour or infrared imagery to the indigenously designed and optimized ground control stations.

Micro Autopilot System

Ground Control Station

Important Parameters Unique to the Development:

- Increased Endurance up to 90 minutes;
- Increased Range of 10 km;
- Modular Construction;
- Interchangeable Payloads (EO or IR);
- Under 5kg all up weight (AUW);
- Autopilot (Both Hardware and software) with safety modes;
- User friendly Ground Control Station;
- Gimbal stabilization, image processing algorithms & target tracking; and
- Hand launch & Belly landing

Major Application(s):

- For surveillance - Raster scan survey of large areas, static object tracking;
- Detection, recognition and identification of objects;
- Aerial mapping applications - open cast mines, sand ridges, lakes, forecast, other civil applications;
- Search & rescue missions;
- Remote sensing of crops using multispectral camera;
- Perimeter monitoring; and
- Border patrolling

Impact of the Technology: Deployment of UAVs for surveillance in different sectors like forest, boarder security and internal security will ease the burden of forces at worksite. Highway traffic monitoring, gas pipeline monitoring, crop estimation and aerial survey of crop health will improve the standard methods of laborious work and bring out the quality in the process. Surveillance of forests will help in assessing the gap areas for plantation, animals can be rescued from poachers. In Mining sector, the aerial images will help in estimating the extent of extraction.

Commercial Status: The developed system has been demonstrated to DRDO-CAIR, HAL-ARDC BEL, BEML and CSIR GIMFR for mining survey application and negotiations are underway for licensing the technology. The technology is available for licensing.

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Handheld Milk Quality Analyzer

India is the world's largest producer and consumer of milk and contributes to about 18% of the world's total milk produce. Milk is a highly nutritious food - a great source of vitamins and nutrients and therefore a key ingredient in everyday's diet. Adulteration of milk reduces the quality of milk and can even make it hazardous. Milk Adulteration is prevalent due to various reasons – Adulterants are added to increase the thickness and viscosity of the milk to gain bigger profits and adulterants are added to increase to keep the milk from going sour and thereby increasing the shelf life. A survey in 2011 by Food Safety and Standards Authority of India (FSSAI) reveals that 68% of the milk samples collected across the country did not conform to standards by being adulterated with various adulterants. Milk adulteration is a very serious problem our society is facing today.

CSIR-CEERI, Pilani has developed a hand-held, battery operated and affordable milk quality analyzer for domestic usage which has the capability of detection of adulteration as well as measurement of fat content of milk using two different modules. Handheld milk quality analyzer comprises of two units viz. (1) the Ksheer Tester which is used for the detection of adulterants; and (2) the Handheld Milk Fat Tester which measures the percentage of milk fat content.

Important Parameters Unique to the Development:

- The system involves green technology-based adulteration detection for detecting not less than eight adulterants (No chemicals used) viz.: Urea, Salt, Detergent, Liquid Soap, Caustic Soda, Boric Acid, Hydrogen peroxide, Ammonium sulphate, Water and Sodium bicarbonate;
- The system not only detects various adulterants but also measures the fat content of milk;

- The system uses reusable electrode which results in long life;
- The system provides the result within 1-2-minute time;
- The detection for the presence of any specified adulterants is done in one go;
- The system is affordable; and
- The system will be handheld type with a single button operation.

Major Application(s):

- In household usage, common man can check the quality of milk (adulteration if present) and decide price based on fat content of the milk;
- It can be used by Common man, Tea and Milk Vendors, Canteens and Community Kitchens, Sweet shops; and
- By using this system, which incorporates the fat content measurement and adulteration detection in milk, Milk vendors who collect milk from farmers can have the opportunity to decide the price based on fat content. This enables value addition to both farmer and milk vendors through fair means of price fixation to increase the return above the base price of the raw milk.

Impact of the Technology:

- The adoption and deployment of the system in households and domestic places would be a step forward in increasing the standards and quality of the milk, thereby increasing the standards of life. As synthetic adulteration in milk has become a major health hazard for all sections of society - including children and elderly, the system will serve the cause of public health by mitigating these hazards. The impact on public health is therefore likely to be very significant. Also, the system will spawn indigenous manufacture, marketing and deployment of systems thereby generating gainful employment and revenues;
- The indigenous development of the system would be a giant step forward in being able to develop systems for our requirements - right from sensor to complete system – thereby strengthening the indigenous development in the nation; and
- The existing method for testing of adulteration in milk is by means of chemical tests which make use of dangerous chemicals which are harmful to the environment. The system has been successfully used for detection of adulterants without making use of any chemicals.

Commercialization Status: The technology of both the systems has been transferred to M/s Rajasthan Electronics and Instrument Limited (REIL), Jaipur and also available for licensing to other interested industries.

Contact: The Director, CSIR-Central Electronics Engineering Research Institute, Pilani - 333031; Tel.- 01596-242111; E-mail: director@ceeri.res.in

MEMS Based Accelerometer

Accelerometer is a device used for measuring linear acceleration of a moving object or body. With the advancement of the technology sensors and systems are becoming smaller and smaller. Development of MEMS-technology based accelerometer is an effort to make micro-accelerometer and readout IC to make smart system. MEMS-based accelerometer has small size, light weight and consumes low power. The current scenario of Indian market is devoid of any key player in this MEMS technology domain. Most of the sensors, especially high grade high performance required for the strategic sector are manufactured by the foreign companies. The present development exhibits specifications that are competitive to the current global market and are highly desirable for the strategic sector. The development of such product has potential to substitute foreign product, and will also save the foreign exchange.

CSIR-CEERI, Pilani has developed a technology for the bulk micromachined piezoresistive accelerometer. Polysilicon piezoresistive accelerometers for ±15g and ±4g have been fabricated. For micromachining a hybrid approach of wet and dry techniques have been adopted.

Important Parameters Unique to the Development:

- Technology development for the high-grade and high performance MEMS accelerometer for the strategic sector applications;
- The technology has potential for post process bulk micromachining to realize CMOS-MEMS;
- Interface electronics for the developed sensors; and
- The developed piezoresistive accelerometer has low leakage current because it is junction less.

Major Application(s): The developed technology for the MEMS Accelerometer has wide varieties of applications, which includes space, aerospace, military, automobile, industrial and consumer electronics. Present development targets strategic sector applications.

Impact of the Technology: Apart from the aforesaid conventional applications, accelerometer has non-conventional applications also, like fall detection of elderly people and capturing the bio-physical signatures for the living beings. In this way, it has potential for improvement of life using such new developments.

Sensor Fabrication and Characterization: Fabricated sensors using bulk micromachining process are shown in Figure 1. Accelerometer module consisting of accelerometer and readout electronics is shown in Figure 2.

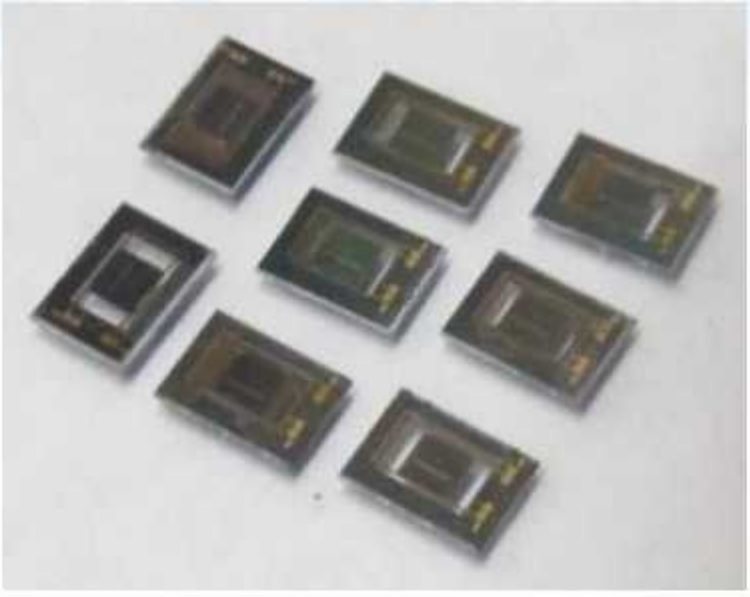

Figure 1 - Accelerometer Sensors

Figure 2 - Accelerometer Module

Commercialization Status: The technology validation and pilot level fabrication are being planned jointly with ISRO-SCL, Mohali. The technology is not available for civilian sector.

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Prevention of Adulteration in Milk- A Real-Time Remote Milk Supply Chain Monitoring Network (PRADUMN)

India is the world's largest producer and consumer of milk. In general, the milk chain flow in India is from milk producer to milk collection agent. The milk collected is then transported to a milk chilling center and bulk transported to the processing plant, then to the sales agent and finally to the consumer. A recent survey from Food Safety and Standards Authority of India (FSSAI) reveal that most of the milk samples collected across the country did not conform to standards by being adulterated with different adulterants like urea, detergent, salt, formalin, starch, glucose, ammonium sulpahte, hydrogen peroxide, caustic soda etc which are spurious in nature. Milk Adulteration is prevalent due to various reasons viz. (a) Adulterants like salt, urea, detergents and glucose are added to increase the thickness and viscosity of the milk to gain bigger profits (b) Adulterants like ammonium sulphate, hydrogen peroxide, sodium bicarbonate and boric acid are added to keep the milk from going sour and thereby increasing the shelf life. Consumption of adulterated milk poses hazardous health effects.

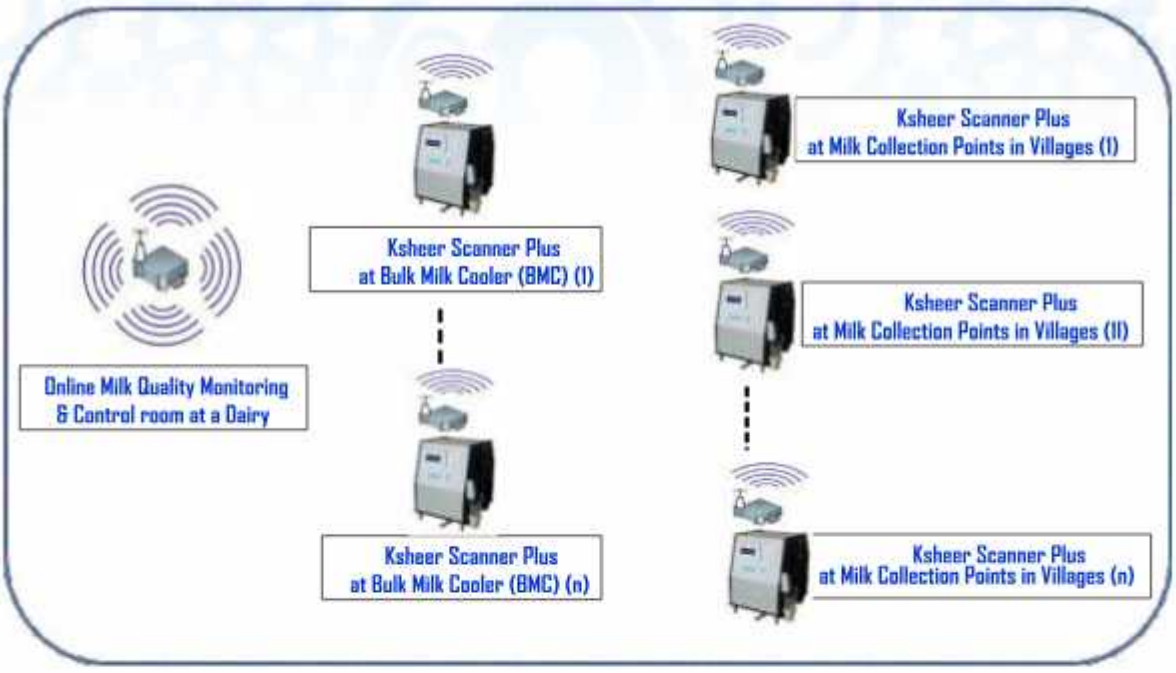
CSIR-CEERI, Pilani has developed a real-time remote milk supply chain monitoring network called 'PRADUMN' which comprises of an integrated milk quality monitoring system for real-time remote monitoring of milk supply chain starting from village level to dairy. Integrated milk quality monitoring system comprises of Ksheer Scanner Plus which provides milk adulteration check and measurement of milk quality parameters (fat, solid-non-fat, protein, lactose and percentage of added water) embedded with a wireless communicating device.

Important Parameters Unique to the Development:

- The system can monitor the entire milk supply chain in dairies;
- The system can detect adulterated milk samples, their compositions as well as real-time monitoring over wireless network; and
- The system is a quick, efficient, and affordable solution to the problem of prevention of adulterated milk samples getting mixed in the milk supply chain.

Major Application(s):

- By using this system at various stages of the milk supply chain, it can be ensured that the milk that we consume is free of adulteration and good quality;
- It can also be used by agencies (food inspectors) to monitor the supply chain of interest from a single point; and
- Various dairies can set up this system in their supply chains to ensure collection of high-quality milk free from adulteration.



Impact of the Technology:

- As adulteration in milk has become a major health hazard for all sections of society including children and elderly, the system will serve the cause of public health by mitigating these hazards. The impact on public health is therefore likely to be very significant. Also, the system will spawn indigenous manufacture, marketing and deployment of systems thereby generating gainful employment and revenues;
- The adoption and deployment of the system in milk supply chain through various dairies would be a step forward in increasing the standards and quality of the milk, thereby increasing the standards of life. Besides it can help in generating employment and income. The system excels in its ability to detect known and unknown adulterants in milk and its monitoring in real-time;
- The indigenous development of the system would be a giant step forward in being able to develop systems for our requirements - right from sensor to complete system – thereby strengthening the indigenous development in the nation; and
- The existing method for testing of adulteration in milk is by means of chemical tests which make use of dangerous chemicals which are harmful to the environment. The system has been successfully used for detection of adulterants without making use of any chemicals.

Commercialization Status: The technology of milk analyzer has been transferred to M/s Rajasthan Electronics & Instrument Limited (REIL), Jaipur on non-exclusive basis. The technology is available for licensing.

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AutoCEPH Software for 2-D Computerized Cephalometric Analysis as a Web Service

Cephalometric Analysis has been used since long in Orthodontic Diagnostics and treatment planning. While, standalone desktop applications are many, they come at exorbitant costs and need to be purchased as a single or multi-user single site licenses. The intended objective would bring the application in an online mode with secure and safe mode of performing the analysis over the web with an ease of accessibility from any location. This would help bring down cost of healthcare along with raising the confidence of both public and private practitioners as they usually have been relying on clinical experience for the reason of non-affordability of existing software.

CSIR-CSIO, Chandigarh in collaboration with CDER, AIIMS, New Delhi has developed an "AutoCEPH" Software as a web-based service where in the end-user needs to have a small app downloaded on their computer with all the hardware, services and server been remotely managed at the lab's end.

AutoCEPH GUI

Important Parameters Unique to the Development:

- Simple, innovative and cost effective technology;
- Easy and comprehensive to use;
- Available with analysis developed as per end user use;
- Validated through three thesis work; and
- Access patient database and analysis anywhere globally.

Major Application(s): Cephalometric analysis is currently utilized by many Orthodontic Surgeons for treatment planning of their patients.

Impact of the Technology: Current solutions available from international market are expensive and thus prohibit usage at primary and secondary level healthcare establishments. Web services utilizing the current penetration of network services globally provide an easy to use platform for patient diagnosis and treatment planning. Only a few such products are currently available in the global market, with none of them been available from the country and hence an indigenous solution for better healthcare delivery has been developed. Currently over 250 plus licenses of competitive products are been utilized in the country. These products costs lakhs in procurement costs and further considerable amount as license maintenance fees. With public availability of AutoCEPH, more than 460 users are currently registered across the globe with more than 1700 patients and 2500 cephalograms analysed. This reflects the value addition it brings to table of orthodontic clinic.

Commercialization Status: The technology is available for licensing.

Contact: The Director, CSIR-Central Scientific Instruments Organisation, Sector 30-C, Chandigarh - 160030; Tel.- 0172-2657190; E-mail: director@csio.res.in

Divya Nayan: A Personal Reading Machine for Visually Impaired

According to a recent survey around 19 million children are visually impaired. 47% visually impaired are illiterate and about 30% of world's blind population is from India. Braille books are only solution available for them but not only these books are limited but also 90% of the visually impaired are Braille illiterate. Also, there is no solution available for Indian regional languages.

CSIR-CSIO, Chandigarh has developed "Divya Nayan" - A personal reading machine for visually impaired or illiterate person where any printed or digital document can be accessed in the form of speech output. The technology may influence the society wherein blind community can access all kind of print and electronic media commonly used by the sighted people. Available imported technologies are very expensive, desktop and are available for English language. User manually scans the document by placing the machine on printed document without knowing the direction of text flow, over the document to be read. It uses optical character recognition technique to convert the image into text and a text to speech converter, further converts the text into audio. The audio files are organized in the machine and can be listened back. The device is standalone, portable, completely wireless and IoT enabled. The device can analyze a multicolumn document to provide seamless reading and is capable of page, text, and word level navigation while reading. It currently supports reading Hindi, English and Bengali, but can be further configured to other Indian and foreign languages. It is equipped with user interfaces such as internal speaker, rechargeable battery, USB, headphones, SD card, Wi-Fi and Bluetooth to control the machine. Further the device is augmented with support for cloud based document processing, storage and sharing.

Divya Nayan: A personal reading machine for visually impaired

Important Parameters Unique to the Development:

- Stand-alone, portable, completely wireless and IoT enabled;
- Currently supports Hindi, English, Bengali documents;
- Configurable for other Indian and foreign languages;
- Multifunctional (Read printed text, e-books, e-news);
- Document storage and updates via cloud; and
- Online Hindi and English news reading.

Major Application(s):

- Accessing printed and digital information over audio; and
- To provide inclusive and independent access to knowledge.

Impact of the Technology: The technology may influence the society wherein blind community can access all kind of printed and electronic media commonly used by the sighted people. This may further help in knowledge building which may lead to employment generation.

Commercialization Status: A 100 pieces limited pilot production and test marketing is under progress in association with M/s Central Electronics Limited (CEL), Ghaziabad. Further, negotiation are undaining with CEL for licensing of technology . Technology is available for further licensing.

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Postural Stability Assessment System

Postural stability is achieved by maintaining an upright body alignment against gravitational force and preserving the equilibrium of the Centre of Mass (CoM) in an individual's base of support. Successful postural control requires the contribution from a complex sensory system comprising visual, somatosensory, and vestibular modalities as well as motor control systems. Ground reaction forces are amongst the prominent parameters used for Gait assessment. It gives an approximation of the projection of body's CoM on the ground. This manual describes wearable sensor module development for estimation of center of foot pressure estimation. Gait events like balance stability and lateral fall is detected. Compact module packaging makes it comfortable in wearing and does not interfere in natural movements. Real time ground reaction forces from all the sensors and center of foot pressure has also determined.

CSIR-CSIO has developed the affordable Postural Stability Assessment System for balance assessment relearning with the help of Biofeedback based therapy tools.

Important Parameters Unique to the Development:

- Development of Static Postural Stability Measurement System; and
- Biofeedback based balance training therapy Modules.

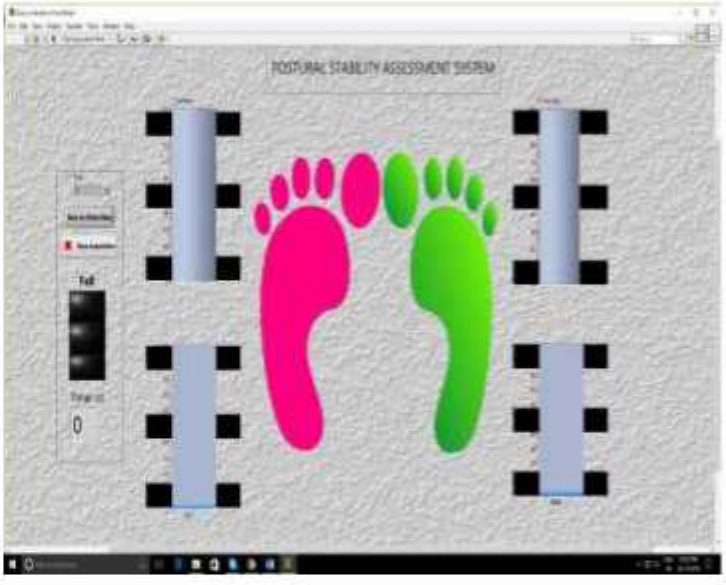
Major Application(s): The developed foot pressure sensor used for assessing balance stability of individuals Postural Assessment System is safe to use as a training tool for sit-to-stand, stand-to-sit, joint movements for stance and gait analysis. It will bring significant improvement in postural sway.

Impact of the Technology: Stiffness, swiftness and damping are the gait variable parameters that are used to quantify and control the postural stability. The system helps in assessment of postural stability of elderly and physically disabled. Measurement of postural balance and stability leads to fall assessment and assessment and therapy of neuro disorders. There are two major companies i.e. Tetrax, Israel and Biodex, USA developing this system at a cost of ₹7 - 8 lakh. The expected cost of similar system in the project is ₹2 - 3 lakh which will be of immense benefit to elderly and physically disabled.

Status of Development: Generating patient balance database for disorder like hemiplegia, stroke. This will help us to develop a customize computer assisted balance diagnosis system.

The present system is useful in two stages:

- Assessment; and
- Therapy



Postural Stability Assessment System and Biofeedback Module

Commercialization Status: The technology is licensed to following three Indian companies on non-exclusive basis:

1. M/s Medicaid System Chandigarh;
2. M/s Oceanic Fitness Mohali; and
3. M/s Bio-med Inc, New Delhi

The developed technology is further available for licensing.

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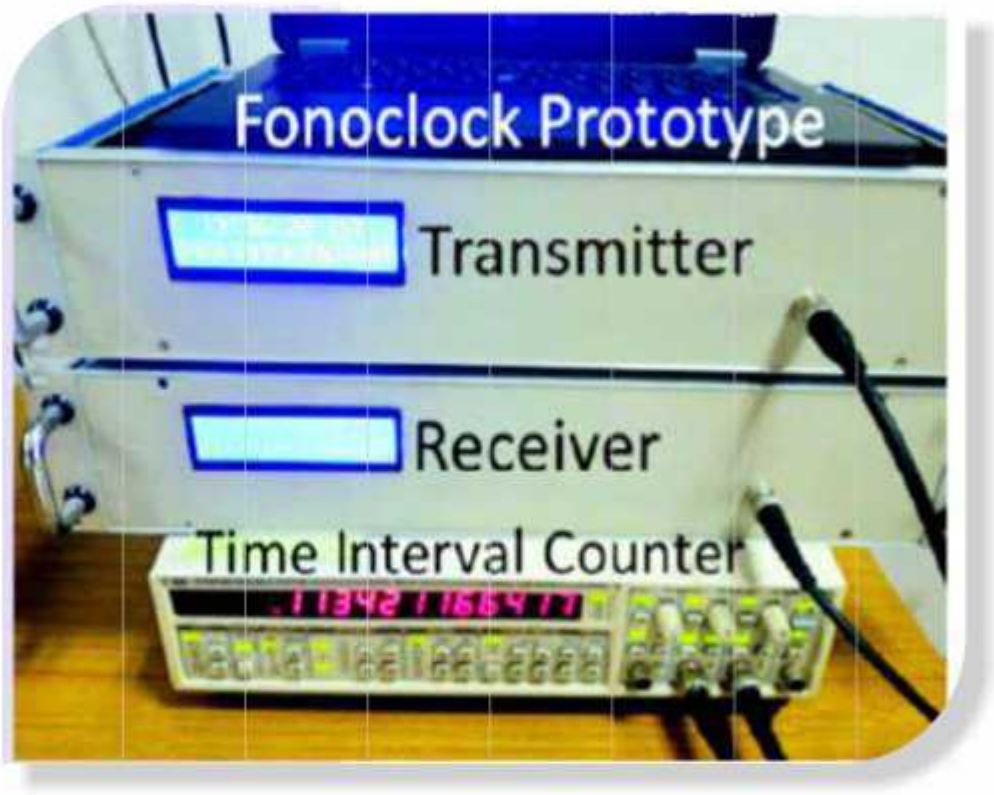
'Fonoclock' with a Time Synchronization Accuracy of ±10 ms

CSIR-NPL, New Delhi maintains Indian Standard Time (IST) by an act of Parliament. The time maintained is disseminated to the users via telephone with a service known as Teleclock (accuracy is 1s). The developed device gives better time synchronization accuracy (±10 ms) with a new and upgraded hardware and software along with communication delay compensation and the service is known as 'Fonoclock'. It is envisaged establishing a robust telephone time dissemination service with accuracy at par with international standards. Another aim is to transfer the know-how to industry for compact and affordable receivers for accessing IST using commonly available telephone line.



Important Parameters Unique to the Development:

- It is a national time service with much better synchronization accuracy than existing technique. All users of present technique will move to this better technique;
- Complete Time-of-Year information is transmitted; and
- Due to better accuracy, it will also appeal to Defense, ISRO etc. and due to 1 pps output, it will appeal to measurement laboratories.

Major Application(s): All users who need time synchronization to IST with millisecond accuracy especially: defense, telecommunication, banking and educational sectors.

Impact of the Technology: In recent years, the instances of cybercrime have increased worldwide and especially in India. Time synchronization to a common reference is necessary to avoid confusion and will help in network forensics. The need for time synchronization is increasing in each sector. As CSIR-NPL maintains time for country known as Indian Standard Time (IST), it is dedicated to disseminate the IST to everyone by all possible means. Defense, telecommunication, banking and even measurement laboratories need time synchronization in millisecond regime. One of easiest and secure (hack proof) way to access time is through commonly available telephone line connection. CSIR-NPL has a telephone time service known as Teleclock, but this is highly inaccurate and has become obsolete. The aim is to provide better service with millisecond accuracy and compact and affordable commercially available receivers to access this service. This service is known as Fonoclock. Due to millisecond accuracy, it will appeal to defense sectors that are afraid to use NTP service which exposes their network to hacking. Even banking and telecommunication sector will benefit with new improved telephone time service. Once IST becomes legal time of the country, this technology will become the most appropriate means to synchronize to IST. Even a common man sitting in a rural village will be able to access IST using is telephone line connection which is really available. It is better than GPS based timing receivers as well which are prone to jamming and they do not work in the basements and inside the building with no clear view for receiving the satellite signals. Telephone lines are available all over India and one of the easiest means to get time even in rural areas. All developed nations, e.g. USA, UK, Germany and Japan still offer telephone time dissemination services and this will hold relevance at least for next one decade.

Commercialization Status: Negotiation meeting was held with M/s Avronica Solutions Pvt. Ltd., Patna. The company submitted a consent letter for buying the know-how. The know-how transfer to the company is expected in few months. The technology is available on non-exclusive basis to other companies also.

Contact: The Director, CSIR-National Physical Laboratory, Dr. K.S. Krishnan Road, New Delhi; Tel.- 011-45609201; E-mail: director@nplindia.org

Low-cost Peltier based Refrigerators for Rural Regions

The use of CFC based compressors in the usual refrigerators is alarmingly raising the concern of the environment worldwide. The whole world is approaching the green energy and clean energy without any carbon footprint and emission-free technology. In this direction, CSIR-National Physical Laboratory (CSIR-NPL), New Delhi has successfully developed a technology related to solid-state Peltier-based low-cost refrigerator, which is maintenance-free with a long life, portable, environmentally-friendly, requires very less electrical power and hence can be operated by a small battery or solar power as well, thus, a perfect example of green cooling.

Peltier coolers are the solid-state devices, which operate with Direct Current (DC). On applying a DC voltage, one of the sides becomes cold, and the other side becomes hot. Utilizing the cool side of the Peltier coolers can be useful for various cooling applications. One of the primary applications is in the refrigeration, where various aspects like heat rejection, aerodynamics, and cooling controls are used for making an active cooling device. The thermoelectric refrigerator so developed has wide cooling applications. The device can be used for not only domestic and household uses but can also be a vital utilization in medical sectors.

This technology has been selected as top 100 technologies as GHG reduction technologies worldwide. The technology has also been selected as top 24 innovative technologies by CNBC-DS Group and also by Social Alpha (A Tata Trusts group) as top 11 energy-saving technologies of India.

Government of India has also launched major programmes across the nation towards the self-sustained green energy and clean energy. The development and dependence on the solid-state devices which can run on solar power and utilize minimal or no refrigerants and can be a right approach in combating the harmful effects of refrigerant gases. This technology is completely a DC based and does not wholly depend on the grid power, so an advantage of running by a small DC battery or solar panels can make it a step towards a clean and green energy initiative.

Important Parameters Unique to the Development:

- Low-cost, solid-state, clean and green cooling technology;
- Environment-friendly and no CFC emission;
- Effective temperature: ~30°C lower than the ambient temperature in a ~30L volume;
- Works on DC so it can be easily integrated with solar panels and battery; and
- Can be converted to a portable system to carry vaccines and medicines over long distances on a small power backup.

Ncool: 10°C to 12°C

Nchill Improved & Robust Design: 5°C to 10°C

Portable Medicine box: -10°C to 10°C

Application(s):

- Providing comforts of a refrigerator to a common man - for food storage and cold water with no dependence on mains electrical power;
- District / Village level hospitals for storage of blood, life-saving drugs and medicines requiring mandatory low-temperature storage;
- Pharma industry / Chemists for storing life-saving drugs and vaccines; and
- Compliment India's immunization program for cool storage of vaccines for transporting them to long distances in remote villages, especially during summers.

Impact of the Technology: During peak summertime, many parts of India do not have access to cool drinking water due to interrupted power supplies and also due to non-affordability. Also, the peak summer season is followed by the monsoon, and during peak summertime, the average temperature raises beyond the prescribed storage temperature of many medicines and vaccines. This leads to the lowering of the efficacies of the many medicines and sometimes they get destroyed unknowingly so may not work with their full potential after the summer season. So this green cooling technology can be a boon to medical sectors for storage of essential medicines and vaccines during summertime.

Market Prospects: The penetration of refrigerators in Indian rural, remote areas and developing countries is highly required. Development of low-cost, energy-efficient and maintenance-free refrigerators customized for rural and off-grid markets can contribute to the increased purchase of refrigerators for households at even lower income levels.

Commercialization Status: The technology is non-exclusively licensed to M/s Joy Trading Company for its first version while the second version is being transferred to M/s REIL Jaipur. Further, the technology is available for licensing.

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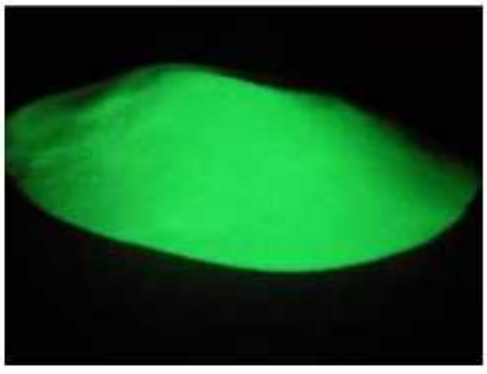
Technology for making Green Emitting Long Afterglow Phosphor Powder and Paint for Emergency Signages

Luminescence is a two-step process and involves excitation of electronic system and emission of photons from the phosphor. The material that shows the phenomenon of luminescence is called a 'Luminescent Material' or simply 'Phosphor'.



The technology offers a simple and novel process of production of a non-toxic, non-radioactive, green emitting photo-luminescent powder that can be coated onto almost any object which causes it to continuously glow in the dark. It can be mixed with glue, paint, resin, candle wax, concrete, varnish, glass etc. For the best glow, it can be used in a clear medium on a white background. The Long Afterglow Phosphor (LAP) absorbs visible or ultraviolet (UV) lights for less than 10 minutes in the daylight and glows in the dark by emitting green-yellow light for almost 10-12 hours. Phosphors are thus able to convert absorbed (visible/invisible) energies in the form of moving particles or quanta of radiation into visible light. These phosphors find wide-range of applications in defense, domestic, commercial as well as in scientific domains.

CSIR-NPL has developed technology for proper indication of emergency signages that does not require continuous source of energy.

Important Parameters Unique to the Development:

Long Afterglow Phosphor Powder (LAP) is a special kind of inorganic light emitting material that is non-radioactive in nature. The interesting feature of this material is that it absorbs ambient room light or sunlight for less than 10 minutes and gets charged up to emit visible radiations in the dark conditions for many hours to days. In other words, LAP is one of such special materials that could emit visible light for several hours even after all light sources are switched off. The laboratory tests have established that the Long Afterglow Phosphor Powder developed by the present technology is of International Standards and the technology has been protected by patents granted in India. Further, some International patents have also been filed. The LAP Powder Products will charge, glow, recharge and glow for years.

Major Application(s): The LAP phosphors have strategic applications that could be used for:

- Escape route signage and rescue guidance systems;
- Warning signs on highways;
- Warning signs in theaters;
- Warning signs and accident prevention measures;
- Dark vision display applications;
- Toys, sports equipment, enamels and ceramic tiles;
- Household Switches;
- Markings of important machinery; and
- Special effects in bars and discotheques.

The phosphorescent glow in the dark LAP powder may be applied as an additive to liquid mediums, printing inks, plastics of all types, glass, porcelain glazes, inks and other transparent media to achieve the self-luminescent affects. The LAP powder may be extruded or injection molded into most plastics and incorporated into most resins, coatings and clear mediums.

Impact of the Technology: The Long Afterglow Phosphor powder has every potentiality in the segments using conventional or other type of materials in the form of fluorescent powders, plastic tapes, paints etc. There is a wide scope of its application on the roads and highways for warning signs, accident prevention indicators, dark vision display and many other areas, which need to be explored.

Safety and escape route markings & codes for Defense establishments, Tall buildings and establishments (as per statutory fire safety enforcement), currency notes and electrical switches may be some of the major consumers for the product.

The vast development of national highways, roads and other infrastructures like hospitals, entertainment and amusement parks would certainly generate huge demand for Long Afterglow Phosphor Powder products.

Commercialization Status: The technology has non-exclusively been licensed to M/s Kataline Infra Products Pvt. Ltd., Plot No. 23, Nelco Housing Society, Subhash Nagar, Jaitala Road, Nagpur – 440 022 (Mah.) for making long after glow phosphor and paint for road safety sinage applications to prevent fatal accidents. The technology is available for licensing further in India and abroad.

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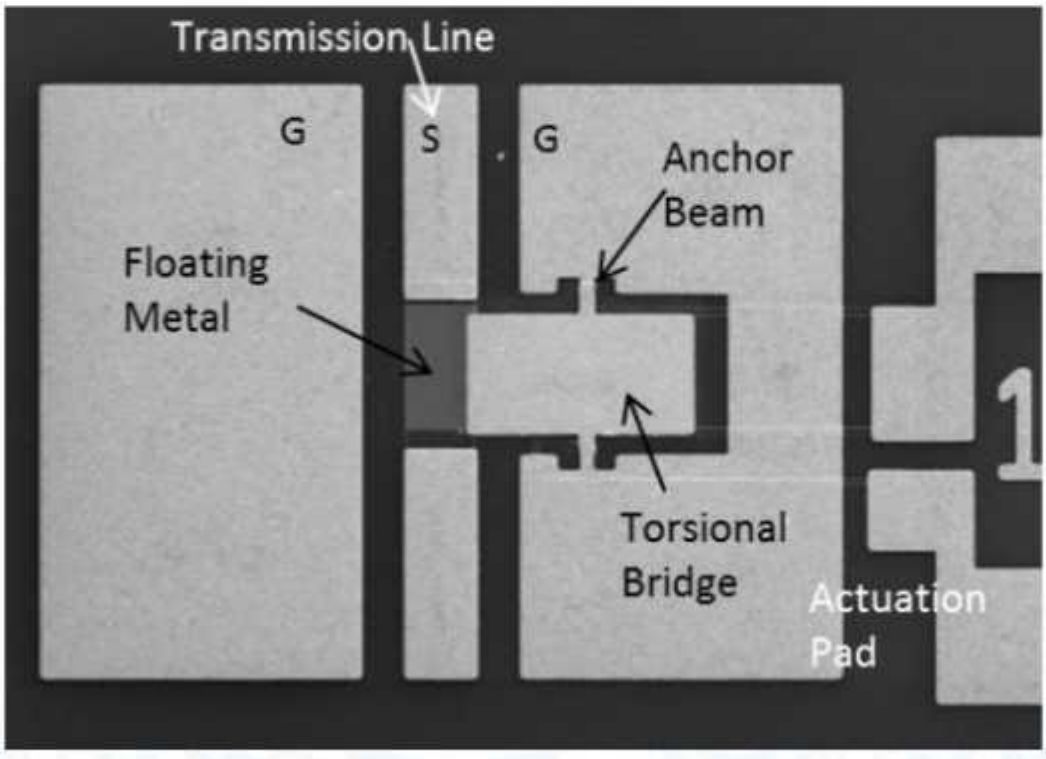
Technology for RF MEMS Capacitive Switches for Strategic Applications

Development and applications of MEMS technology in radio frequency regime, generally, referred as RF MEMS, are more recent. It includes MEMS devices viz: switches, tunable capacitors, high Q inductors, resonators and filters, which constitute the `Building Blocks' of radio frequency applications (such as; communication and control sub-systems for space-born systems, munition control and automotive systems). Switches are one of the most vigorously pursued MEMS devices by academic and industrial research communities. The outstanding advantages are: reduction in power consumption, volume and weight, superior RF characteristics and compatibility with existing integrated circuit technology and systems. In general, the outstanding performance of the RF MEMS is attributed to the physical gap, mostly air gap, between the `active' elements and `lossy' substrate, use of high conductivity metals and high integration compatibility with existing IC fabrication technologies.

CSIR-CEERI, Pilani has developed RF MEMS design and fabrication technology. Reliable packaged RF MEMS switches have been fabricated and tested at CSIR-CEERI and SAC-ISRO, Ahmadabad. It is expected to lead to compact ultra-lightweight systems / payloads used in satellites thus reducing the overall weight and size of the satellites with increased reliability and slashed launch cost. RF MEMS switches due to its low power consumption and software defined tunability, it has commercial potential also. MEMS market is expected to be more than US $ 20 Billion in 2020 with CAGR of 13%.



RF MEMS switch developed at CSIR-CEERI

Important Parameters Unique to the Development:

- Reliability of the switch is increased by reducing contact area;
- Indigenous set up is made for packaging of RF MEMS switches;
- In-house equipment for shear strength measurement has been developed;
- Power consumption of RF MEMS switch is practically zero;
- Isolation of the switch is greater than 20 dB;
- Size of switch is 2.5 mm X 2.5 mm; and
- Weight of the switch is less than 5 gm.

Major Application(s): Currently used mechanical switches for space / defense applications consume high power and are bulky in size. Compact light weight RF MEMS switch can be used for space communication and security applications. ISRO is interested in space communication system and DRDO is interested in radar security systems.

Impact of the Technology: The systems developed based on such devices are compact and lightweight, this eventually will lead to lower carbon foot print during fabrication and also when used in space and automotive systems. The ingenious development of RF MEMS switches is likely to change the architecture of conventional communication system for defense and space, improving the functionality, re-configurability and volume / weight of the system. Substantial foreign exchange saving is expected. Indigenous start-ups would boost the Indian technology and employment creation.

Commercialization Status: The technology is ready for commercialization. As its major applications are limited to strategic sector, especially ISRO, the lab is in discussion / talk with them. Further, the lab has also signed MoU with M/s SCL, Mohali for limited production to ISRO-SAC, Ahmedabad. Due to strategic nature of the technology, it is not available for licensing in civilian sector.

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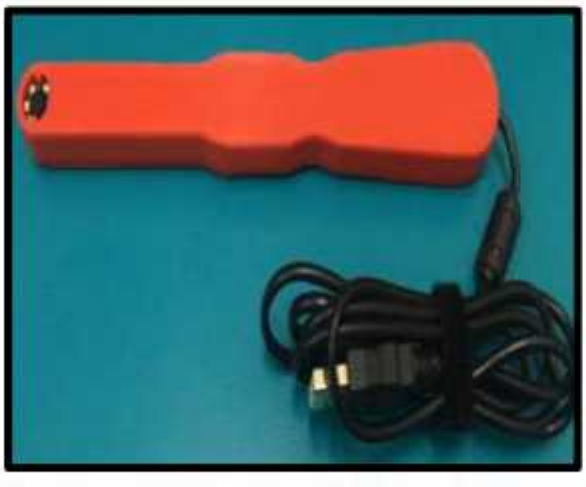
3D Rigid and Flexible Endoscopes for Dental Examination

Recent development in visualization technology has transformed the tools available to the surgeons in a remarkable way. Out of the many-sophisticated visualization techniques such as: Magnetic Resonant Imaging (MRI) and X-ray Computed tomography (CT scanning), Endoscopy enable the surgeon to visualize the internal damaged area of the human body and subsequently enabling him to identify the disease. Traditionally, 2D Endoscope was used to perform the surgery. However, it has severe drawbacks such as lack of depth perception and image distortion. We, Human beings are 3D creatures living in 3D world but our eyes can show us only two dimensions. The depth we can see is a trick of our brain; it puts together two 2D images in such a way to extrapolate depth leading to stereovision. The eyes are located at a small distance to each other. Therefore, they can present the slightly offset images captured by left & right eye to their brains. It creates a depth illusion of the scene. To have the similar depth of field and stereoscopic vision, 3D endoscope is developed.

CSIR-CEERI has developed 3D Endoscope Technology using single miniature camera. The 3D Endoscope Technology developed has 2 versions i.e. High Definition (HD) and Full HD (FHD) Endoscope.

Important Parameters Unique to the Development:

- Simple and cost-effective technology;
- Live display of 2D/3D output;
- Snapshot & Video storage in both 2D/3D format; and
- Zooming the selected area for detailed, magnified view.



Dental Scope HD Prototype

Dental Scope FHD Prototype

Major Application(s): 3D Endoscope can be used for dental examination. Zooming the selected area for detailed, magnified view of dental and soft tissue structures in the mouth, saving the 3D videos from the examination for future use, such as for follow-up exams or for consult with other Doctors.

Dental Examination

Impact of the Technology: A study revealed that over 50 per cent of Indians suffer from tooth decay problems and nearly 25% of them visit the dentist. Dental tourism forms 10 per cent of the total Indian medical tourism which is projected to grow at 30 per cent costing to ₹ 9500 crores by 2018. Existing 2D Endoscope helps the dentist to examine the dental damaged area of the patient but without depth perception. Developed 3D Endoscope using miniature cameras gives HD view of the damaged dental area from a very close distance. 3D Endoscope not only reduces the width of the endoscope, so as to make it easily inserted into the mouth, but the overall cost also becomes approximately equivalent to the normal 2D Endoscope. Translation of this technology paves way for creating start-ups leading to value and employment creation.

Commercialization Status: The technology is available for licensing.

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Silent Killer Gas Detector using LTCC Technology

Defense Forces at high altitude face multiple problems because of harsh weather conditions. Maintaining proper nutrients in the available food, cutting of frozen butter and frozen meat products etc. in extreme cold conditions for Army Jawans is very difficult.

To address this requirement, CSIR-CEERI and DRDO-DIHAR Scientists have developed micro-farming unit for growth of tiny plants and demonstrated battery operated thick film hotplate and integrated hot knife. These are rugged, reliable and can withstand cold and harsh weather conditions while maintaining requisite temperature in the range of 15 - 20°C for proper growth of tiny nutritious plants. Hotplate can serve many people / organizations for various heating applications. For societal applications, spreading of dangerous disease through mosquito bites can be avoided by developing heating machine for mosquito repellant which can easily carried to remote places. A portable mosquito repellant heating machine has been developed. It has societal as well as strategic applications. These are fabricated using thick-film process techniques in conjunction with Alumina or Low-Temperature-Cofired Ceramic (LTCC) technology. Commercial Off the Shelf (COTS) based silent killer gas detector has also been developed using this technology which is highly reliable. These developments have high strategic as well as societal impact. Detector will be useful for detection of toxic gas in bunkers, industries, garages, hot air blowers etc.

(i) LTIVA *[LTIVA: **LT**- LTCC with, **I**- Interconnects through, **V**- Vertical, **A**- Access based]* Hotplate with specifications as follows:

- Provides usable temperature up to 300°C;
- Power consumption is 450 mW at 150°C; and
- Miniature, stable interconnections & reliable

(ii) LTISK *[**LT**CC / Alumina **I**ntegrated **S**ilent-**K**iller-Gas]* Detector: YES/NO type detector module with following specifications:

- Detects CO and gives an alarm at 100ppm;
- Miniature, highly sensitive, stable & reliable; and
- Operates at 190-250 V AC, 50/60 Hz

Derivative Products of LTIVA Hotplate:

(i) Thick Film Integrated Micro-Farming Unit

- Operates at 12V DC;
- Hotplate temperature: 80-100°C and the temperature maintained at 15-20°C; and
- Highly stable and reliable Interconnections

Applications: Useful to grow tiny plants to provide nutrients to Indian Army Jawans living in extreme cold climatic conditions.

Growth of crops inside the Hotplate integrated micro-farming unit at DRDO- DIHAR, Leh

(ii) Thick Film Integrated Hot Knife

- Operates at 5V/220V; Power ~3W; and
- Temperature up to 70-80°C

Applications: Useful for slicing of frozen butter and other meat products even at high altitude and extreme cold climatic conditions.

(iii) Thick Film Integrated Heating Machine for Mosquito Repellant

- Operating Voltage: 220 V; and
- Temperature: 120°C and Power ~ 1W

Applications: Useful for avoiding dreadful diseases caused by mosquito bites.

First two micro-farming units were successfully demonstrated at DRDO-DIHAR, Leh, Ladkah and DRDO-DIHAR, Changla. Further field trials are done successfully at Leh, Ladakh & Changla at height of 17600 feet.

Important Parameters Unique to the Development

- The novelty is in the Interconnects through Vertical Access (IVA) for providing thermally and mechanically stable environment friendly Pb-free joints;
- Rugged and reliable due to high temperature stable LTCC;
- Novelty for Detector is in the use of high temperature stable LTCC / Alumina technology for enhanced stability, ruggedness and reliability; and
- Silent Killer gas detector using LTCC technology is unique as the product will not have trapped heat due to inherent property of making thermal vias in LTCC.

Major Application(s):

- Micro-farming in high altitude and cold deserts and Hot Knife (For high altitude cold weather conditions);
- Detection of silent killer gas in houses, offices etc.; and
- Heating Machine for Mosquito Repellant.

Impact of the Technology: Targeted deliverables and its derivative products may have huge impact on the society. These will be used for civilians living in extreme cold and harsh weather conditions.

Commercialization Status:

- DRDO-DIHAR, Leh has invested for customization of hotplates for warming of micro-farming unit at high altitude and cold deserts;
- Hot Knife was successfully demonstrated at DRDO-DIHAR (Leh);
- Technology "Thick Film Hotplate and Process Technology" is selected for incubation at CSIR-CEERI's Jaipur Centre under the aegis of M/s NRDC, New Delhi; and
- Technology is available for licensing.

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Technology for Antiglare Filter (AGF) for Automobiles

Many of the fatal road accidents occur at night, dusk and dawn because of the problem of poor visibility caused by blinding glare of the oncoming headlights, powerful road lights etc. The similar effect is seen with the glare caused by the sun reflections from road and other reflecting objects, and the scattering of light caused by sun light falling on transport windshield falling directly on driver's and codriver's eyes.

CSIR-CSIO has developed Anti-Glare Filter Device renamed as Day & Night Glare Reducing Device (D&NGRD) for automobiles which is mounted on the car's/transport vehicle's in place of sun-visor or on sun-visor in co-existence of the two to block the blinding glare caused by the sun-reflections and glare cause by the high beam light of the oncoming vehicles without compromising on forward and side vision look through the device.

CSIR-CSIO has developed the AGF technology which has huge potential in the automobile sector as manufacturers are now primarily focusing on passenger safety and comfortable driving experience for the customer. The technology will boost indigenous optical coating industry through commercialization of the filter for various vehicle platforms and spinoffs as well. Deployment modalities are being worked out in consultation with leading automobile industries and optical component manufacturers. The technology would also help the small and medium optical coating industries to take up fabrication of these filters for catering to the automobile segment. The anti-glare filter (AGF) ensures better driving experience and enhanced safety for users in the automobile segment.

Important Parameters Unique to the Development

- A filter with first-of-its-kind glare reducing technique;
- Reduces light intensity almost uniformly over the visible range over the areas before driver's eyes, where there is maximum glare;
- Maintains high transmission to see road signs and other passing vehicles;
- Will ensure passenger and public safety during night driving; and
- The technology upon successful commercialization would reduce the hazards of night driving and have the potential to capture automobile market with further improvements.

Major Application(s): Drop-in replacement for sun-visor for car, bus, truck, other surface transports for reducing glare.

AGF prototype developed for hatchback car and CTU bus

Test Results

Impact of the Technology: The developed AGF will improve public safety during night time driving of automobiles by minimizing the glare of the incoming vehicle.

Commercialization Status: The initial discussions have been held with M/s Tata Motors, M/s Abilities Piston Pvt. Ltd. and M/s KPIT, Pune on commercialization aspects and their feedback on the same have been taken into account and will be ready for transfer after certification by CIRT, Pune. The technology can be further customized for wearable anti-glare devices in the form of spectacles or on helmets for two-wheeler riders. The manufacturing of AGF would require large investments hence would require larger setups for mass manufacturing. Technology is available for licensing.

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Technology for Avionics Head Up Display Test Rig (AHTR)

Head-Up Display (HUD) is an essential aid to the pilot of aircraft, especially fighter aircraft. It is a transparent display that presents data without requiring the pilot to look away from his usual viewpoint. The information is projected on to the display surface which is usually referred to as the beam combiner, through a combination of special projection technology, optical assembly and display source. HUD displays flight information such as altitude, airspeed, angle of attack, navigation, weapon aiming and other flight information in collimated form so that the pilot is able to view the information looking forward, instead of looking down on other instruments mounted in the cockpit.

The technology of AHTR has been developed by CSIR-CSIO and has now been renamed as Military Head Up Display Test Platform incorporated as part of Aviation Cockpit Display Validation Platform – ACDVP. The Military Aviation Head Up Display Test Platform (MAHTP) is used to evaluate the electronic, optical and mechanical interface functionality of the cockpit displays and optronic systems which includes verification of performance and design parameters. This platform makes the process of automated testing & debugging less time consuming for ground staff and Maintenance Personnel using Intermediate Level (I-Level) & Operator Level (O Level) MAHTP at Defense Base Station, while system and subsystem level automated testing, fault rectification and maintenance is done using Depot Level MAHTP at manufacturing agency.

Important Parameters Unique to the Development:

- Cutting Edge Features
    - Accurate and repeatable parallax measurements within 6" for horizontal movement of 200 mm and 100 mm of vertical movement;
    - Positional accuracy measurements in single setup within 6" for entire design eye position of a simulated aircraft cockpit
    - Brightness measurements from 2 fL to 20000 fL for background varying from 0 fL to 12000 fL;
    - Measurement of ghost images and electrical and optical parameters.
    - Simulation of ambient brightness fluctuations;
    - Symbology writing speeds up to 25°/ms, 70°/ms & 190°/ms; and
    - Correction of geometric errors within the specified limits, etc.
- The challenging target of achieving harmonization accuracy of 1 mR for a target distance of 60 m has been achieved through the design of telescope optics, precision mechanical assembly along with fine motorized control and alignment of both axes within 6 secs;
- Simulation of head motion box achieved through precision x-y-z slide movement;
- Customizable to any aircraft platform; and
- State-of-art technology solution, first of its kind, provides "Optical harmonization, optical and electrical functionality testing in one single technology package".

Major Application(s):

- It provides complete end-to-end solution to perform testing, validation and error correction on Line Replacement Units (LRUs) such as Head Up Display & Multifunction Displays for error correction, testing, pre-flight clearance and post flight analytics and testing, validation, calibration and pre-installation checks on Gun Sights, Bore Sighting Tool for Laser Ranger & Marked Target Seeker (LRMTS), SPA Payloads, Bore Sight Harmonization Tool, Optical Sights and Holographic Optical Sights employed in aircraft, tanks, ships, helicopters & military surface vehicles;
- Scope of optical evaluation also include measurements of parallax error, binocular disparity, symbol positioning accuracy, linearity, field of view, photometric, line width and ghost images measurements, etc;
- Functional testing at LRU Level, module and sub-module levels as well as component Level;
- Pre-flight & installation checks; and
- Calibration of optronic equipment for target delivery at infinity.

AHTR (MAHTP) in Operation

Impact of the Technology:

Economic

- The technology, if imported, costs more than ₹ 6.5 crores/system while the expected cost of this technology will be ₹ 3.9 crores/system; and
- As BEL is expected to get order of about 120 nos. of HUD units for LCA, it will be required to manufacture and produce MAHTP to cater to the requirement of Intermediate, Overhaul and Depot level of maintenance as well as to meet operational requirements of Air Force. The indigenous manufacturing would boost the MSME sector in key strategic area and lead to growth of smaller industries around Chandigarh, Punjab, Haryana and Himachal Pradesh for manufacturing jobs.

Strategic

- The MAHTP would be tremendous value addition to opto-avionic systems of aircrafts, improving self-reliance of IAF and other defense establishments in case of technology denial to key defense sectors;
- Development of MAHTP is an effort towards providing end-to-end solutions to pre and post-flight test & evaluation requirements of cockpit displays. Such systems being developed by other international players offer limited capabilities in terms of optical performance valuation and symbology generation that too at almost double the cost. Indigenous MAHTP provides full scale functionality testing of optronic displays at LRU level, automated and semi-automated module level and component level. It is capable of snag diagnostic even at the individual component level of the LRU;
- These technologies are not available in open source;
- Market Potential: 12 numbers required at squadrons, BEL, HAL & ADA; and
- With this facility, Gun Sights, Bore Sighting Tool for Laser Ranger & Marked Target Seeker (LRMTS) & SPA Payloads can also be tested.

Industry

BEL Panchkula has been identified as the production partner as BEL has already received an order of 37 of HUD units for LCA and also received EOI to supply two full units of AHTR (MAHTP). Since, the work on LCA squadron 'Flying Daggers' is now in advanced stages after the 'Final Operation Clearance (FOC)' received for LCA, number of HUDs and AHTR will be required by HAL to supply Indian Air Force, this would boost the indigenous manufacturing sector in key strategic area. It would also lead to growth of smaller industries around Chandigarh for manufacturing jobs such panel, PCB & cable assemblies, PCB manufacturing, mechanical and optical components manufacturing, etc.

Commercialization Status: Technology transferred to M/s BEL with a ToT fee of ₹ 2.0 crore and GST plus 3.5% royalty.

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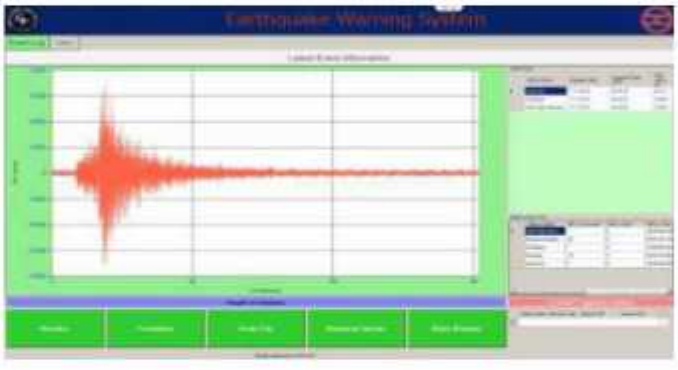
Earthquake Warning System

Earthquake Warning System is a technological intervention to avert colossal loss of human life and infrastructure as earthquake forecasting is not yet possible. An earthquake warning system is the solution provided herein to activate the appropriate actions for safety, during impending earthquake.

Developed Earthquake Warning System (EqWS) is network of a number of Seismic Sensing Nodes (SSNs) consisting of seismic sensors, communication, processors. It is devised for regional notification of a substantial earthquake while it is in progress. SSNs communicate to the master server - EqWS Graphical User Interface for Central Control Unit (CCU) for generating alert signals.

The technology is proven for one Delhi Metro Rail and is ready for deployment to other metro rails, nuclear plants etc. with site specific customizations as per user's requirements.

Seismic Sensing Node



Central Control Unit

Important Parameters Unique to the Development:

- **EqWS-Seismic Sensing Node (SSNs)**

  SSNs is equipped with accelerometer sensor, GPS, Processor, and IoT (Internet of Things) communication modules. SSNs are capable of sensing and distinguishing the cultural noise from actual seismic event.

- **Graphical User Interface (EqWS-GUI)**

  EqWS-GUI is the main user interface which provides information regarding latest event details, event log of all seismic activities and health status of all connected seismic sensing nodes.

- **Health of Station**

  Several operational parameters of all the SSNs connected to this network are displayed at EqWS-GUI to depict the health of the SSNs.

- **Current Triggered Station**

  It displays details of all current triggered stations. A true event is declared on the basis of programming parameters and the Latest Event Information section is updated.

- **Event Information**

  It displays the latest true seismic event which is sensed by more SSNs along with the Peak Ground Acceleration (PGA) sensed by the triggered SSN along with earthquake signature from the first triggered stations.

- **Report**

  A report is generated for all the true events and the following programmable three levels have been defined for severity-based warning.

PGA Value (g)	Intensity of Seismic Activity	Colour Indication
PGA <= 0.039	Not Felt/Weak	Cyan
0.039 < PGA <= 0.18	Moderate	Amber
PGA > 0.18	Strong	Red

Major Application(s): EqWS developed may be utilized to safeguard vital installations such as – Refineries, Nuclear establishments, Power Plants, Metro & High-Speed Railway, Airports, Hospitals etc. by stopping / initiating the emergency facilities as per requirement.

Impact of the Technology: India like all other developing countries, has established lot of infrastructure which needs protection against damage due to imminent ground shaking during and after an earthquake of large magnitude. To avoid colossal damages in earthquake occurring situations, preventive actions must take place before the seismic waves travel down to shake the sites of vital installations. This can be achieved by utilizing the alert signal generated by EqWS. For immediate safeguards against seismic hazards, the preventive actions are to be taken immediately in the areas which are vital and are likely to be affected.

Commercialization Status: The technology is deployed and operational at Delhi Metro. Major earthquakes felt in the region of installation i.e. NCR have been reported by the EqWS. An Agreement has been signed with Delhi Metro for a period of three years. It is also available to other players in the field on non-exclusive basis.

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Touch based Finger Gesture Control for Intelligent Patient Vehicle

There are millions of paraplegic people worldwide who are suffering from motor disabilities, including weak upper limbs, due to which they are unable to drive motorized wheelchairs without the need of caregivers. Elderly / paraplegics having motor disability and the weak upper limbs cannot hold the joystick. Therefore, Joystick-based controls generally available with motorized wheelchairs are unsuitable for people with special needs i.e. weak upper limbs conditions.

Maneuvering of wheelchair through finger gestures on the touch screen device has been found to be comfortable solution for such persons with disability, who wants to maneuver their wheelchair independently. Presently, all types of alternate drive control modules and motion control drives are being imported. The imported model with similar specifications costs more than ₹ 2 lakhs.

Prototype of Finger Gesture control module with commercial motorized

Important Parameters Unique to the Development:

- Industry ready touch based finger gesture control interface enables PWDs with weak upper limbs, elderly and stroke patients to maneuver their mobility device independently by means of sliding fingers on graphical touch screen device comfortably with required safety, such as rear collision detection;
- The finger gesture drive control is fully functional and configurable as per the user needs as the operation is based upon simple touch only and no pressure is required. The touch screen requires simple touch to activate and drag as per the direction and speed requirements similar to virtual Joystick operation including turning, veering, and spinning around; and
- The indigenously developed affordable, innovative finger gesture module with alternative drive controller supports customization as per user needs.

Finger Gesture control module & alternate drive controller

Major Application(s): The indigenously developed affordable, innovative finger gesture based Alternative Drive Controller (ADC) is very useful for persons suffering from motor disability with weak upper limbs, elderly and stroke patients as it can create a custom driving platform without needing any hardware changes required in their current motorized wheelchair chassis. Joystick-based controls are generally available with motorized wheelchairs that are unsuitable for people with special needs i.e. weak upper limbs conditions. The developed finger gesture based technology enables Divyangjans with weak upper limbs to maneuver their mobility device independently.

Impact of the Technology: The technology is affordable and useful for weak upper limb persons with motor disability as no such technology is available in India. Moreover, the imported non-graphic touch pad based solutions costs 20 times with no scope for customisation / feature addition.

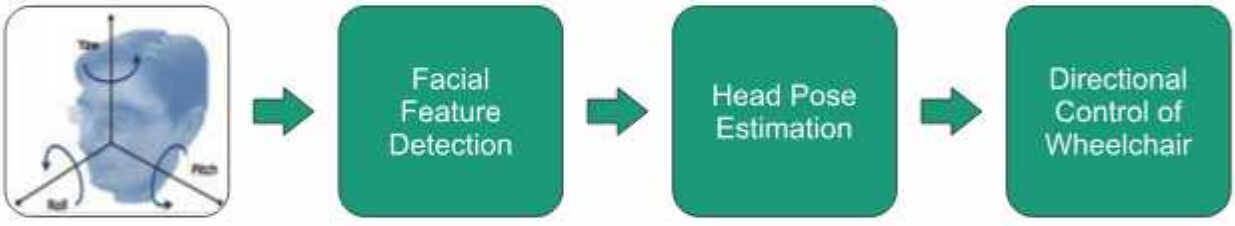
Commercialization Status: Technology has been transferred to M/s Pentagon Rugged Systems India Pvt. Ltd., Hyderabad on non-exclusive basis. It is available for further licensing.

Contact: The Director, CSIR-Central Scientific Instruments Organisation, Sector 30-C, Chandigarh - 160030; Tel.- 0172-2657190; E-mail: director@csio.res.in

Head Gesture based Control Module for Intelligent Patient Vehicle

Due to the absence of care-givers, currently available mobility solutions needs to be upgraded using alternative drive controls to help make independent mobility possible for Divyang Jans and elderly, suffering from full body disabilities, having all their four limbs non-functional or weak. Specifically, there is no alternate unobtrusive solution available yet that can empower the quadriplegics and persons with full body disability other than the obtrusive and uncomfortable modified mechanical Joystick controlled by chin.

In the developed system, the control signals for manoeuvring the wheelchair are generated by tracking head movements using machine vision. The head gesture based alternative drive controller works similar to Joystick controller and it consists of facial feature tracking based head pose proportional controller to manoeuvre motorized wheelchair in indoor environments. It helps to make independent mobility possible for quadriplegics / stroke patients with all their four limbs non-functional, where manual joystick is not an option.



Head gesture control interface

Important Parameters Unique to the Development:

- Prototype of head gesture based alternative drive control module is compatible with windows tablet and requires no proprietary cameras;
- It works well in indoor and illuminated environments and suitable for front hanging wheelchair adjustment;
- Head Gesture control module consist of software to acquire facial features in real-time, detection and tracking of head pose and face gestures to generate control signals fed to the alternate drive controller to manoeuvre motorised wheelchair. No such product is commercially available; and
- Indigenously developed affordable alternate drive controller has universal input capability and optional rear obstacle detection.

Major Application(s): The device is useful for quadriplegics having motor disability who want to manoeuvre their wheelchair using head gestures.

Societal Impact: The wheelchair manufacturing in India is expensive at the moment due to the fact that the motion controllers are currently not manufactured in India. Moreover, the imported versions come with stiff Joysticks only that may not be suitable for all kinds of people. The proposed technology is useful for persons with full body disability when Joystick based controls are not appropriate. Imported versions of chin based Joysticks are available in India at very premium prices but such systems are obtrusive and uncomfortable to user.

Status of Development / Commercialization: Software for facial features and head movement tracking using the camera is ready for indoor environments. The indigenously developed motion drive has been tested on commercial wheelchair chassis available in India. It includes rear obstacle detection, battery health monitoring and integrated heat sink. The technology is available for licensing.

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Technology for Head Up Display Mk1N-NP for Naval LCA

Head-Up Display (HUD) is an essential aid to the pilot of aircraft, especially fighter aircraft. It is a transparent display that presents data without requiring the pilot to look away from his usual viewpoint. The information is projected on to the display surface which is usually referred to as the beam combiner, through a combination of special projection technology, optical assembly and display source. HUD displays flight information such as altitude, airspeed, angle of attack, navigation, weapon aiming and other flight information in collimated form so that the pilot is able to view the information looking forward, instead of looking down on other instruments mounted in the cockpit. It can also be used to adequately overlay imagery that has a physical relation to the real environment, which makes the information easier to apprehend, such as the runway symbology under poor weather conditions. HUD interfaces electronically with Open Architecture Computer (OAC) of the aircraft and generates deflection signals i.e. symbology and characters. The HUD accepts these deflection signals and converts them into the optical image seen by the pilot.

Naval LCA gets only ~150 m length of airstrip to land and thus requirement of HUD with higher instantaneous field of view to see aircraft nose and ship deck clearly and thus also requiring arrestor landing shock resistance of 50 g. It has a requirement of wide Instantaneous Field of View (IFOV) - Elevation 22° (19° below +3° above FRL) and Azimuth 20°. It is compatible with Naval Aircraft Carrier requirements of radiated susceptibility standard up to 200V/m along with the several features such as contrast ratio ≥ 1.2, brightness non-uniformity: 1.5:1, and multimode operations: Stroke mode for day flights, stroke in raster in low visibility & night mode. It also has feature of real time communication with Mission Computer for Human Machine Interface and extensive online built in test.

Important Parameters Unique to the Development:

The HUD Mk1N-NP technology has few critical, novel and stringent specifications, specific to naval aircraft operation requiring stringent Field of View (FOV) and environmental screening requirements, such as:

- Higher nose drop of Navy Aircraft necessitates higher over the nose vision requirement through HUD to enable deck landing, electronically and optically compatible with LCA-Navy;
- Instantaneous field of view IFOV in elevation of: 22.5° (19.5° below + 3°above FRL) and in azimuth of 20°;
- Higher electric radiated susceptibility compatibility upto 200V/m, arrestor landing shocks, etc;
- Wider Instantaneous Field of View - Elevation of: 22.5° (19.5° below + 3° above FRL); Azimuth of 20°;
- Raster & stroke modes of display; Built in Test;
- Writing speeds: 25°/ms, 70°/ms, 190°/ms;

- Parallax error: 0°-6°: 1.3 mR; 6°-12.5°: 2.3 mR;
- Symbol positioning accuracies limits: 0°-5°: <1.5 mR; 5°-10°: <2.0 mR; 10°-12.5°: < 3.6 mR;
- Binocular disparity: 0°-6°: <1.0 mR; 6°-12.5: <1.7 mR;
- Normal stroke line luminance at a writing speed of 25°/ms: 2800 fL; Stroke in raster flyback line luminance at a writing speed of 190°/ms: 1400 fL; Peak raster luminance: 700 ft;
- Contrast ratio ≥ 1.2; Brightness non-uniformity: 1.5:1;
- Line width ≤ 1.0±0.5 mR; Linearity > 1.3% FSD; Jitter < 0.5 mR; and
- Bore sighting error < 1.0 mR.

Major Application(s):

- HUD for various Naval aircraft platforms such as Fighter Naval Aircrafts, Dornier and Boeing P-8 Aircrafts with state-of-the-art features and specifications; and
- The similar solution is being implemented in HUD MK2.

Head Up Display HUD Mk1N for Tejas Navy Aircraft

HUD MK1NP QT Unit completion of FQT testing as per MIL-STD 461E, 704F and 810E

Bore Sighting System customized for HUD Mk1-NP

Impact of the Technology:

- The HUD Mk1-Np technology has the potential to boost the indigenous defense equipment manufacturing sector and would further help in skill development in the areas of electronics, precision optics and opto-mechatronics. Its customization is quite expensive with difficulty in achieving the desired specification which CSIR-CSIO can meet due to its expertise in opto-avionics and superlative optics and opto-avionics facilities. Additionally, customization as per pilot's requirement from time to time is generally not feasible, if imported. The technology has improved performance specifications compared to available solutions and is economical in view of its technological parameters;
- The HUD as well as the associated Bore Sight Equipment development would invite fabrication related business to Indian industries especially MSMEs; and
- The technological intervention would help the nation in creating a niche in the areas of cockpit instrumentation and opto-avionics and would foster innovation and generate opportunities for industrial growth in strategic sector.

Commercialization Status: The technology has been demonstrated and discussed with senior officials from Naval Air Staff and Naval Officers from Naval Head Quarters and Naval base situated at Goa. As a result of this, CSIO has been approached by HAL Kanpur through Naval Hqrs for development of Low Profile Head Up Displays for Dornier and Boeing P-8 Aircrafts of Navy under aircraft upgradation programme undertaken by HAL-K and Indian Navy.

Contact: The Director, CSIR-Central Scientific Instruments Organisation, Sector 30-C, Chandigarh - 160030; Tel.- 0172-2657190; E-mail: director@csio.res.in

Technology for Head Up Display (HUD) for Intermediate Jet Trainer Aircraft

The HUD is prime flight display used by modern day aircraft pilots which presents flight information/data without requiring pilot to look away from his/her usual viewpoint. The information is projected at infinity using combination of special projection technology comprising optical assembly, folding mirror and display source. A pair of multilayer semi-reflective optical thin film coated glasses called as beam combiner combines outside view and the flight information such as altitude, airspeed, angle of attack, navigation, weapon aiming and other flight information. This combined information is available to the pilot in collimated form so that the pilot can view the information with his/her head "up" and looking forward, instead of looking down on other instruments mounted in the cockpit. It can also be used to adequately overlay imagery that has a physical relation to the real environment, which makes the information easier to apprehend, such as the runway symbology under poor weather conditions.

HUD H-Series for Hindustan Jet Trainer Aircraft (HJT-36) has been developed with several state-of-art features. The challenge of HUD design for HJT-36 Aircraft has been huge owing to the requirement of very compact size, low weight and requirement of thermal management without forced air cooling within the available HUD geometry. The unit has been tailored for HJT-36 Cockpit with high field of view of 25°, Instantaneous field of view of 20° in elevation and 18° in azimuth. The biggest achievement has been the low weight of HUD along with mounting tray which is 12.5 Kg. The thermal management without forced air cooling has been achieved due to its excellent mechanical modelled structure and very low power consumption. The feature of electronic standby has been built-in into the system to provide critical display to the pilot in case both the mission computers fail. SBS provides the necessary flight data to the pilot through standard graticule scale which is controlled through a knob provided on Data Entry Panel. User friendly data entry panel provides the pilot interface to the mission computer while automatic brightness control maintains the comfortable contrast level of the symbology to the pilot ensuring sun light readability and good contrast at lower ambient brightness levels.

Important Parameters Unique to the Development:

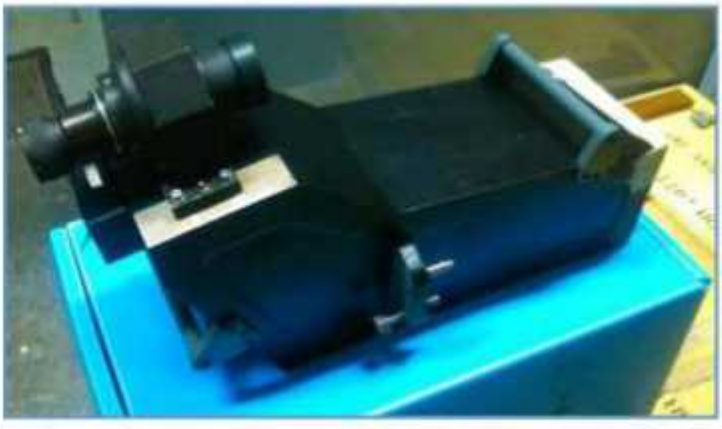
- It is customized end to end solution to IJTA requirements with globally competitive specifications;
- Previously HUD from GE UK was installed in IJT/AJT aircraft. It has now been replaced with CSIO HUD due to better brightness and image quality, better reliability and lower power consumption offered by CSIO-HUD; and
- Based on trans-disciplinary expertise demonstrated by CSIO in successful development of HUD technology for three platforms: HUD Mk1 for LCA-AF, HUD Mk1N for Tejas-Navy and HUD H-Series for IJT/AJT Aircrafts, the lab has now been entrusted with the responsibility of developing newer GEN5 versions of HUD for two aircraft platforms. In addition, CSIO is in process of getting projects of developing GEN5 Smart HUDs for two other aircrafts.

Major Application(s):

- HUD with customized specifications for aircraft variants for Air Force and Navy Platforms;
- HUD for helicopters;
- Helmet Mounted Display;
- Head Mounted Display; and
- HUD for Military Vehicles with IR capabilities

HUD H Series in IJTA Cockpit

Head Up Display H-Series & Bore Sighting Equipment



Bore sighting System with Digital Readout (BASDR)

HUD H-Series

Automated Test Equipment for HUD H-Series

Impact of the Technology:

- There are only four other countries namely Israel, UK, USA and China working on HUD technology;
- The technology would help in indigenizing one of the key avionics components for HJT-36 Aircraft. This would further help in saving huge amount of foreign exchange;
- The technology would boost the defense manufacturing sector in India and would be a vital step towards self-reliance in manufacturing cockpit instrumentation; and
- Being a strategic technology, the envisaged product would be a value addition to the indigenous trainer aircrafts and would improve the preparedness of Indian Air force and other defense establishments in case of any emergency resulting in technology denial to key defense sectors.

Commercialization Status:

- CSIR-CSIO demonstrated HUD H-Series developed for Intermediate Jet Trainer Aircraft on various occasions to the concerned Officers of Indian Air Force, Indian Navy and HAL as well as during International Aero Shows and other exhibitions and events; and
- Positive feedback of HUD H-Series developed for IJTA platform has resulted in fruitful turn-out in form of new opportunities namely
    - Design & development of Pilot Display Unit (PDU) for Hawk-I aircraft (project under progress with HAL- MCSRDC, Bangalore);
    - Techno-commercial proposal under active consideration by HAL, Nasik;
    - Indigenization proposal for design and production of ~100 nos. of principal optical component called Beam Combiners for British Hawk Aircrafts with HAL, Korwa under active consideration; MoU to be signed with HAL, Korwa in May 2019. This is a high cost item having stringent requirements not available from the OEM;
    - Indigenization proposal for design and production of ~150 nos. of Beam Combiners for Russian Sukhoi Aircrafts with HAL Korwa under active consideration. This is a high cost item having stringent requirements not available from the OEM;
    - Based on the performance of this HUD unit, CSIR-CSIO was approached to develop the Pilot Display Unit (PDU) for Hawk-I aircraft with additional features of Raster and Mixed Mode operation;
    - Mock up unit of PDU for Hawk-I ready; and
    - Form-Fit-Functional Unit of PDU for Hawk-I is ready

Contact: The Director, CSIR-Central Scientific Instruments Organisation, Sector 30-C, Chandigarh - 160030; Tel.- 0172-2657190; E-mail: director@csio.res.in

Indigenous Development of Laser Lithotripsy System for Medical Applications

Laser lithotripsy is currently the most common application of lasers in urology. In laser lithotripsy, a pulsed laser beam of special properties is used for ablation of urinary stones. Due to photo-thermal effect the stone is fragmented and the fragmented pieces are washed out of the urinary tract. Laser lithotripsy is a noninvasive and is quite effective for any size, location, and/or hardness of stone. The Laser Lithotripsy machines are required in India in large numbers and presently there no any Indian manufacturer of this system. In order to provide good quality treatment with high rate of success, painless treatment, fast recovery time indigenous development of laser lithotripsy system need of time. Thus the indigenous development will check import, save money and provide treatment to urology patients at affordable cost.

CSIR-CSIO has developed technology of Laser Lithotripsy System indigenously for urology applications.

Important Parameters Unique to the Development:

- The system provides control over various parameters of the laser pulse like pulse width, repetition rate, energy etc; and
- System operates in both modes i.e. fragmentation mode and dusting mode.

Major Application(s): Laser lithotripsy is currently the most common application of lasers in urology. It provides an effective treatment of kidney stones.

Impact of the Technology: Kidney stone problem now-a-day is growing at a very fast rate worldwide. Millions of people are facing the extreme pain due to kidney stone. Laser lithotripsy is a noninvasive process so the fear of pain is also low. Laser lithotripsy is quite effective for any size, location, and/or hardness of stone. The procedure has been shown to be effective for a patient with multiple stones. This process is able to successfully treat stones made of any type of chemical composition.

The Laser Lithotripsy machines are required in India in large numbers and presently there no any Indian manufacturer of this system. The developed machine will serve

the general public having urology stone problem. Thus the indigenous development will check import, save money, and provide treatment to urology patients at affordable cost. Company may export the machine to other countries. With indigenously developed machine it will also be possible for even smaller hospitals to keep such machines, enabling patients benefitting with affordable treatment.

Commercialization Status: The technology has been commercialized by M/s Allengers Global Healthcare (P) Ltd., New Delhi. It is also available to other interested industry on non-exclusive basis.

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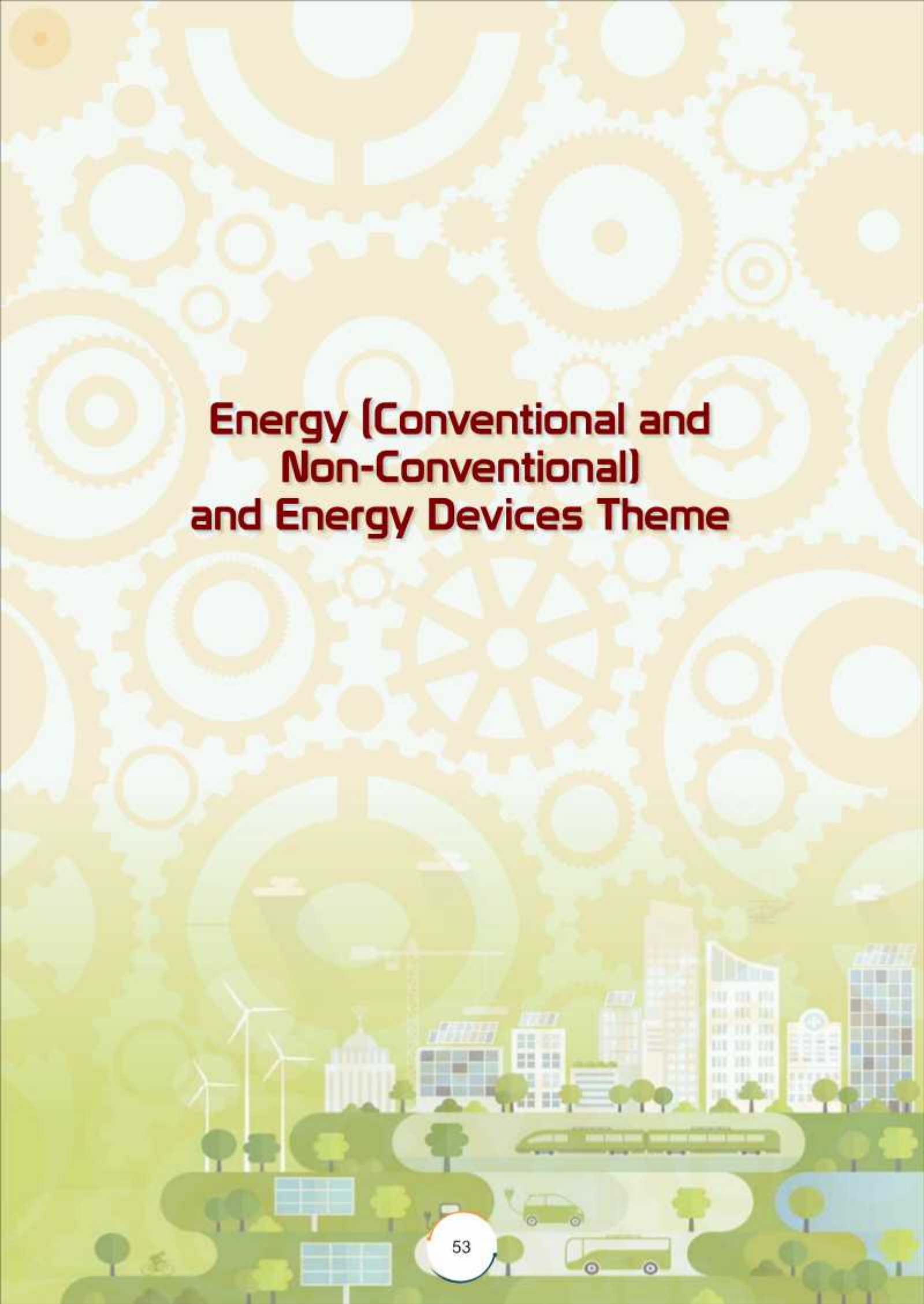
Energy (Conventional and Non-Conventional) and Energy Devices Theme



Energy (Conventional and Non-Conventional) and Energy Devices Theme

Micro Fuel Cell

Micro fuel cell is a power source for electronic devices that converts chemical energy into electrical energy. The scaled down fuel cells can be used in electronic devices such as digital cameras, radios, toys and other low power applications. CSIR-CMERI has developed cost effective, simple and easy to fabricate micro fuel cell for use in low power applications. The developed micro fuel cells are light weight with high energy density, rechargeable and re-usable and can generate 1.5 V, ~1000 mAh per cell which can be stacked upon to extract more energy (~1W). The developed liquid based fuel cell can undergo in-situ charging-discharging process like batteries, eliminates the complexities associated with micro fuel cells and can contribute in the development of affordable and novel rechargeable batteries to meet the growing need of energy of low power applications.

Important Parameters Unique to the Development:

- Hand held, rechargeable and re-usable;
- Solution for battery waste management;
- Light weight with high energy density;
- Developed liquid based fuel cell can undergo in-situ charging-discharging process like batteries; and
- The novel and cost effective rechargeable fuel cell can contribute significantly in the growing energy market of low power electronics

Major Application(s): The developed micro fuel cell can be used for different applications such as Toys, LED light (3.2 Watt), Wall clocks, Calculators, Radios, Diagnostic kits, Micro-nano sensors, Military and defense gadgets etc.

Impact of the Technology: The direct beneficiaries of the micro fuel cell are school kids to teach them about alternative sources of energy especially about microfluidics based fuel cells. The developed fuel cell is non-hazardous for the environment because H_2O is the only bi-product after the electrochemical reaction. In addition, the fuel cell can be both recharged and re-filled thus cost effective and minimizes the amount of waste generated from batteries.

Commercialization Status: Technology has been transferred to M/s Victor Industries Pvt. Ltd., Sangli, Maharashtra for commercialization on non-exclusive basis. The technology is available for licensing.

Contact: The Director, CSIR-Central Mechanical Engineering Research Institute, Mahatma Gandhi Avenue, Durgapur - 713209, West Bengal; Tel.- 0343-2546749, E-mail: director@cmeri.res.in

Technology for Pump Efficiency Monitoring System (PEMS)

Department of Commerce, Government of India has identified development of Smart Pumps as one of the mission mode activities. Energy efficiency is one of the key parameter in meeting the challenges of energy sector to meet the demand supply gap. Pumps houses are not maintaining the pumps at their best operating point as many of the pumps are oversized or throttled for regulating the flow. 5-10% of Energy savings can be achieved through operating pumps at their Best Operating Point (BOP). Monitoring of pump efficiency helps in life cycle assessment of pumps which can save downtime and money in terms of productivity.

CSIR-CSIO has developed Pump Efficiency Monitoring System based on measurement of energy and calculation of losses using thermo dynamic methods. PEMS performs pump efficiency estimation by calculating pump losses from the measurement of inlet and outlet fluid temperature and the dynamic head developed by pump, and also monitoring the electrical power to the motor thus pump flow rate is also calculated. This product helps improve the efficiency of pumps and lead to energy savings. This technology is relevant and affordable for industries and pump houses for maintaining the pumps at their best operating point as many of the pumps are oversized or throttled for regulating the flow.

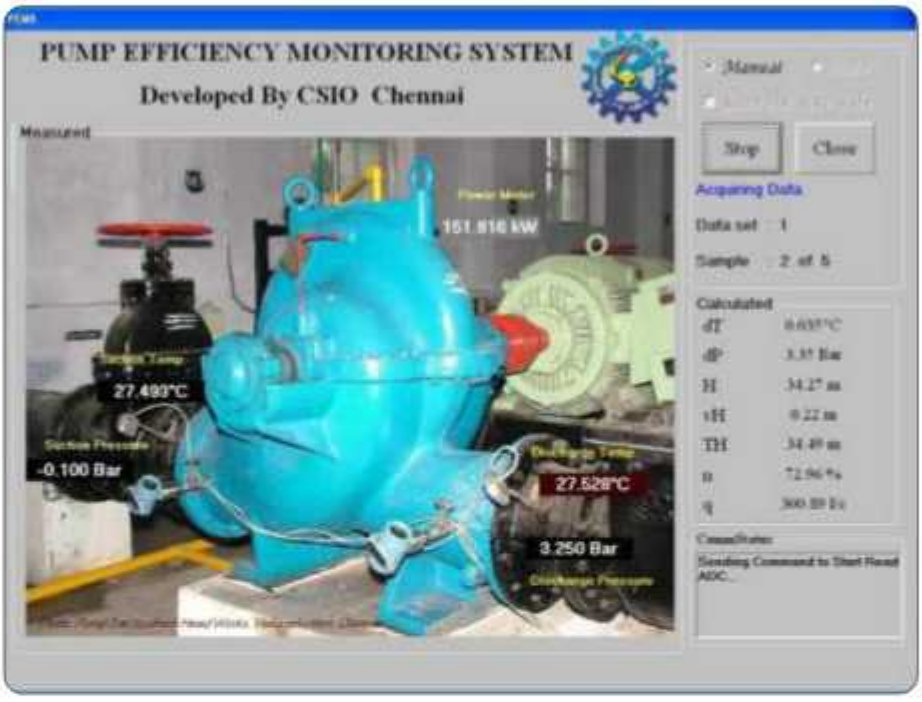
Important Parameters Unique to the Development:

- 5-10% of energy savings through operating at BOP and helps life cycle assessment of pumps which can save downtime and money in terms of productivity;
- Energy efficiency is one of the key components of meeting the challenges of energy sector to meet the demand supply gap. This product helps improve the efficiency of motors and energy savings; and
- This technology is relevant and affordable for industries and pump houses for maintaining the pumps at their best operating point as money of the pumps are oversized or throttled for regulating the flow. This technology was developed using thermodynamic principle of operation.

Major Application(s):

- Single unit capable of monitoring on-line power, head, flow and efficiency of the pump;
- Power measurement with accuracy of 1% and on-line flow and efficiency measurement with an accuracy of 1%;
- Capable of configuring the pump parameters and displaying all measurements and parameters of the pump online;
- Capable of logging data as .CSV format for analysis of the pump;
- Proper planning and maintenance of the pump to operate pump with optimum energy consumption;

- Refurbishment of the pump at appropriate time periodically to increase the life of the pump;
- Facilitate operation of pump at best operating point (BOP);
- Pump efficiency estimation by calculating pump losses from the measurement of inlet & outlet fluid temperature and dynamic head developed by pump, and also monitoring the electrical power to the motor; Pump flow rate is also calculated; and
- Capable of logging data as .CSV format for analysis of the pump.



Pump Efficiency Monitoring System

Impact of the Technology: This product helps improve the efficiency of pumps and lead to energy savings.

Commercialization Status: The technology has been transferred to M/s Hexmoto Ltd., Mysuru and its marketing partner M/s Solvier One Ltd., Pune. Further, it can be transferred to other interested companies on non-exclusive basis.

Contact: The Director, CSIR-Central Scientific Instruments Organisation, Sector 30-C, Chandigarh - 160030; Tel.- 0172-2657190; E-mail: director@csio.res.in

Technology for Portable Energy Audit Tool (PEAT)

Energy efficiency is one of the key components of meeting the challenges of energy sector to meet the demand supply gap. Portable Energy Audit Tool (PEAT) has been designed and developed with multitasking features of microcontroller for comprehensive measurement of electrical parameters. The PEAT can log different parameters i.e. by taking signals from the existing transmitters and enables display of real time data. The system supports standard MODBUS protocol. This product will help to improve the efficiency of many utilities like motors, compressors etc. This technology is relevant and affordable for industrial energy audits as it is having both energy and physical parameters monitoring and logging. With the help of this product, the performance / efficiency of utilities can be evaluated for better energy conservation. 5 - 10% of energy savings can be obtained through energy studies and maintaining the utilities, which can save downtime and money in terms of productivity.

Important Parameters Unique to the Development:

- Handy, portable and cost-effective tool for energy auditors / managers for demonstrating and validating concepts of energy savings proposal by logging different electrical parameters;
- Multitasking features for comprehensive measurement of electrical and physical parameters;
- Logging of parameters like electrical energy, temperature, pressure, flow, etc. from the existing transmitters and enables display of real time data;
- Capability to log for 72 days' storage of energy and physical parameters;
- Data downloadable into PC through a serial port; support for standard MODBUS protocol; and
- Application software establish communication with data logger, generating off-line trend graph, Bar and Pie Chart, on-line data display & graphs, alarm setting.

Major Application(s):

- This product helps to improve the efficiency of many utilities like motors, compressors etc; and
- 5-10% of energy savings through energy studies and maintaining the utilities save downtime and money in terms of productivity.

PORTABLE ENERGY AUDIT TOOL

Impact of the Technology: Energy auditors are giving energy saving proposals based on the data provided without real-time measurement as affordable and logging equipment as a single unit is not available. The Portable energy audit tool is developed keeping in view the requirements of energy auditors to log different parameters (electrical energy, temp, pressure, flow etc.) i.e. taking signals from the existing transmitters. This product helps to improve the efficiency of many utilities like motors, compressors etc.

Commercialization Status: Technology is available for licensing

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Technology for Power Quality Analyzer (PQA)

Today, monitoring the power quality is becoming more important due to the usage of automation and digital controllers. The requirement of power quality monitoring is increasing in domestic sector due to high rise buildings and also power quality monitoring is one of the key parameter in the smart grids.

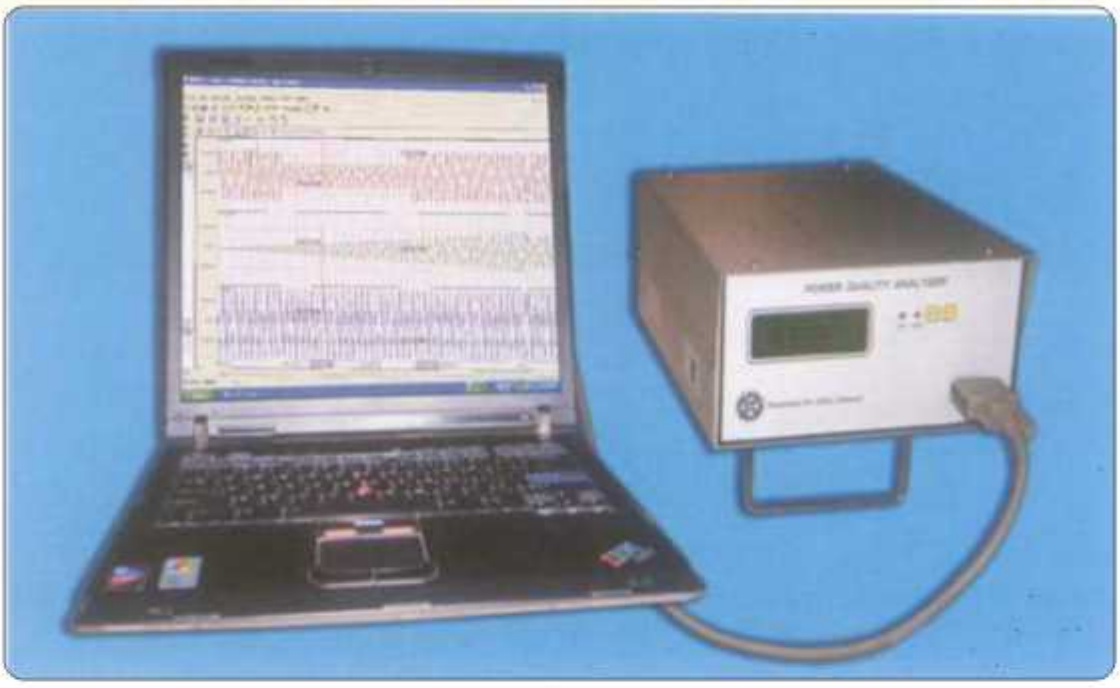
To meet these goals, CSIR-CSIO is upgrading earlier developed system by using newly emerged high-end embedded controllers at an affordable cost. Power quality of a system expresses to which degree a practical supply system resembles the ideal supply system. If electrical distribution power quality is good, any connected utilities will run satisfactorily and efficiently resulting in reduced installation, running costs and carbon footprint. Presently, many transmission and distribution companies levy penalties on consumer for non-maintenance of the power quality parameters within the set limits prescribed. Hence, power quality monitoring is one of the key parameters in the context of smart cities and smart grids.

Important Parameters Unique to the Development

- Monitors and measures basic electrical parameters (voltage, current, power factor, frequency) and power quality events, such as; sags and swells, harmonics, transients, phase sequence, imbalance with data logging and downloading facility to PC;
- Simultaneous sampling of voltage and current signals; Measurement up to 100^{th} order harmonic & transients to the order of 50 µs;
- Provides valid data for justifying investment in improving power quality of the distribution system; Safeguarding industries from penalties; and
- Identification of causes of equipment failures in critical sectors, such as health, energy, IT, ceramic / glass industries etc.

Major Application(s):

- It gives solutions to mitigate power quality problems in the system;
- Power quality is one of the key parameters in maintaining the productivity of manufacturing line. Its impact and meeting the challenges in the present-day digital technology in energy distribution is very important; and
- This technology is of particularly relevant and affordable for industrial and commercial establishments by providing power quality parameters of the system and also helps to maintain the power quality parameter like harmonics generated in the utility side can be kept within the prescribed limits.



POWER QUALITY ANALYSER (PQA)

Impact of the Technology: PQA will help to take corrective steps for improving the power quality of the supply, which in turn will reduce the down time and increase the productivity. Power quality is one of the key parameters in maintaining the productivity of manufacturing line. PQA is useful to measure the quality parameters of the electrical supply fed to the manufacturing line in the industry which can be used to protect the machines / equipment from the damages / breakdown.

Commercialization Status: Technology is available for licensing

Contact: The Director, CSIR-Central Scientific Instruments Organisation, Sector 30-C, Chandigarh - 160030; Tel.- 0172-2657190; E-mail: director@csio.res.in

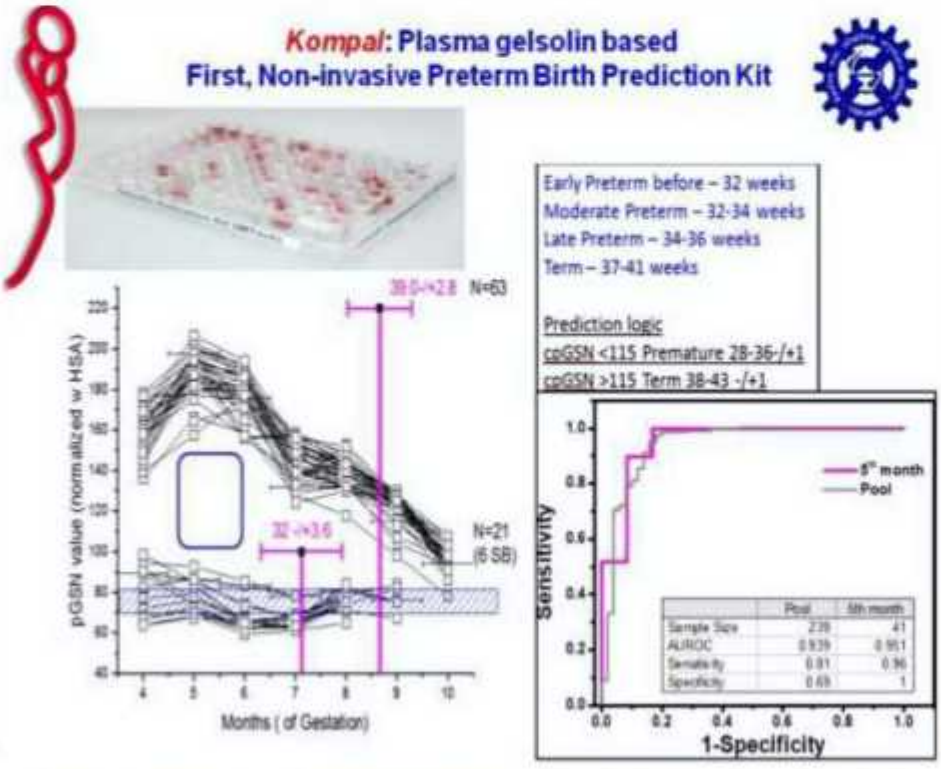
Affordable Healthcare Theme

Affordable Healthcare Theme

Mother's Plasma Gelsolin Estimation Kit to Predict Premature Birth

An estimated 15 million babies are born too early every year. That is more than 1 in 10 babies. Approximately 1 million children die each year due to complications of preterm birth. Many survivors face a lifetime of disability, including learning disabilities and visual and hearing problems. Globally, prematurity is the leading cause of death in children under the age of 5 years. And in almost all countries with reliable data, preterm birth rates are increasing. Inequalities in survival rates around the world are stark. In low-income settings, half of the babies born at or below 32 weeks (2 months early) die due to a lack of feasible, cost-effective care, such as warmth, breastfeeding support, and basic care for infections and breathing difficulties. In high-income countries, almost all of these babies survive. Suboptimal use of technology in middle-income settings is causing an increased burden of disability among preterm babies who survive the neonatal period.

While gelsolin is emerging as a biomarker for premature birth and survivability from sepsis and injuries, no gelsolin estimation kit for therapeutic purposes is available. Ability to forewarn premature births coupled with therapeutic intervention would lead to saving lives at birth.



Working with the shape-function properties of gelsolin, CSIR-IMTech and others work led to conclusion that plasma gelsolin levels aid in body's ability to recover from injuries, both physical and biochemical. CSIR-IMTech has developed a diagnostic kit for an estimation of plasma gelsolin based on patented aptamers and protocol to coat them on ELISA plates. The prototype was first tested in samples from PGI Chandigarh which indicated plasma gelsolin is lower in mothers delivering prematurely. Further research done with plasma samples from Rajasthan, Gujrat and Madhya Pradesh also showed that method developed and mathematical model can predict un-induced birth prediction time with about 82% accuracy in the fifth month of singleton gestation. A PCT has been filed.

Salient Features of Diagnostic Kit:

- First diagnostic kit for pre-term birth in world;
- Rapid Estimation from 2 drops of blood (4.6 Hours);
- Preclinical study in PGI Chandigarh, Rajasthan, Gujrat and Madya Pradesh done;
- Field Results show ~82% correlation (P 4E-5); and
- Helps in alerting mothers prone to delivering prematurely.

Commercialization Status: The diagnostic kit after pre-clinical trial has been transferred to Oniosome Healthcare Pvt. Ltd on non-exclusive basis for commercialization. The technology is available for licensing.

Contact: The Director, CSIR-Institute of Microbial Technology, Sector-39A, Chandigarh - 160036; Tel.- 0172-2690785, 2690684; E-mail: director@imtech.res.in

Non-Vascular Self-Expandable Stents

Stents are used in the treatment of numerous GI tract diseases, ranging from benign diseases to malignant strictures. Two types of stents find extensive use: plastic stents and self-expanding metallic stents. Amongst these while the self-expandable metal stents offer longer patency their prohibitive cost makes them unaffordable. On the other hand plastic stents get clogged very often causing great inconvenience to the patient. CSIR-NCL in collaboration with a start-up has developed a new class of self-expandable stents based on a novel scroll design. These stents have been made with simple polymer-metal composites unlike the shape memory alloy based stents. The novel design allows these stents to meet the characteristics of shape memory alloy based stents. These stents could be made a much lower costs than the currently available ones.

Important Parameters Unique to the Development:

- New class of self-expandable stents based on a novel scroll design;
- These stents can be made with simple polymer-metal composites unlike the shape memory alloy based stents;
- The novel design allows these stents to meet the characteristics of shape memory alloy based stents; and
- These stents could be made a much lower costs than the currently available ones.

Our Prototype **Ottomed stent®**

Impact of the Technology: The currently available self-expandable metal stents are priced in the range of USD 1100 - 2600. These stents are made of shape memory alloys such as nitinol which is a major component of cost. In addition, these stents are fabricated using expensive techniques such as precision cutting using lasers, followed by electro-polishing. The developed stent designs are based on radically different approach where it neither requires expensive materials nor processes to manufacture. Thus the stents being developed are expected to be available at lower costs but still possessing the characteristics of self-expanding stents. An estimated 3.5 Lakh stenting procedures (Esophageal alone) are expected to have been performed in India (Source: World cancer research fund international). Even if,it is assumed that 60% of these are performed on people with low and medium income levels - the stents developed could make huge societal impact.

Commercialization Status: The technology has been transferred to Embryyo Technologies Pvt. Ltd. (Embryyo), Pune for further development on non-exclusive basis. Technology is available for licensing.

Contact: The Director, CSIR-National Chemical Laboratory, Pashan Road, Pune - 411008; Tel.- 020-25902600, 25902028; E-mail: director@ncl.res.in

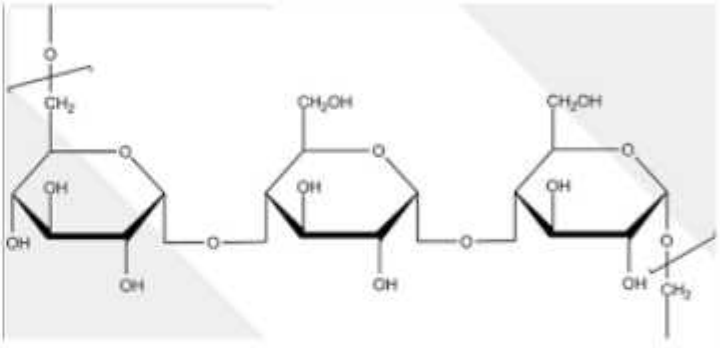
Technology for Production of Pullulan

Pullulan is an extremely versatile ingredient with capability of providing a technology platform for product innovation. Chemically, pullulan is a homo-polysaccharide consisting of maltotriose subunits. This biopolymer has found applications in diverse industrial sectors including food, pharmaceuticals and biomedical industries.

CSIR-IMTech has developed process technology at 500 L fermenter level. The process is ready for demonstration.

Important Parameters Unique to the Development

- The process is developed using an osmotolerant non-pigmented strain of Aureobasidium pullulans;
- More than 70 g/L pullulan has been obtained after process optimization in laboratory scale fermenters; and
- Waste to wealth: Utilization of inexpensive agri-industrial residues would significantly reduce the cost of production.



Major Application(s): Pullulan has been used as a food ingredient for over 20 years in Japan. It has Generally Regarded As Safe (GRAS) status in the US for a much wider range of applications and thus higher intakes than the current application. It is an excellent film-former, producing a film which is heat sealable with good oxygen barrier properties and which can also be printed. Pullulan can be formed into capsules for use with pharmaceutical and nutraceutical products. Its non-animal origin ensures there are no safety concerns with the consumers and it is suitability for all the consumers groups.

Impact of the Technology: Pullulan has potential application in several industrial sectors. It will be mid-volume, mid-priced product. According to a report published in 2009, the global market size of pullulan is 10000 TPA. It is expected that present technology will make the product relatively inexpensive. Hence, attempts are being made to capture the market of competitive products (xanthan and gellan) and also to develop novel applications. This will enhance the total market size significantly.

The development is highly relevant and inline with the "Make in India" Mission. There is no manufacturer of this product in India and all the requirements of the country are fulfilled by import.

Status of Commercialization: The technology is available for licensing.

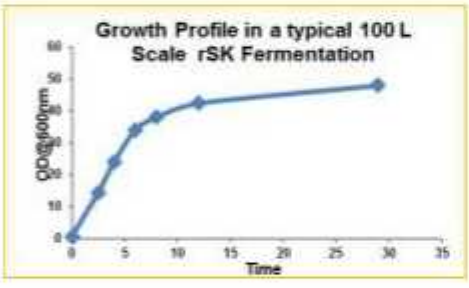
Contact: The Director, CSIR-Institute of Microbial Technology, Sector-39A, Chandigarh -160036; Tel.- 0172-2690785, 2690684; E-mail: director@imtech.res.in

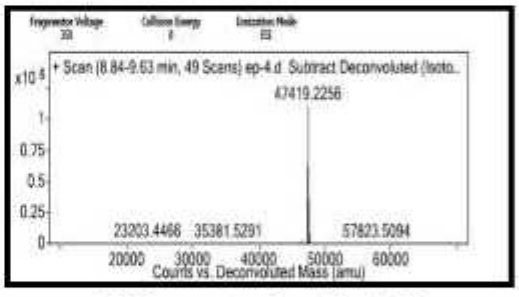
Scale-up of Recombinant Streptokinase Technology

Streptokinase is an effective and inexpensive clot dissolving drug used in the treatment of myocardial infarction and pulmonary embolism and belongs to the category of fibrinolytics/clot busters which work by activating plasminogen to produce plasmin which in turn helps in dissolving the clot.

CSIR-Institute of Microbial Technology had developed the technology for producing recombinant streptokinase at 3 liter scale and transferred to M/s Shasun Chemicals and Drugs, Chennai. The product is in the market. CSIR-IMTech has done improvement in the same technology and has developed it at 100 litre scale with the purification process at 10 liter scale. The purity and characteristics of final DS (Recombinant Streptokinase) confirms to those of innovator molecule.

The technology entails the culture of *Escherichia coli* harboring appropriate plasmid DNS encoding streptokinase in fed batch High Cell Density Fermentation (HCDF). The highlight of this HCDF process is high-level intracellular expression of rSK without noticeable change in its specific yield (g rSK/g dry cell weight) on process scale-up. The process also involves a highly optimized two-chromatographic step down-stream scheme capable of yielding around 70% of highly purified (>98% purified) rSK. The overall process yield is > 0.60 g purified rSK/L (equivalent to ~ 40 therapeutic doses per litre of fermentation liquid). The purified rSK shows biological activity that is comparable to highest purity natural SK (~1.0 x 105 IU/mg protein).





LCMS spectra of purified rSK

Impact of the Technology: Streptokinase (SK) is used for the treatment of diverse circulatory disorders such as myocardial infraction, deep vein thrombosis and pulmonary embolism. The most notable point regarding this rSK production technology is its attractive cost of production. This translates into lower cost of the drug for the end-user.

Status of Commercialization: Data on consistency batches of production, purification, characterization, formulation and stability of recombinant streptokinase has been generated (as per RCGM requirement) for M/s Epygen, Mumbai for pre-clinical toxicology studies and RCGM has approved pre-clinical toxicology studies data based on DS and DP prepared and data generated at CSIR-IMTech (RCGM Permit No. BT/BS/17/551/2013-PID, dated 27.12.2018). The technology has been transferred on non-exclusive basis and is available for further licensing.

Contact: The Director, CSIR-Institute of Microbial Technology, Sector-39A, Chandigarh -160 036; Tel.- 0172-2690785, 2690684; E-mail: director@imtech.res.in

Handheld Forced Oscillation Device for Improved Detection and Monitoring of Airway Diseases (Pulmoscan)

Increasing global urbanization and pollution has led to a steady increase in both Obstructive Airways Diseases (OAD) like Asthma and Chronic Obstructive Pulmonary Diseases (COPD) similar to those caused by smoking and second hand smoke inhalation. Together, OAD and COPD, affect an estimated 650 million people globally. A major global challenge is that a significant number of OAD and COPD cases remain undiagnosed, under diagnosed or wrongly diagnosed, due to lack of easy to conduct diagnostics. At present spirometry is used by doctors for diagnosis of airway respiratory diseases. Spirometry requires patient training by the trained technician and is thus expensive affair. The diagnosis is also not accurate if it is not done by a trained technician.

In collaboration with M/s Cognita labs, USA, CSIR-IGIB has developed the world's first handheld, portable and battery-powered FOT device, called PulmoScan, for measurement of lung function. The new device will significantly expand the usage scenarios for medical professionals to conduct lung function test. Early and accurate diagnosis could lead to lifestyle modification and therapeutic interventions that improve the quality of life and reverse or arrest the decline in lung function.

Important Parameters Unique to the Development:

- Portability with ability to run from tablets, without electrical supply;
- Open tube design for disinfectability in Indian conditions, with TB being a common problem;
- It is simple (requires normal breathing by patients), enables faster diagnosis, safe (low frequency sound waves safe for children as low as 3 years of age) and accurate (forced oscillation technique); and
- PulmoScan is battery-operated and can conduct out-of-clinic testing at low operational costs.

Major Application(s): Diagnosis and monitoring of asthma or COPD.

Impact of Technology: Early diagnosis of COPD prevents progression of respiratory airway diseases and reducing complications.

Commercialization status: Device is being commercialized by M/s Cognita labs exclusively.

Contact: The Director CSIR-Institute of Genomics and Integrative Biology, South Campus, Mathura Road, New Delhi ; Tel.- 011-27662407 E-mail: director@igib.res.in

Comprehensive Pipeline for Diagnosis of Mitochondrial Diseases using Next-generation Sequencing Technology (Mit-o-Matic)

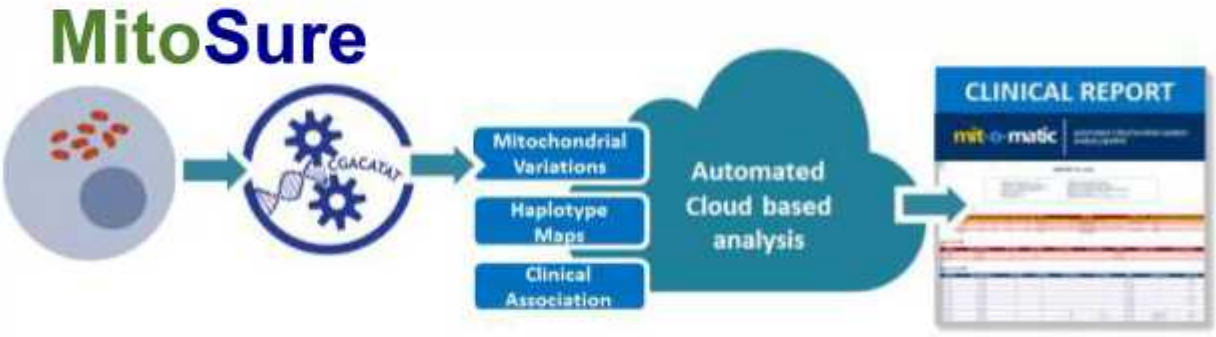
Dysfunction of the mitochondrial genome, through genetic variations is well known to cause mitochondrial diseases. Mitochondrial diseases are one of the most common genetic diseases, with an incidence of approximately 1 in every 5000 births. A comprehensive pipeline, including experimental methodologies to sequence mitochondrial genomes using next generation sequencing and appropriate methods to analyze and interpret the data has been developed. This methodology has application in fast diagnosis of mitochondrial genomic variations, with additional advantage of detecting heteroplasmy in the mitochondria. This technology enables clinical diagnosis, prenatal testing and carrier screening.

Important Parameters Unique to the Technology:

- NGS based pipeline for fast and accurate diagnosis of mitochondrial genetic mutations;
- Point-of-click mitochondrial mutation identification and reporting for clinical application;
- Unique ability to identify Heteroplasmic variation in the mitochondria; and
- In built reporting for pathogenic mutations.

Major Application(s):

- Mit-o-Matic has application in fast diagnosis of mitochondrial genomic variations and diseases associated with the variations; and
- Mit-o-Matic enables clinical diagnosis, prenatal testing and carrier screening.



Impact of Technology: Mitochondrial diseases are one of the most common genetic diseases, with an incidence of approximately 1 in every 5000 births, which for India amounts to almost 5000 children born every year with mitochondrial disorder. Thus for a country such as India, mitochondrial disorders impact our socio-economic wellbeing in a significant manner. The availability of this NGS based technology now allows screening of eight mitochondrial dysfunction related disorders thereby providing timely therapeutic interventions to the inflicted patients.

Commercialization Status: The technology has been licensed to M/s Eurofins Clinical Genetics India Pvt Ltd for commercial application. This is marketed under the trade name MitoSure.

Contact: The Director, CSIR-Institute of Genomics and Integrative Biology, South Campus, Mathura Road, New Delhi; Tel.- 011-27662407 E-mail: director@igib.res.in

Platform for Genomics and other Omics Tools for Enabling Medical Decisions (GOMED)

Genetic diseases, though are individually rare, cumulatively affect a large number of individuals. It has been estimated that genetic diseases affect over 70 million Indians (ORDI 2015) and a total of over 300 million worldwide. In majority of the cases, an appropriate diagnosis is not arrived at, due to lack of general awareness on genetic diseases, lack of access and high-cost of appropriate genetic diagnostic services. The concept of GOMED provides a unique platform leveraging CSIR-IGIB's research expertise and clinical collaborative network in disease genomics to enable equitable access to genetic testing for patients and caregivers.

Important Parameters Unique to the Development:

- Capillary sequencing-based genetic tests encompassing a variety of disease conditions and specialties including Movement Disorders, Motor Neuron Disease, Familial Stroke, Mitochondrial Disorders, Developmental and Inborn error of metabolism, Leukodystrophies, Ophthalmological diseases;
- Pharmacogenomics tests for common drugs with prevalent adverse drug events; and
- Unique genetic test panels which encompass prevalent monogenic diseases/conditions in India including Thalassemia and Sickle Cell Anemia, Muscular Dystophies.

Major Application(s): Enables molecular diagnosis in many genetic diseases enabling evidence based therapy, genetic counselling and prenatal testing.

Impact of the Technology: Availability of an accessible, affordable testing system would go a big way to significantly reduce the diagnostic dilemma and enable a reduction in social and economic burden through appropriate interventions. More than 120 genetic tests have been deployed. A total of over 7500 referrals and over 28,000 tests have been handled enabling a unique model for accessible genetic testing in India. The program caters to a hospital network of over 50 centers across the country.

Commercialization Status: CSIR-IGIB has licensed the first set of 27 genomic tests with India's largest and leading diagnostic chain, Dr Lal Path labs. This set of genomic tests cover 80 genes, 275 amplicons spanning a variety of prevalent diseases/disorders such as Movement Disorders, Motor Neuron Disease, Mitochondrial Disorders, Developmental and inborn error of metabolism, leukodystrophies and Pharmacogenomics of 5 fluorouracil. Technology is available for further licensing.

Contact: The Director, CSIR-Institute of Genomics and Integrative Biology, South Campus, Mathura Road, New Delhi - 110020; Tel.- 011-27662407, 27667298; E-mail: director@igib.res.in

Technology for Carbonated Fruit Juice Beverages from Selected Fruits

Carbonated beverage market is dominated by carbonated beverages with synthetic colors and flavors with no fruit juice. Commercial production of carbonated fruit juice beverages is not carried out for many of the tropical fruits. The beverage market is growing every year by more than 30% which provided opportunity for CSIR to develop a nutritious and quality fruit drink with carbonation to impart tanginess of the fruit beverage. Carbonation of fruit juice beverages will result in utilization of locally grown fruits for value addition and impart better nutrition. CSIR-CFTRI has developed a technology for developing carbonated fruit juice beverages containing natural fruit juice/pulp in concordance with FSSAI regulations for fruit juice beverages.

Important Parameters Unique to the Development:

- Carbonated fruit juice beverages contain natural fruit pulp/juice with better nutritional quality as compared to synthetic flavored carbonated beverages;
- Fruit pulps/juice extracted from the mature ripe fruits were pre-treated and stabilized for the production of carbonated fruit juice beverages;
- The carbonated fruit juice beverages produced has variety of colors and flavors due to use of various locally grown fruits;
- Carbonated fruit juice beverages from a variety of fruits viz., grape, lime, orange, mango, guava, pomegranate, apple, jamun etc. can be prepared using the indigenously developed technology;
- The beverages can be packed in glass or food grade PET containers or cans;
- The products are shelf stable and highly acceptable; and
- The products meet the FSSAI regulations.

Major Application(s):

- Technology facilitates the production of carbonated fruit juice beverages from different fruits which is profitable for beverage industries;
- The indigenously grown fruits can be used for the production of carbonated fruit juice beverages; and
- The products developed will add value and open up new markets in the food processing industry.

Impact of the Technology: The technology will help in utilizing the indigenously grown fruits into processed products, there by resulting in value addition. It will create demand for the locally grown fruits and increase the production. Further, excess of fruit

produce can be used by beverage industries which will generate additional income or give better returns to the farmers.

Commercialization Status: A pilot scale Carbonated fruit juice processing plant as per the process design developed in the project has been installed and commissioned at CSIR-CFTRI, Mysore. The technology has been transferred to industry. The technology is available for further licensing.

Contact: The Director, CSIR-Central Food Technological Research Institute, Mysuru – 570020; Tel.- 0821-2517760, Fax.- 0821-2516308; E-mail: director@cftri.res.in

Serum and Urine Based Kit for Diagnosis of Human and Canine Visceral Leishmaniasis (VL) and Post Kala-azar Dermal Leishmaniasis (PKDL)

Antigen rK39 (39 amino acid kinesin-related protein) coated rapid diagnostic tests are commonly used for sero-diagnosis of VL. However, performance of this test is moderate. Currently the technology is in dipstick format for serum-based diagnosis of human kala-azar and PKDL and canine kala-azar as well as urine-based diagnosis of human VL and PKDL. KAtex is the only urine-based test available for kala-azar diagnosis which detects leishmanial antigen in urine but the sensitivity of the test is low and obligation to boil the samples is an awkward step. The dipstick is based on enzyme catalyzed reaction which takes 90 minutes to complete. There is no rapid diagnostic test available which performs equally well in all endemic region. CSIR-IICB has developed a serum and urine based diagnostic test system/kit which utilizes lateral flow technology and purified recombinant antigens that reduces the time of detection.

Important Parameters Unique to Development:

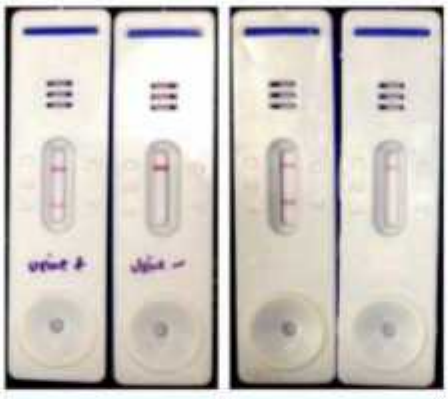
- A novel urine based non-invasive diagnostic test;
- Colloidal gold based rapid strip used;
- Simple and field adaptable test which gives result in a minute;
- Purified and Recombinant antigens used for diagnosis;
- Non-invasive utilizing urine samples;
- Capable of detecting anti-leishmanial antibodies in serum and urine;
- Equally effective for post kala-azar diagnosis;
- Doesn't cross-react with cutaneous leishmaniasis; and
- Detects anti leishmanial IgG antibodies in urine.

Major Application(s): For neglected tropical diseases like kala-azar, early diagnosis is a key factor for effective control of the disease. Lateral flow technology for diagnosis delivers healthcare directly in the field settings without the need of sophisticated instruments and invasive procedures.

Impact of Technology: Early and easy diagnosis of leishmaniasis which mainly occurs in poor rural settings of tropical regions would immensely benefit the affected population due to timely treatment.

Commercialization Status: The technology has been developed and validated using Indian patients' samples. Validation of the test in other endemic countries is in process. Technology is available for licensing.

Human Serum



Human Urine | Canine Serum

Lateral flow test for diagnosis of kala-azar

Contact: The Director, CSIR-Institute of Chemical Biology, 4, Raja SC Mullick Road, Jadavpur, Kolkata - 700032; Tel.- 033 - 24735368, E-mail: director@iicb.res.in

Simple and Affordable Diagnostic Protocols and Diagnostic Kit for Genetic Diagnosis of Musculopathies and Hemoglobinopathies

Genetic disorders like musculopathies and hemoglobinopathies add considerable health burden to Indian society. In the absence of any treatment, prevention by genetic testing is the only option. Many of the existing genetic diagnostic methods are cumbersome, time-taking and expensive. Thus, development of simple, rapid and affordable diagnostic methods for genetic testing that preclude the need of sophisticated setup is required. CSIR-CCMB has developed affordable diagnostic methods for identification of these genetic disorders.

Important Parameters Unique to the Development:

- Simple, rapid and affordable diagnostic methods;
- Obviates the need for sophisticated setup;
- Tests can be performed at any place with minimal personnel training; and
- Utility for medical colleges, Govt. hospitals, patient support groups, etc.

Major Application(s): Affordable and accessible genetic testing for patients affected with hemoglobinopathies and musculopathies.

Impact of Technology:

- Early diagnosis will help prevention of birth of affected fetuses;
- The use of the affordable diagnostic methods will lower the societal burden and long-term treatment costs of patients with musculopathies and hemoglobinopathies; and
- Reduced emotional stress and improvement in quality of family life due to timely detection of genetic disorders

Status of Development:

- Participation in the patient screening camps of Indian Association of Muscular Dystrophy (IAMD) and Training imparted to personnel of Indian Association of Muscular Dystrophy (IAMD) in history taking, sample collection and transport to the CCMB;
- About 100 patients have been subjected to SMA and DMD testing and the organization (IAMD) is following them for further carrier testing and prenatal diagnosis in future;
- Identified a local university in Solan, where the facility for molecular diagnosis using simple protocols will be established. Scientists from the university will be trained at CCMB and will execute the preliminary genetic testing at their place;

- Similar efforts have also been ongoing with Muscular Dystrophy Association of India (MDAI), Sickle Cell Institute (Raipur, Chhattisgarh), Nizam's Institute of Medical Sciences (Hyderabad);
- MoU signed with the Directorate of Medical Education, Government of Telangana, for transfer of protocols for regular diagnosis at its affiliate medical colleges; and
- Validated protocols and their SOPs available for testing:
    - Standardized PCR conditions for genetic testing of β-thalassemia, spinal muscular atrophy and Duchenne and Becker Muscular Dystrophy using blood, dried blood spot and DNA.
    - PCR conditions for screening of common mutations in Hemoglobinopathies (beta-thalassemia & SCA) have been worked out using dried blood spots, blood and genomic DNA.
    - Protocols for detection of multiple deletions for DMD have been standardized. ARMS-PCR based protocol for simultaneous detection of exon 7 and exon 8 deletion in SMA patients have been established using dried blood spots, blood and genomic DNA.

Contact: The Director, CSIR-Centre for Cellular and Molecular Biology, Uppal Road, Hyderabad - 500007; Tel.- 040-27160789; E-mail: director@ccmb.res.in

IND Filing of Anti-Cancer Lead IIIM(N)-290/13 (Cdk Inhibitor)

IIIM-290/13 is a new semi-synthetic chromone alkaloid possessing potent inhibition of Cdk-1/A, Cdk-2/A, Cdk4/D3 Cdk5/p25, Cdk-6/D1 and Cdk-9/T1 with IC_{50} values in the range of 1.9 to 50 nM. It possesses promising in-vitro cytotoxicity in different types of cancer tissues, with most potent cytotoxicity in leukemia and pancreatic cancer cells (IC_{50} < 1 µM). It was found to be highly selective for cancer cells over normal fibroblast-cells. It did not have CYP/ efflux-pump liability, was not mutagenic/genotoxic or cardiotoxic and was metabolically-stable. It was found to be stable in different pH buffers (pH 1.2-7.4) as well as in SGF, SIF and rat plasma. It displayed excellent plasma exposure and oral bioavailability (%F = >60%) in mice as well as in rats; whereas both the clinical candidates flavopiridol and riviciclib from this scaffold are available only by IV route. Furthermore, compound showed dose-dependent (3, 10, 30 mg/kg) pharmacokinetics profile in rats and mice. It showed excellent aqueous solubility (8 mg/ml) in '70% PEG-400, 25% PG & 5% DMSO', a vehicle selected for in-vivo studies. The in-vivo anticancer activity (by oral route) has been demonstrated in murine as well as in human xenograft models (MOLT-4, MIAPACA-2, HCT-116). The regulatory safety pharmacology of the lead has also been completed.

There is great scarcity of drugs for pancreatic cancer. This orally bioavailable anticancer candidate will have huge market potential for treatment of pancreatic cancer. The objective of the project was completion of IND-enabling studies for this candidate and to file an IND with DCGI.

Important Parameters Unique to the Development:

- The identified lead is orally bioavailable, whereas earlier clinical candidates from this scaffold (flavopiridol and riviciclib) are available only by IV route;
- Short-synthesis (single step synthesis from a natural product). Natural product is present in abundance in leaves (a renewable source) of the plant material Dysoxylum binectariferum. Therefore, the ease of synthesis of this lead makes this molecule affordable; and
- If successful, this lead will add a value of oral administration versus intravenous administration.

Major Application(s): There is great scarcity of drugs for pancreatic cancer. The present orally bioavailable lead will have huge market potential for pancreatic cancer treatment.

Impact of the Technology: Cancer has high prevalence throughout the world. Particularly, for pancreatic cancer there is scarcity of drugs. Thus, there is great need of newer and effective medicines for this cancer. If successful, this drug will make huge societal impact.

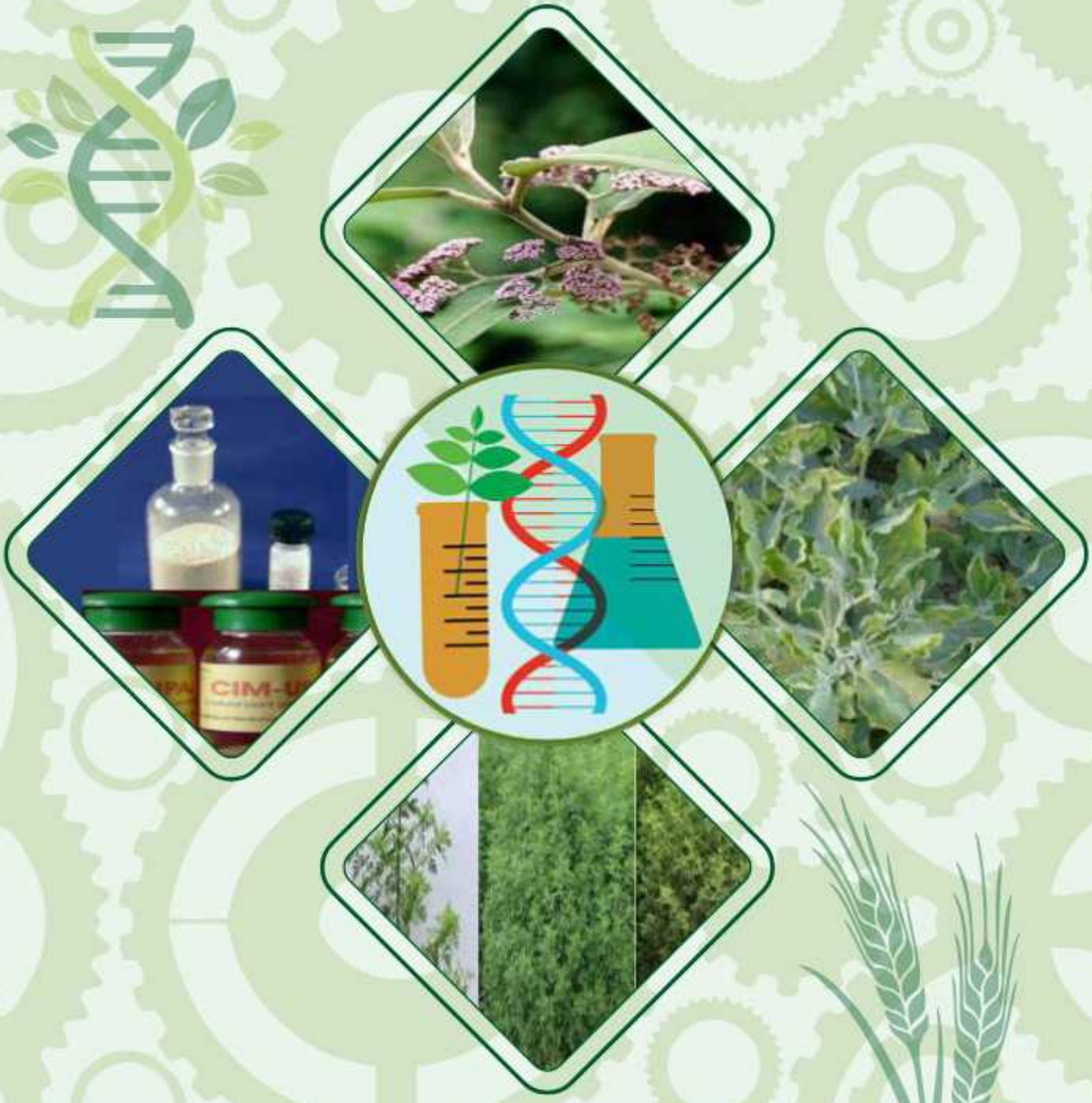
Commercialization Status: IND related studies have been completed except for the stability studies, which are in progress. CRO has been identified for preparation of IND dossier and preparation of Phase I clinical study protocol. The CRO shall file the IND dossier.

Details of Technology Transfer: CSIR-IIIM will out-license this lead to the pharmaceutical company after IND filing. Following companies have shown interest in this product:

- Aveta Biomics, Inc. USA; and
- Two French Pharmaceutical Companies - Pierre-Fabre & Servier Laboratories

Contact: The Director, CSIR-Indian Institute of Integrative Medicine, Post Bag No. 3, Canal Road, Jammu - 180001; Tel.- 0191-2584999, 2585222; Fax.- 0191-2586333; E-mail: director@iiim.res.in

Agri, Nutri and Biotech Theme



Agri, Nutri and Biotech Theme

Anacardic Acids: A Potential Molecule to Increase Cotton Fibre Yield and Quality

India tops the world in having largest area under cotton cultivation. However, the yield of cotton in India is very less, being 500 Kg/ha compared to the country like Brazil which has cotton yield about 2000 Kg/ha. Thus, innovative technologies are needed to improve yield in India which will be a direct benefit to the farmer. CSIR-NBRI has developed a formulation which improves cotton yield. Multi-location trials in different cotton growing states showed 10 - 15% increase in yield of popular cotton hybrids. The formulation also brings earliness in boll bursting. It works by augmenting actions of phytohormones involved in cotton boll development.

Important Parameters Unique to the Development:

- Technology promises at least 10% increase in cotton yield that will contribute ₹ 2000-5000/hectare increase in the income of a farmer;
- Technology leads to earliness in cotton production that will help farmers to prepare land for next crop. This will be substantial especially in North Indian states like Punjab; and
- Earliness will also help in better pest and resource management for farmers

Major Application(s): The development has application in cotton cultivation. Technology will be useful to Agri-business.

Impact of the Technology: Considering even moderate 2% coverage of the technology to cotton growing areas, it can lead to ₹ 50 to ₹ 100 crores business/year across the country. The technology will affect life of millions of farmers directly, since increase in the income from same farm area will be especially beneficial for small and poor farmers

Commercialisation Status: Proof of concept has been established through multi-location trials. Application of Anacardic Acids showed significant yield increase and earliness. UCP Chemicals Ltd., Chennai has been identified to take up the technology for commercialization. They are a natural partner for this technology since they are the bulk manufacturers of Anacardic Acid in India. Their involvement and availability of cheap source of Anacardic acid will have significant impact on techno-economics. Non-Disclosure Agreement (NDA) has been signed and details of the technology and field trial shared with them. UCP has shown further interest in licensing the technology provided that molecule is registered with Pesticide and Insecticide Board of India. Tierra Seed Sciences has also shown keen interest in marketing the formulation. Technology is available for licensing.

Multi-location trials on Cotton with Anacardic acid application

Contact: The Director, CSIR-National Botanical Research Institute, Rana Pratap Marg, Post Box No. 436, Lucknow - 226001 (UP); Tel.- 0522-2205848, 2208876
E-mail: director@nbri.res.in

High Yielding Variety of *Artemisia annua*

The best available variety of *Artemisia* so far is "CIM Arogya" containing artemisinin content of around 1%. After the availability of semi synthetic artemisinin (SSA) in the market and continuously falling international prices of artemisinin, it has been felt that the production cost of the natural artemisinin (NA) must be brought down in order to make it sustainable / competitive in the international market.

Extensive breeding work carried out during last 12 years by CSIR-Central Institute of Medicinal and Aromatic Plants (CSIR-CIMAP) resulted in development of a new variety having artemisinin content of 1.2% (an increase of at least 20% over existing variety CIM Arogya). The variety, named 'CIM-Sanjeevani', is a poly cross between two existing varieties i.e. Jeevan Raksha and CIM Arogya. Two way selections were practiced, which involves the selection for maternal parent and rejection of poor pollinators from the population simultaneously.

Important Parameters Unique to the Development:

- The new variety, CIM Sanjeevani, has an average yield potential of 43 - 45 quintal per hectare dry herb with artemisinin content of 1.2%; and
- The plants of the population have intermediate morphology between Jeevan Raksha and CIM Arogya.

Major Application(s): Artemisinin *from Artemisia annua* is used for treatment of patients suffering from cerebral/drug resistant malaria.

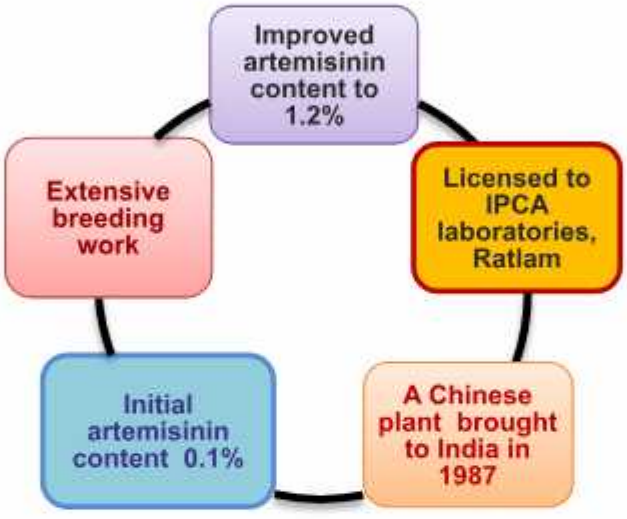
Artemisia varieties developed by CSIR-CIMAP

Jeevan Raksha (0.8%) CIM Arogya (1%) CIM Sanjeevani (1.2%)

Impact of the Technology: CIM Sanjeevani, with high artemisinin content, is beneficial for both farmers and industries involved in *Artemisia* cultivation / business. The higher yielding variety (10-12% higher yield of dry leaves compared to CIM Arogya) has potential to increase farmer's income up to ₹10,000 to 15,000 from one-hectare crop. The reduced cost of production of artemisinin by a margin of about 20% would benefit industry.

The main product is dried leaves (sold to the company). This crop also provides about 150 q/ha of dried stems which can be used as fuel wood easing pressure on forests. Till date no serious insect-pest or disease has been observed on this crop. This crop has an extremely bitter taste and no wild animal have been found to damage the crop, rather it is playing a role of bio-protectant against wild animals.

In real time technology dissemination, CSIR-CIMAP developed a unique biovillage model, wherein it facilitated linkage between farmers and user industry. Farmers can earn a minimum profit of ₹50,000/- per hectare within a period of 3 months. It has potential to generate employment opportunities worth 4-5 lakh man-days. Besides, employment in artemisinin processing industry will also be generated.



Variety development cycle

Commercialization Status: Know-how has been licensed to IPCA Lab, Ratlam on non-exclusive basis. It is available for further licensing.

Contact: The Director, CSIR-Central Institute of Medicinal & Aromatic Plants, P.O. CIMAP, Lucknow - 226015; Tel.- 0522-2718503, 2718509, 2719083; E-mail: director@cimap.res.in

A Withanolide Rich Advance Breeding Line of Ashwagandha (*Withania somnifera*) with Novel Ideotype and Good Root Quality for Release as Variety

Ashwagandha is a medicinal crop suitable for climate resilient and sustainable agriculture for rainfed and marginalized lands and a major source of withasteroids having diverse pharmacological potential. It falls in Generally Regarded as Safe (GRAS) category of medicinal plants and FDA approved. Current production of Ashwagandha in India is 3500 tonnes against the estimated demand of 10,000 tonnes.

To meet the growing demands for bioactive withanolides against the current production to cater the requirement of pharmaceutical and nutraceutical industries through in planta production, withanolides targeted breeding programme is being undertaken at CSIR-CIMAP. As a result of high throughput phenotyping of economic agro-morphological, root quality traits and withanolides content screening, specific withanolide genetic stocks and their cross derived advance breeding line has been developed to be released as variety 'CIM-Pushti'.

Important Parameters Unique to the Development:

- Ashwagandha varieties so far released in India are indigenous selections in the germplasm and hence carry the feature of either one ecotype out of the two most widely found in India; and
- The developed plant variety has been generated through intra-specific hybridization and combines the root quality of Nagouri type (cultivated and annual type) and withanolide yield of Kashmiri type (wild, perennial type) in one genotype background.

The unique features of the new variety are:

- Withanolide A content is around 2.7-2.9% and average dry root yield is around 6 quintals per hectare;
- Undulated sub-coracious leaves;
- Strong semi-erect culm with culm angle at base around 45-55°;
- Mature berries yellow-orange;
- Cream colored, smooth, 25-30 cm long root with even fracture and high starch to fiber ratio; and
- Maturity in 165-175 days.

Major Application(s): The new variety will serve as a uniform quality raw material for nutraceutical and pharmaceutical industries using Ashwangandha plants parts, fresh or dry, or their derived extracts in any form. The farmers cultivating Ashwagandha will be directly benefited for the higher price of their produce.

Impact of the Technology: The proposed variety will give 30% extra yield in terms of root biomass in comparison to existing Nagouri type variety available in farmers' field, returning 40% extra revenue to the farmers with a tune of ₹50-60,000 per hectare.

CIM-Pushti

Apart from this, leaves rich in Withaferrin A will also generate an additional income to the farmers with a tune of ₹15000 per hectare. The cultivation of Ashwagandha in about 10,000-hectare area in different states will also generate employment during its cultivation, with an additional manpower of 50 man days per acre per year for root processing. Farmers can obtain a net income of ₹70000/ha per annum with the newly developed genotype which require very low inputs (₹20000/ha) with high returns within a period of 6-8 months. One-hectare plantation of Ashwagandha yields on an average 7-10 quintals of dried roots which are sold at about ₹15,000 per quintal giving a net return of about 80,000 from as 6-8 months' crop. Due to cultivation of this crop about 12.5 mandays are created in rural areas every year. Thus the beneficiary will be the society, as manpower, farmer, trader and pharmaceutical and nutraceutical companies

If taken up by industry, an economic raw drug source may reduce the cost of drugs and products which use Ashwagandha plants parts or its extracts in any form. Ashwagandha growing farmers will be directly benefited for the higher price of their produce. This high yielding variety will reduce the uprooting of this plant collected through the forests.

Commercialization Status: Two pharmaceutical manufacturing companies Pharmanzaa Herbal Pvt Ltd, Bangalore and Natural Remedies, Bangalore have visited CSIR-CIMAP, Lucknow and have shown interest in cultivation of Ashwagandha in a larger area through contract farming to meet their demand for quality roots raw material.

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Developing L-Asparaginase with Low Glutaminase Activity for Therapeutic and Food Processing Applications

Asparaginase industry is a multi-crore business worldwide. L-Asparaginase is well known for its chemotherapeutic properties, being an important component of Acute Lymphoblastic Leukemia (ALL) treatment and also helps in the reduction of acrylamide (a potential carcinogen) formation in food products during high temperature heating.

Currently, L-asparaginase from bacteria such as *E. coli* and *Erwinia* are commercially used. The presence of glutaminase activity in the L-asparaginase limits its use as potential therapeutic, thereby causing immunogenic and several associated side effects. Therefore, it is desirable to search for robust/engineered L-asparaginase having novel properties with less adverse effects. CSIR-IHBT has screened the bacterial diversity of unexplored western Himalayan regions in Himachal Pradesh for L-Asparaginase with novel properties and less adverse side effects. The institute has identified an efficient L-Asparaginase with no Glutaminase activity which has been evaluated for normal and cancerous cells lines for desired results.

Important Parameters Unique to the Development:

- An efficient Asparaginase enzyme from Himalayan microbial source which has wide temperature functionality;
- Asparaginase with no glutaminase activity;
- Gene for asparaginase has been cloned and successfully expressed in the E. coli host for high yield; and
- Evaluated in normal and cancerous cell-lines with desired results.

Major Application(s): Asparginase finds use in both pharmaceutical and food industry. In the former, for treatment of Acute Lymphoblastic Leukemia (ALL, childhood blood cancer) and pancreatic carcinoma and in the latter, it is used for reduction of acrylamide (a potential carcinogen) formation during high temperature heating.

Impact of the Technology: The commercially available Asparaginase drug is currently derived from bacteria *E. coli* and *Erwinia*. Since, this drug works in dose dependent manner, therefore, it is always associated with hypersensitivity and other major side effects. Hence, new sources of this therapeutic protein which are serologically different but have efficient therapeutic effects with low glutaminase activity were desired.

It is estimated to be $57,893/30 weeks (~40,00,000 INR) treatments and cost gets double in case of allergic response (Tong et al., 2014). EUSA's company improved Asparaginase drug Erwinaze cost about $150,000 to $175,000 (more than one crore) for a full course of treatment. However, the final prices vary with origin of Country and taxes thereupon. According to import data of Govt of India, more than $ 43,41,344 of Asparaginase has been imported for last 2 yrs It has been estimated that world enzyme market will grow to $6.2 billion by 2020 and 40% will account for therapeutic enzymes whereas Asparaginase contribute to 1/3rd of total sales. Therefore, there exists a high scope for directly generating bio-economy while improving the quality of life.

Commercialization Status: Secrecy agreement has been signed between the Phyto Biotech Pvt Ltd., Kolkata and CSIR-IHBT Palampur for sharing of scientific information to assess the commercial aspect of Himalayan version of Asparaginase. Expression of Interest (EoI) from the same company has been signed for further commercialization of the L-asparaginase technology.

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Calliterpenone for Enhancing Crop Yields

Application of chemical fertilizers and pesticides, though were important for achieving food security but their excessive usage has critically affected the soil ecosystem and health. With the current public concerns about the side effects of agrochemicals, there is an increasing interest in identifying biologicals which can improve the ecosystem functioning and crop health yielding zero-toxic crop produce generally called "Organic".

CSIR-CIMAP has developed a novel plant growth promoter "Calliterpenone" from an important medicinal plant *Callicarpa macrophylla*. Calliterpenone is about 6 times cheaper to GA_3. It is estimated that application of calliterpenone contributing to the improved growth and yield of the plant would reduce the application of fertilizers, growth hormones, etc and hence would reduce the cost of cultivation by 10% and simultaneously enhancing the yields by at least 10%. Exploitation of this CSIR-CIMAP technology can substitute use of costly growth promoters and be made available to poor farmers with small land-holdings for use in almost all the agricultural crops.

The process for isolation of the molecule and its activity as growth promoter has been patented in many countries.

Important Parameters Unique to the Development:

- Calliterpenone is about six times cheaper as compared to other expensive plant growth hormones like GA_3, the usage of which is mainly restricted to only high value crops;
- Enhances seed germination, rooting, production of bio-mass of roots, shoots and flowers in angiosperms thereby increases grain yield in several crops (wheat, paddy, tomato, potato, onion, mentha, artemisia etc.);
- Calliterpenone is eco-friendly and it promotes population of beneficial soil microorganisms like Rhizobium and Bacillus and retards the detrimental effects produced by allelochemical;
- Behaves synergistically with bio-inoculants; and
- May enhance the shelf life of several bio-inoculant formulations.

Major Applications: A formulation for crop growth promotion and yield enhancements; a potential candidate of organic agriculture.

Impact of the Technology: With the growing population, especially in developing countries like India, there is increasing pressure for maximizing yields through indiscriminate use of chemicals in agriculture. The widespread application of agrochemicals to intensify crop cultivation is known to severely affect the arable soils. The use of this molecule will reduce the use of chemical fertilizers and growth hormones improving the quality of food and ground water and significant enhancement in crop yields an increase of even 10% will enhance the overall benefits to the farmers by about ₹10000 per hectare.

Commercialization Status: CSIR-CIMAP has developed a Calliterpenone based natural formulation called as CIM-UPAJ which is currently under evaluation at the farmers' field. As soon as all the safety parameters are tested and verified the technology would be transferred to the interested industries. The technology was initially transferred to JK Agriseeds for pre-transfer evaluation. Also a company named M/s Royal Crop Science and Technology has been taken on board and a secrecy agreement has been signed with them for testing the chemical in fields.

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A Consolidated Biomass Process for Integrated Production of Multiple Products from Fresh Marine Macroalgae

Seaweeds have worldwide distribution and are well known for their uses in human foods and in phycocolloid industries. Current annual production of seaweeds worldwide has been estimated at 27 million tons fresh, with a value USD 7.3 billion. Recently, it has been reported that the agar supplies in global market declined due shortage of raw material supply. In India, most of the agar industries imports the raw material for agar production for domestic market consumption as well as export market. Therefore, there is an opportunity for India to capitalize this and emerge as a leading producer as well as supplier of agar/agarose and agarophytic resources to global market. Development of a cost effective technology for production and processing of seaweed biomass is envisaged for production of various chemicals of commercial value using the bio-refinery model.

Important Parameters Unique to the Development:

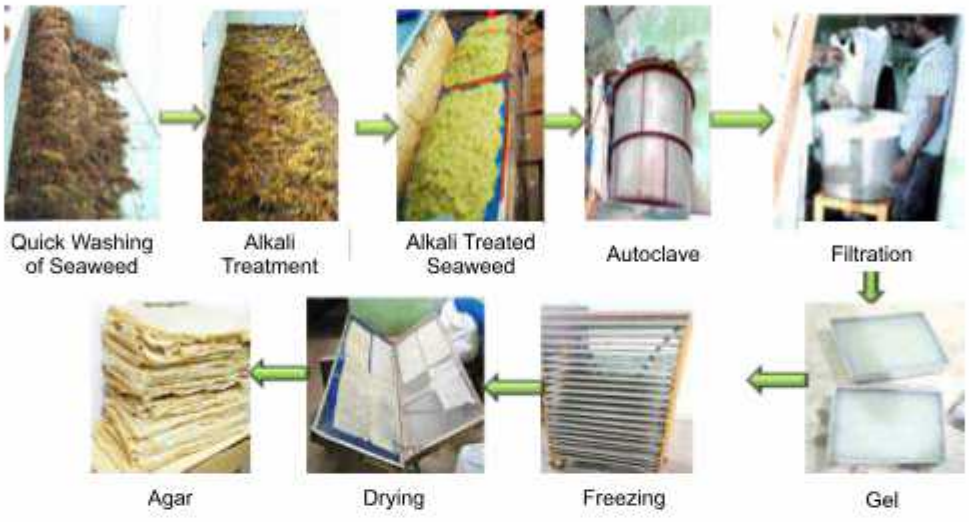
- Total utilization of feedstock without any leftover residue as solid waste;
- Technology platform for production of different products;
- The water in pigment extraction and solvents in lipid extraction are recyclable;
- The amount of reagents required for extraction of product is significantly reduced in successive steps due to substantial reduction in mass (densification);
- High throughput method with least effluent discharge; and
- Provide scope for value addition of products.

Major Application(s): The phycocolloids (hydrogels) are used as thickeners, emulsifiers, gelling agent in many food, pharma, agro-based products. Pigments can be used as natural colorants and lipids in nutritional supplements. Cellulose can be used as feedstock for bioethanol or alternatively as excipient in pharma.

Impact of the Technology: India with more than 7500 km coastline and EEZ of 2.3 million sq. km has immense potential to use the available sea front for meeting her growing demands for food, fertilizer, chemicals and energy. Most of the products extracted are of consumer use and have well established global markets with several billion USD. The innovation applied in this technology has indeed potential to form marine-based macroalgal bio-refinery contributing to self-reliance and economic growth of the country in future.

The bio-refinery demands huge volumes of biomass that can only be augmented through farming practice, which itself is manpower intensive and creates new employment opportunities in coastal regions which are normally resource starved. The secondary benefit of seaweed farming is that it creates new prospects for establishing seaweed bioprocessing industry which not only create employment to coastal rural community but also promote socio-economic development of such regions which are lagging behind in development in the country.

Commercialization Status: The continuous and steady supply of seaweed biomass through scaling up is a pre-requisite for process/product development. Further, systematic studies on cultivation enable understanding the techno-economic feasibility of whole cultivation activity. The seaweed farming of *Gracilaria* spp has been initiated following tube net method using the seed germplasm maintained at CSIR-CSMCRI cultivation farm at Simar (near Una), Gujarat. Pilot scale production of agar has been achieved.



The agar was found having gel strength of 1600 g/cm^2 with yield of 24% and the quality was at par with the one supplied by HiMedia Laboratories, Mumbai.

Five kg dry Gracilaria dura/batch was used at the institute pilot plant (CSIR-CSMCRI, Bhavnagar) to produce 550 g agar in a single batch. [Properties of agar: Gel strength = 2500 g cm^{-2}; gelling temperature = 38 °C; pH = 7.3, and suitable for bacteriological use]. M/s Himalaya Ice factory, Bhavnagar facility was used to freeze thaw the agar gel.

M/s. HiMedia Laboratories, Mumbai as industry partner agreed to take active part in the project by purchasing seaweed produce from beneficiaries from time to time as per prevailing market rate. A Non-Disclosure Agreement has been signed with the company to produce 30 Kg agar using their pilot plant facility.

Ice making pot filled with 150 kg agar extract of G. dura

60 h at -6 °C

150 kg agar extract of G. dura after freezing

Make small pieces for melting/Thawing

Agar product after thawing

Contact: The Director, CSIR-Central Salt and Marine Chemicals Research Institute, Gijubhai Badheka Marg, Bhavnagar - 364002, Gujarat; Tel.- 0278-2567760, 2568923, 2565106; Fax.- 0278-2567562, 2566970; E-mail: director@csmcri.res.in

Agrotechnology Transfer and Thymol Crystal from Jammu Monarda

Thymol is known for its biological activities such as antifungal, potent inhibitory effect on membrane-bound enzymes etc. and is in great demand by various pharmaceutical companies. The main source of thymol is Ajwain (*Trachspermum copticum*). Until now, various natural sources for thymol and process for its production have been reported but most of them are limited as well as costly because crude oil of related crops contains maximum 50% of thymol. In particular, existing crops for purifying thymol from crude thymol oil may require long process to isolate thymol from the crude thymol oil compositions.

Monarda citriodora is an annual herbaceous plant. This plant species is suitable for subtropical climatic conditions of Jammu and temperate climatic conditions of Kashmir. It has potential for large-scale production of essential oil. The essential oil possesses high level of antifungal activity against common post-harvest fungal pathogens of a variety of crops both by direct contact and in the vapour phase. The essential oil contains high amount of thymol (53-85%) and carvacrol. The demand of thymol containing essential oils is increasing every year. Essential oil of *Monarda citriodora* has been accepted by pharmaceutical houses as an additional and alternative source of thymol. The prevailing price of the oil in Indian market is ₹1500/kg.

CSIR-IIIM introduced the plant in Jammu region and developed a cultivar of the plant containing 70-85% thymol content and suitable for cultivation in the region along with its agro-technology. The cultivar has been named Jammu Monarda. The institute has also developed process for the production of thymol from *Monarda citriodora* that allows direct preparation of high purity thymol in maximum quantity from crude thymol oil. In the production process, thymol crystals are formed directly from crude oil under controlled cooling of the crude thymol oil in a closed system without the necessity of human contact with the crude Jammu Monarda oil. Thus, the method can be easily adapted to GMP regulations, and may be used to produce pharmaceutical grade thymol.

Important Parameters Unique to the Development:

- Jammu Monarda contains high amount of thymol (53-75%) and it was first introduced by CSIR-IIIM;
- At laboratory scale, experiments have been carried out at 1-liter scale with recovery thymol with 99% purity;
- Large scale cultivation of Jammu Monarda (Monarda citriodora) in Jammu regions and multi-location trial in Uttar Pradesh, Jammu and Kashmir;
- Development & standardization of process for thymol crystal production at laboratory scale; and
- Preparation of thymol as Certified Reference Material (CRM).

Major Application(s): The cultivation of Jammu Monarda by the farmers is a step towards their socio-economic upliftment through the high economic return crop. It will also fulfil the industrial demand of plant based natural thymol crystals.

Impact of the Technology: The plant species is suitable for subtropical climatic conditions of Jammu and temperate climatic conditions of Kashmir, and has potential for large-scale production of essential oil. The essential oil contains high amount of thymol (70-85%). New knowledge of cultivation, optimized harvesting time and post-harvest processing of Jammu Monarda in different locations and improved technology developed in the project will be useful for farmers for cultivation of the crop in scientific manner and higher yield with quality to get the higher economic return.

Commercialization Status: MoU has been signed with progressive growers and quality planting material shared with them for cultivation in Hisar (Haryana) and Batote (Distt. Ramban, J&K). Process patent is being filed for thymol crystals from *Monarda citriodora*. Thymol crystals have been submitted to Ultra International Company for R&D process related to value addition.

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Low Grain Arsenic Rice Variety for Safe Human Consumption

One of the main causes for Arsenic (As) exposure to the human is through consumption of rice cultivated in arsenic contaminated fields, contributing to more than 60% of dietary As exposure as rice is the major cereal food in As-contaminated regions of South-East Asia. According to an estimate, the total As concentration in rice ranges between 0.005 to 0.710 mg kg−1 dw in different varieties and from one geographical region to other, e.g., <0.01–2.05 for Bangladesh, 0.31–0.76 for China, 0.03–0.44 for India, and 0.11–0.66 for USA (Zavala and Duxbury 2008). In West Bengal, out of 18 districts, nine have been identified where the groundwater contains arsenic above 0.05 mg l-1 (the maximum permissible limit of arsenic in drinking water, recommended by WHO). In the combined areas of West Bengal and Bangladesh, around 150 million people are at risk from As-contaminated groundwater which included exposure due to consumption of arsenic contaminated rice. As of now there is no known cultivar of rice which accumulates less arsenic, which can significantly reduce the arsenic exposure to the poor peasants of arsenic affected regions. According to WHO, the permissible limit is 2 µg per Kg body weight per day, and with average consumption of rice by an adult is 400 gms. The arsenic found in the cultivar ranges between 35-180 µg Kg-1, given that an average weight of adult person is 65 kg, it turns out to be 72 µg of As intake per day, considering the highest level (180 µg Kg-1), which is within the safe level.

A low-grain arsenic rice variety CN1794-2-CSIR-NBRI (IET 21845) was developed by joint efforts of CSIR-NBRI and Regional Research Station, Chinsurah, West Bengal. The variety was developed by screening and selection of rice germplasms from both seasons (*Boro*, the summer and *Aman*, the Rainfed) including more than 100 rice germplasms in collaboration with Rice Research Station (RRS), Chinsurah, West Bengal. It accumulates arsenic 147 µg kg-1 dw in its grains, which is 1.18 µg of arsenic kg-1 body weight (Maximum tolerable daily intake (MTDI) for arsenic is 2 µg kg-1 body weight (WHO). It was approved by the State Variety Release Committee (SVRC), Govt. of West Bengal on 15th of January, 2016 for cultivation in West Bengal.

The variety possesses light aromatic property and grain size is comparable to popularly accepted variety i.e. *Shatabdi* and *Khitish*. Maturity from sowing to harvest is 130 days. Average Yield is 4377 kg/ha (*Kharif*), 5743 kg/ha (*Boro*), seed rate is 35 kg/ha and optimum dose of N:P:K @ 120:60:60 kg/ha (*Boro*); 60:30:30 kg/ha (*Kharif*).

Important Parameters Unique to the Development

- CN 1794-2-NBRI has average arsenic content in its grains not more than 147 µg kg-1 dw, which translates to 1.18 µg of arsenic kg-1 body weight; and
- The yield of the cultivar is comparable to the local popular cultivars (4.2 Kharif and 5.2 t ha-1 during boro).

Impact of the Technology

- Arsenic contamination of water and soil in West Bengal is severely affecting the production of rice. In severely arsenic affected regions 20-50% yield loss has been

observed in various rice varieties. CN 1794-2-NBRI cultivation will benefit farmers by increasing their income particularly in arsenic contaminated areas due to arsenic induced yield loss;

- CN 1794-2-NBRI demonstrated a yield advantage of 10-15% over popularly grown varieties which would increase income of farmers;
- The primary advantage of CN 1794-2-NBRI, is less arsenic intake through food thus decreasing the risk of cancer and arsenicosis;
- Cultivation of CN 1794-2-NBRI may reduce the chance of rejecting rice during exports to developed nations;
- CN 1794-2-NBRI can be cultivated by the farmers of other arsenic contaminated states of India including Indo-Gangetic plain (West Bengal, Chattisgarh, Bihar, Uttar Pradesh, Uttarakhand, Punjab etc.); and
- CN 1794-2-NBRI may be sold to neighbouring countries particularly to Bangladesh having similar agro-climatic conditions and arsenic contaminated paddy fields.

Commercialization Status: The field trials of CN-1794-2-NBRI in comparison to two other popular cultivars viz. Gotra Bidhan-II and Shatabdi, have been performed in three locations of arsenic contaminated regions in West-Bengal with different level of contamination Dist Hoogly (10.32) low arsenic, Dist. Nadia (15.50) medium arsenic and Dist. 24 parganas (25.04) high arsenic (µg kg-1 dw) for their comparable arsenic accumulation into their grains and their yield penalty. The trials of the three rice cultivars were conducted for three *Aus, Aman* and *Boro* seasons (Figure 1). The analysis for the arsenic (µg kg-1) in the grains shows significant variation ($p<0.05$) between the three seasons, among three locations along the soil arsenic gradient and also between the three varieties i.e. CN1794-2-NBRI, *Gotra Bidhan* and *Shatabdi.* Arsenic level in Muktashree was lower than *Gotra bidhan II* and *Shatabdi* in the high and low soil As contaminated areas.

Data on the grain yield suggest that there is no yield loss in the cultivar CN1794-2-NBRI when grown at As-contaminated site. The yield of CN-1794-2-NBRI was higher to the yield of another long grain rice variety i.e. Shatabdi (Table 1).

CN 1794-2-NBRI has been approved for national release by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops, Shastri Bhawan, New-Delhi. A Ludhiana based company i.e. Ebro India Pvt. Ltd. (an Indian subsidiary of Ebro Foods, Spain) has expressed interest in cultivating this low arsenic cultivar. However, without the national release of the cultivar the Punjab based company is unable to procure and cultivate elsewhere outside West Bengal. Technology is available for licensing.

Figure 1: Rice varieties viz. A. CN-1794-2-CSIR-NBRI (*Muktashree*), B. *Gotra Bidhan-II* and C. *Shatabdi* grown in Birnagar (Nadia) for the *Boro* season ready to be harvested for *Boro* season

Table-1

		Aus (2017)			*Aman* (2017)			*Boro* (2018)		
		Muktashree (CN-1794-2-NBRI)	Gotra Bidhan-2	Shatabdi	Muktashree (CN-1794-2-NBRI)	Gotra Bidhan-2	Shatabdi	Muktashree (CN-1794-2-NBRI)	Gotra Bidhan-2	Shatabdi
High soil As level (>25 µg g $^{-1}$) Gaighata	Yield (tons/ ha)	3.0	3.25	2.5	3.6	4.5	2.7	3.5	3.0	3.0
Medium soil As level (14-16 µg g $^{-1}$) Birnagar	Yield (tons/ ha)	2.8	3.0	2.4	2.4	4.5	3.0	4.1	3.9	3.7
Low soil As level (8-11 µg g $^{-1}$) Khamargachi	Yield (tons/ ha)	2.9	3.5	3.0	3.6	3.5	3.0	3.4	2.9	2.7

Grain yield of the three cultivars, *viz.*, CN-1794-2-CSIR-NBRI (*Muktashree*), *Gotra Bidhan* and *Shatabdi* cultivated in high, medium and low soil As contaminated location of West Bengal for *Aus*, *Aman* and *Boro* seasons.

Low Grain Arsenic Rice

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Thebaine-rich Opium Poppy Lines for Suitable Cultivation through Narcotics Department

Thebaine is medicinally important molecule required by pharmaceutical industries for manufacture of a number of lifesaving drugs. In recent years, global demand of thebaine has increased multifold (210 tons in 2016 to 363 tons 2018). US ranks first in the world in thebaine utilization and demand varies depending upon US market. India's share in global production of thebaine is only 2 tons. Globally no thebaine rich variety/line/cultivar exists.

In existing indigenous opium poppy cultivars, approximately 2% thebaine accumulates in capsule latex. CSIR-National Botanical Research Institute (CSIR-NBRI) has developed breeding lines of opium poppy with thebaine content up to 10% in the latex. One line NBIHT-3 having thebaine content up to 10% was selected. After multiplication and registration in NBPGR, the seeds of the line have been deposited with the Narcotic Department, Ministry of Finance.

Important Parameters Unique to the Development: Thebaine content in opium poppy.

Major Application(s): Use in manufacture of lifesaving drugs by pharma industries.

Impact of the Technology: CSIR-NBRI has developed breeding line with thebaine content up to 10% in latex for the first time. The developed thebaine rich line(s) can substantially fulfil the demand of thebaine for pharmaceutical industries in India, improving Indian economy. Simultaneously, the socio-economic condition of the opium cultivators can also be uplifted.

Thebaine has $500 to $600 million market in Canada and a multibillion-dollar market in United States. Therefore, if cultivated in large scale using the developed line, India will not only reduce the import of thebaine and its derivatives for its requirements but would also be an exporter of Thebaine.

Commercialization Status: The passport data on 11 thebaine rich lines along with two checks collected on opium, seeds, specific alkaloids along with thebaine content compiled was submitted for the registration of promising thebaine rich line NBIHT-3 at NBPGR, New Delhi. The line has been registered at NBPGR, New Delhi.

Beside this, the line has also been released by the Institutional variety release committee. Seeds of NBIHT-3 are under possession of Narcotics Deptt. for suitable cultivation. Rusan Pharma, Mumbai, a Pvt. Company is doing trial cultivation of the line for suitability of its commercial cultivation with the permission of MOF.

A MoA between company and CSIR-NBRI is signed under consultancy mode. Technology is available for licensing.

Multiplication of Breeder Seeds

Field view - NBRI Campus U.P.

Field view - Mandsaur M.P.

Field view - Chittorgarh Rajasthan

Opium Poppy

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An Improved Variety of Yellow Satawar (*Asparagus adscendens* Roxb.) For High Root Yield with Better Quality

Satawar is an important medicinal plant. Yellow Satawar (*Asparagus adscendens* Roxb.) is preferred in pharmaceutical/nutraceutical industries and is in great demand. India is importing roots of yellow Satawar from Nepal where collection is mostly from wild sources. There is wide gap between demand and supply for Pili Satawar roots. The estimated annual demand of the roots in pharmaceutical industry is about 8000 to 9000 tons. India is producing/collecting about 1000 to 2000 tons of white/yellow Satawar roots annually. Dried roots of yellow Satawar sell at a rate of ₹450-500/ kg while dried roots of white Satawar are sold at rate of ₹100-150 /kg.

At first, CSIR-CIMAP, through consistent breeding efforts, has developed a plant type having high dry root yield, averaging at about 97.6 quintals per hectare with 11.3% saponin content. The harvesting time is also reduced from 24 months to 18 months, which will enable the growers to cultivate any other suitable short duration crop in the same field after harvesting of Satawar. Growing demand of yellow Satawar combined with high productivity of the new variety CIM-Sunahari, and a net profit potential of about ₹4.5 lakh to 5.0 lakh per hectare within a period of 18 months is an attractive proposition for farmers to take up its cultivation. The performance of the variety was tested through multi location trials conducted at the C.R.C. Pantnagar, Bangalore, Hyderabad and Purara.

Important Parameters Unique to the Development:

- First such development of a variety of Yellow Satawar; and
- Developed variety has high root yield of 97.6 quintals per hectare with 11.3% saponin content.

Major Application(s): Yellow Satawar has application in the pharmaceuticals and nutraceutical industries.

Impact of the Technology: There will be availability of authentic, high yielding better quality, stable variety, which also provide sufficient quantity and quality raw material for the phytopharma-ceutical and nutraceutical industries. The new variety has potential to provide high income to farmers especially in stress prone and shade affected areas. There is potential of about 35-40% reduction in the cost of production per kg root due to enhancement in the yield. Hence, farmers will get same level of profit under reduction of the price up to 30-35%. There is scope for additional employment generation for rural women with post-harvest processing activity.

Close-up view of flowering and fruiting stage of Yellow Satawar

High Quality Dried roots and Seeds of Yellow Satawar Var. CIM-Sunahari

Farmers field view of yellow Satawar (Var. CIM-Sunahari)

Commercialization Status: This is first such development of a variety of Yellow Satawar. The new variety has been named "CIM-Sunahari" CSIR-CIMAP is disseminating the knowhow using its biovillage model through scientist-farmers-industry meet, survey, goshthi, training, meeting and campaign to develop awareness and buy back arrangement between farmers/industry. Approximately 63-acre area has been brought into cultivation of yellow Satawar variety CIM-Sunahari.

Contact: The Director, CSIR-Central Institute of Medicinal & Aromatic Plants, P.O. CIMAP, Lucknow (UP) Tel.-0522-2718503,2718509, E-mail: director@cimap.res.in

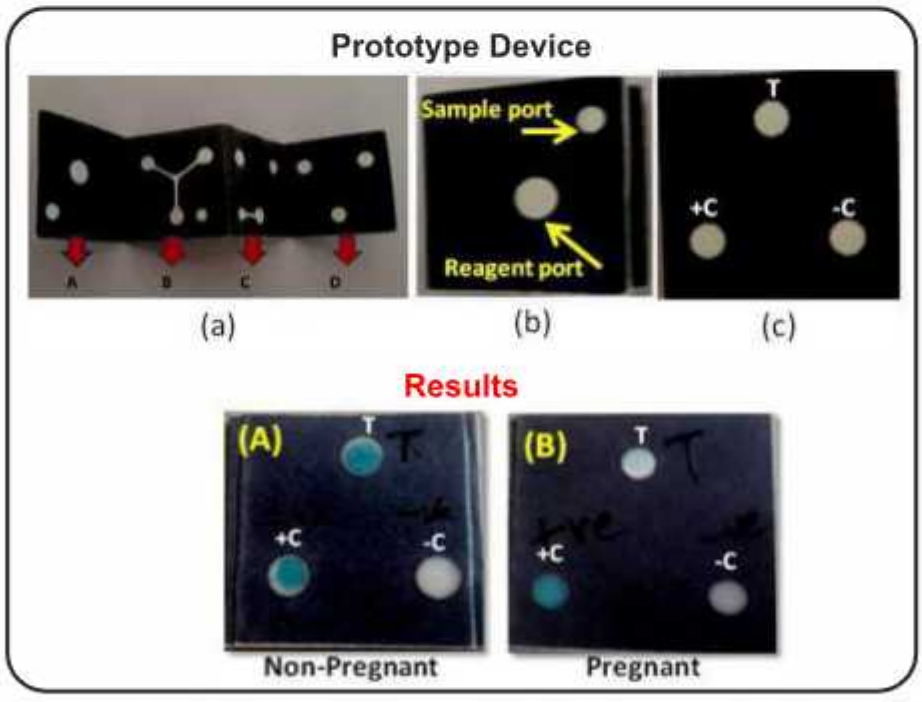
Paper-based Affordable Microfluidic Kit for Early Pregnancy Detection in Cattle and Buffaloes

The Dairy industry is about ₹ 1,07,504 crores annually and 7 crores farmers are involved in it. Early detection of pregnancy is important to maximize the milk production and shortening of calving interval. Traditionally, pregnancy in livestock is detected after 3-4 months of conception. CSIR-CCMB has identified a biomarker from dung sample for early detection of pregnancy in cattle and buffaloes. Using this biomarker, an affordable, rapid, easy to use, paper-based prototype device for early detection of pregnancy has been developed.

Important Parameters Unique to the Development:

- It is non-invasive. Fecal samples are used for detection of pregnancy;
- Pregnancy can be detected within 3-4 weeks;
- It is an affordable paper-based device;
- Easy to use on-site detection in the rural areas;
- It is easily disposable therefore environmentally green; and
- No equipment, no cold-chain is needed.

Major Application(s): Non-invasive early pregnancy detection in cows and buffaloes.



Complete Prototype Kit

Impact of Technology:

- The device would help dairy farmers to detect pregnancy at an early stage and plan for pregnancy management and artificial insemination as needed;
- This leads to both improved reproductively outcome and milk production resulting in economic benefit to the farmers; and
- Early detection of pregnancy will have strong socio-economic impact on farmers and dairy industry

Commercialization Status: Technology is available for licensing.

Contact: The Director, CSIR-Centre for Cellular & Molecular Biology, Uppal Road, Hyderabad - 500007; Tel.- 040-27160789; Fax.- 040-27160252; E-mail: director@ccmb.res.in

Accurate, Reliable and Cost Effective Sensor for the Electrochemical Detection of Multiple Analytes- Farmer Friendly Hand-held Soil Testing Kit

In the agricultural sector, soil analysis is highly essential to know the nutrient content, composition and other characteristics such as the acidity or pH level. This has become a valuable tool for assessing soil fertility and arriving at proper fertilizer recommendations. To evaluate the soil quality, the farmers have to collect soil samples as random and benchmark procedures. Further, they have to consult with the laboratory regarding analyses of the soils and later for the expert recommendation.

To avoid all the present cumbersome procedures and to make the soil analysis easy for the farmers, CSIR-CECRI has developed a soil test sensor kit which assesses the soil health [levels of primary nutrients (N-P-K), Electrical Conductivity (EC), and pH] by the farmer himself through a very simple approach. In addition, the kit is capable of identifying the location using GPS, soil moisture, temperature and extends data storage also. Based on the collected soil health information, it can predict the fertilizer recommendation for a particular crop using a Mobile App. So, using this kit, the farmers can assess the exact soil condition, and they can decide the crop as well as the fertilizer plan more efficiently and economically. The developed meter is capable of measuring the core soil health parameters in the field itself.

Salient Features:

- The present meter is capable of measuring soil pH, electrical conductivity, macronutrients - N, P & K, with the soil extract prepared onsite;
- It works based on the colorimetric principle for the estimation of pH, N, P and K;
- Measurement of electrical conductivity is governed by the electrochemical principle; and
- Meter provides color based indication as Low, Medium, High & Excess levels of the NPK analyte.

The preliminary laboratory version of the kit was released on 25th Feb. 2017 by Hon'ble Union Minister of Science and Technology Dr. Harsh Vardhan, while visiting CSIR-CECRI, Karaikudi.

To take it to the next level, the Kit was exhibited at the Kisan Mela-2018 organized by CSIR-CIMAP, Lucknow on 31st Jan. 2018. The kit was introduced to the farmer community by Shri Giri Raj Singh, MSME Minister and Shri Surya Pratap Shahi, Uttar Pradesh Agriculture Minister. The demonstration was witnessed by large number of farmers, technocrats and scientific community who has showed their interest on this development. This has gained more confidence on Scientists in launching this technology in the near future for our Nation farmers, with suitable up-gradation

Merits of the Soil Test Kit:

- The developed meter is simple, quick and convenient to use;
- Test can be carried out on the spot where the problem exists and facts & conditions related to the issue are fresh in mind;

- It cuts down on the cost of time, transportation, and materials that may be needed to carry soil samples to the laboratory for analysis;
- It provides a much better guide than blanket fertilizer recommendations; and
- It enables the literate and enlightened farmers to conduct their on-the-spot analysis and interpretation of the test result without the assistance of official extension agent.

Status of Development / Commercialization: In a recent development, the above soil senor kit was demonstrated to Krishi Vigyan Kendra (KVK), Kundrakudi during May 2019. It was well appreciated as a predictive model gadget for the prediction of soil health monitoring. Based on that, ten such units have been fabricated and were handed over to Krishi Vigyan Kendra for further field deployment in a function of CSIR-CECRI Foundation Day celebrations on 25th July 2019 where Dr. Shekhar C Mande, DG, CSIR handed over the soil testing kits to the KVK officials.The technology is available for licensing

Contact: The Director, CSIR-Central Electro Chemical Research Institute, Karaikudi - 630003; Tel.- 04565-241502, 227778; E-mail: director@cecri.res.in

Mupirocin + IIIM-1133/06: A Topical Formulation for Improved Bio-efficacy

Mupirocin is used as a topical treatment for bacterial skin infections. However, there are increasing reports of high-level mupirocin resistance that necessitates the development of complement therapies/novel combinations.

CSIR-IIIM, Jammu has developed a novel formulation that will minimize the changes of development of mupirocin resistance. The proposed combination of mupirocin with bacterial efflux pump inhibitor (IIIM-1133) will also increase the potency of the drug. IIIM-1133/06 has no lethal effect of its own on the bacterial so there are no changes of bacteria developing resistance against this compound.

Important Parameters Unique to the Development:

- The developed formulation has potential to reduce the chances of emergence of resistance;
- The formulation will improve the efficacy, shorten the healing time. In-vivo efficacy results with the cream formulation revealed that a formulation of mupirocin 2% + IIIM-1133 (0.5%) improves the efficacy and decreases the healing time to 3 days compared to 2% mupirocin which takes 5 days to heal; and
- IIIM-1133 has no lethal effect of its own on the bacterial so there are no chances of bacteria developing resistance against this compound.

Major Applications: The major application of the mupirocin formulation will be as a topical treatment for bacterial skin infections caused by Gram positive bacteria including MRSA. It would also have perioperative nasal application before a patient undergoes a major surgery.

Impact of the Technology: The identified lead is aimed to improve the therapeutic outcome of the topical formulation of mupirocin in the patients suffering from topical bacterial infections. The formulation will also provide protection to the patients during hospital stay and during major surgeries.

Commercialization Status: Pre-clinical studies have been completed. For filing IND, pre-clinical dossier along with Phase-I clinical trial protocol is under preparation and will be submitted to DCGI for approval. The potential stakeholders will be involved at this stage for out-licensing the lead to them for further development.

Contact: The Director, CSIR-Indian Institute of Integrative Medicine, Post Bag No. 3, Canal Road, Jammu -180001; Tel.- 0191-2584999, 2585222; Fax.- 0191-2586333; E-mail: director@iiim.res.in

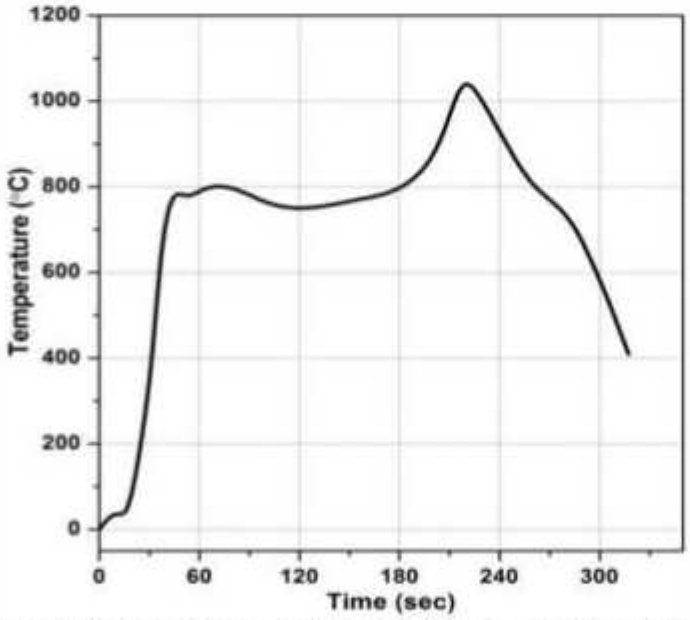
Mining, Minerals, Metals & Materials Theme

Mining, Minerals, Metals & Materials Theme

High Temperature Ceramic Thermal Barrier Coatings (TBCs) for Missile Components

Surface to surface missiles are designed to operate at speed of 7 mach and at this juncture the skin temperature of airframe experiences the high temperature. Catastrophic increase in temperature is detrimental to the electronic navigation systems in the missiles and the protection of these systems is essential for defense. Currently our country is using Russian technology; hence, there is demand for indigenous technology development.

Considering aforesaid, CSIR-CECRI has developed multi-layered thermal barrier coatings for missile surfaces to protect the electronic navigation systems and control surface structures from extreme temperatures during flit time.

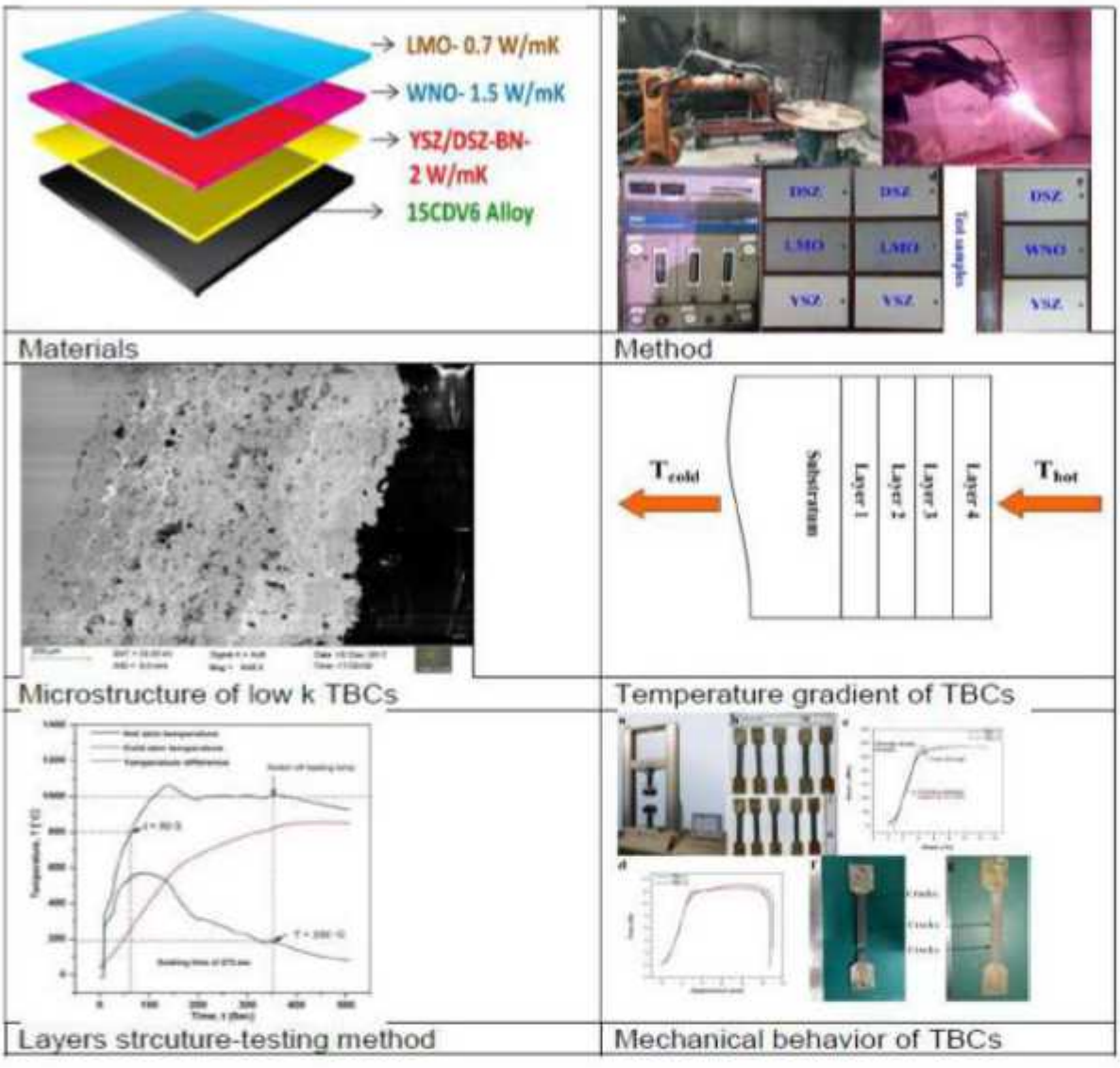


The wall temperature vs time profile of missile surface

Important Parameters Unique to the Development:

- High temperature resistant TBCs developed using low k oxide materials ($La_2Mo_2O_9$, $W_3Nb_{14}O_{44}$) by plasma spray process;
- A four-layer structure with gradation in thermal conductivity and thermal expansion co-efficient;
- Temperature gradient – 150 - 200°C (at 850°C);
- Surface roughness of TBCs - 3 mm; and
- Coatings thickness: 700 - 900 mm.

Major Application(s): Major applications of TBCs are found in Defense, Space and Aerospace sectors.



Impact of the Technology: Development of high temperature resistant TBCs can address many problems in Defense, Space and Aerospace sectors. Globally TBCs are applied to protect components from high temperature. Till now their applicability restricted to aerospace turbine and Re-entry space vehicles. However, the application TBC coatings for Missile parts to protect inner electronic components have not been attempted.

Commercialization Status: The technology has been licensed for DRDO. The technology is also available for licensing abroad and other related industries and ISRO.

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A New Class of Hybrid Composite Wood for Civil Infrastructure

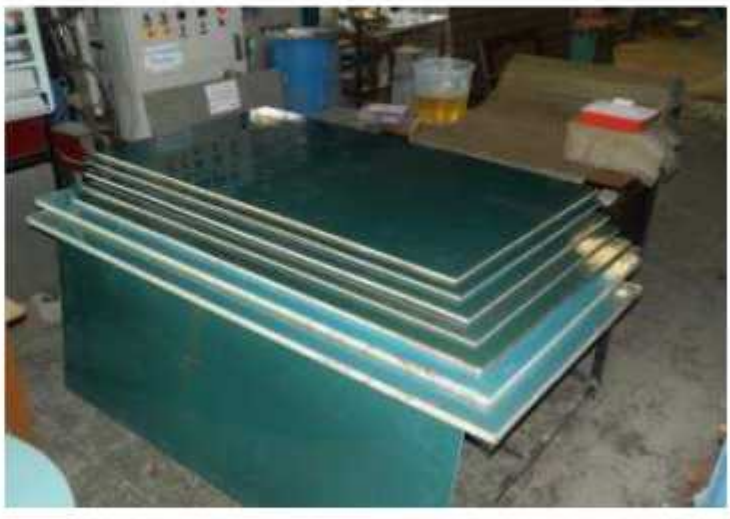
In India, wood is not available easily and is expensive. Excessive use of wood leads to deformation and global warming. Moreover, wood, particle board, MDF board, ply wood are not resistant to moisture, termite, fungus and fire. Glass fibre reinforced plastic and composite products are made of petroleum-based polymer and fibres, which is not renewable and environment friendly. Such composite materials are expensive, energy intensive and disposal at the end of their service life become a problem as they are hazardous in nature.

India produces about one billion tons of industrial wastes annually and disposal of such huge wastes is a major challenge for the country. India produces more than 300 million tons of natural fibres annually which has not been effectively utilized.

CSIR-AMPRI, Bhopal has developed a technology for manufacturing "hybrid green composite panels and boards" using industrial waste particulates and natural fibres in polymeric system. This technology would provide holistic solution for effective utilization of different industrial wastes such as red mud, fly ash, marble and granite waste and other mineral wastes and natural fibres leading to solution of various environmental threats associated with mismanagement of industrial wastes, deforestation and ecological imbalance.

Problems Addressed and its Impact:

- Avoid deforestation and save environment;
- Find alternative materials for timber, synthetic wood, plastic and GRP composites;
- Convert industrial waste into a wealth;
- Utilise unexploited renewable natural fibres and avoid use of synthetic fibres; and
- Create employment and income through sustainable manufacturing a new class of highly durable composite materials to the society.



Hybrid composites made of industrial wastes

Advantages of Hybrid Composite Materials:

- Almost 30 % economical in price than teak wood and more than four times stronger than teak wood and maintenance free products;
- As compared to synthetic wood (particle board, MDF board, ply wood), the hybrid composites are about 15% cheaper and far better in quality;

- Production process is simple, energy saving and environment friendly;
- No swelling and no shrinking under all weathering conditions; and
- Hybrid composites are resistant to termite, fungus, moisture, fire and maintenance free materials.

Applications: Hybrid composites find applications in doors and door frame, wall tiles, false ceilings, roofing sheets, floor tiles, partition wall, architectural cladding panels and materials for furniture. Hybrid green composite materials have ample scope to be used in civil infrastructure and in transportation system.



IPR and Commercialisation Status: Three patents on the process knows- how for manufacturing hybrid composite materials have been filed in eight countries under PCT and four technologies have been licensed in this area to three industries in Gujarat, Maharashtra and Chhattisgarh as well as to Government of West Bengal on non-exclusive basis. As part of the technology licensing, training was provided to entrepreneurs and industries at CSIR-AMPRI,Bhopal and technical support provided to ease the commercialization at their respective locations. New linkages have been made with about 20 industries and agencies including Tata Power and Aditya Birla Group for commercialisation.


Developed Panels

Realization of this technology would significantly contribute to "Make in India, Clean India and Skill India programs of Government of India and has ample scope to create new entrepreneurship with export potentials.

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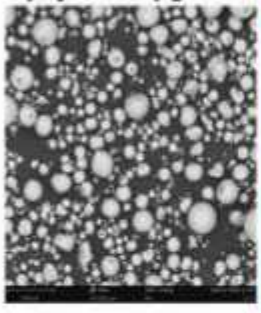
With and Without Novel Ion Doped Plasma Spray Grade Hydroxyapatite Granules for Biomedical Application

General hydroxyapatite (HAp) coating technology using plasma spraying is not available in India (especially in biomedical industry). Further, current metallic implants (such as hip prosthesis, knee prosthesis, bone plates, screws, etc.) that are being coated abroad are very expensive and are not affordable by majority of Indian patients, particularly those 800 million people below the poverty line. To address the aforesaid CSIR-CGCRI has optimized the Hap granule preparation and plasma spray coating parameters and developed a technology to provide affordable healthcare to Indian Patients. Currently there is no Indian technology available till date and no doped HAp technology is available throughout the globe.

It has been reported that cell growth rate increases for the HAp coated implants which lead to better fixation with bone and artificial implant. Powder composition, particle size, feed rate, substrate roughness & cleaning, primary/secondary gas flow rate, gas pressure, plasma power, standoff distance, coating time are some of the main parameters for achieving good coating for plasma spray. Thus main focus of the project was to: (a) develop freely flowable HAp granules with/without ion doping by spray drying method and; (b) optimize plasma spray coating parameters using these powders.

Spray dried HAp granules



Plasma spray HAp coated hip joint stems and shell

Director, CGCRI handing over the Technology Transfer Document to the representatives of M/s Orthotech, Gujarat on 14/02/2018

Plasma spray HAp coated nasal implant

Plasma spray HAp coated finger joint

Plasma spray HAp coated dental implant

Important Parameters Unique to the Development:

- First of its kind indigenous technology for Manufacturing of plasma spray grade hydroxyapatite granules; and
- Cost-effective indigenous solution for cement-less fixation of orthopaedic implants and dental bone filler material which has huge market potential.

Impact of the Technology: Cement less fixation of hip stem and shell, finger and other joints, for example maxilla and mandibular dental implants, spine screws, etc.; this will directly improve the quality of life in terms of implant life when used clinically. Significant improvement in quality of patients' life with HAp coated implants due to faster healing, increased bonding and overall increase in the service life.

It is an indigenous technology with significant cost and time saving. If adopted by Govt. hospitals, through policy decision by Govt., there will be huge savings in Govt. annual expenditure on healthcare via replacing the imported implants with implants processed using this technology.

Commercialization Status: Technology for manufacturing plasma spray grade hydroxyapatite granules has been transferred to M/s Orthotech, Gujarat. Technology is available for further licensing.

Contact: The Director, CSIR-Central Glass and Ceramic Research Institute, Kolkata - 700032; Tel.- 033-24735829, 24839241; E-mail: director@cgcri.res.in, dir_office@cgcri.res.in

Packaged Fiber Laser Modules for Industrial and Medical Applications

Presently, Indian industries import the fiber laser modules from abroad for material processing and clinical use since the product is not available in India.

An indigenous technology of Fiber Laser has been developed for fulfilment of user defined parameters of Indian industries and medical practitioners at the competitive cost. Novelty of this technology is to fabricate specialty Yb-fiber for amplifier and the pulse-shape technique by applying Q-switching principle which is applied for generation of 'clean' and 'undistorted' laser pulse. This clean pulse is very much useful for material marking, stent-cutting, diamond processing, solar-cell scribing etc. The CW laser at 1.94 μm has potential to replace the clinically used Ho:YAG laser with greater efficiency and less surrounding damage in tissue surgery.

Significant Achievement:

- Prototype module of Pulsed Yb-fiber laser @ 1064nm of 20W power is developed and field-trial is successfully done by using the module in commercial marking machine;
- Prototype demonstration of 2 micron Tm-fiber laser and preclinical testing in soft tissue surgery is done; and
- Technology for 'development of Pulsed Yb-fiber laser and CW Tm-fiber laser has been transferred to Bharat Electronics Ltd (BEL, A Govt. of India Enterprise), Bangalore.

Specifications of the Products:

Impact of the Technology: In manufacturing, laser processing is a basic prerequisite for high-volume, low-cost manufacturing. The fiber laser may substitute all the conventionally used solid state / gas lasers in manufacturing and medical applications. It is one of the cutting-edge technologies that will impart a substantial impact on the Indian economy and employment generation. The indigenously developed fiber laser technology will fulfil the requirement of desired specifications of the end-users as well as make it cost effective.

Indigenous development of 1 micron Yb-Fiber Laser Systems would open up avenues of the business opportunities and huge employment generation and creating manufacturing hub for following development areas and sectors:

- Precision marking & engraving;
- Automobile industry;
- Solar Cell scribing;
- Printing circuit boards; and
- Marking medical components

2 micron Tm-fiber laser will be used in the following medical fields:

- Soft and hard tissue surgery;
- Fragmentation of kidney stone; and
- Oncology

Commercialization Status: Pulsed Yb-fiber laser and CW Tm-fiber laser technology has been transferred to Bharat Electronics Ltd (BEL, A Govt. of India Enterprise), Bangalore.

Contact: The Director, CSIR-Central Glass and Ceramic Research Institute, Kolkata - 700032; Tel.- 033-24735829, 24839241; E-mail: director@cgcri.res.in, dir_office@cgcri.res.in

Reaction Bonded Silicon Nitride Ceramic Radome – A Technology of Immense Importance for the Strategic Self Reliance of India

High speed missiles for air defence systems need advanced ceramics based radomes for protecting the antenna located in the front. Silicon nitride is a suitable ceramic material for radomes due to its high strength, high thermal shock resistance, high wear resistance, good thermal conductivity and excellent EM properties. As the technology of fabrication of radomes is denied to India, indigenous defence programmes have been initiated for development of radomes for several missile programmes. CSIR-CGCRI has developed infrastructure and technology for fabrication of Reaction Bonded Silicon Nitride (RBSN) radomes for PRALAY missile.

Salient Features of the Development: CSIR-CGCRI has developed a process chain comprising green processing based on slip casting and ceramization of the dried green radome shape under high temperature in a large, high temperature controlled atmosphere furnace. The mechanical, thermal and electromagnetic properties of the reaction bonded silicon nitride material developed for radome have been extensively characterized at CSIR-CGCRI and RCI and tuned over a period of time with respect to slip chemistry and various processing parameters at various stages of the process chain. The properties obtained for the RBSN till date have shown excellent match with the target values set by RCI, Hyderabad.

Impact of the Technology: The indigenous technology of fabrication of RBSN radome developed in CSIR-CGCRI is of enormous strategic importance in the Indian context as the same is denied for India by foreign military powers. The development of silicon nitride radome will make Indian defence establishment capable of developing very high Mach no. air defence missiles which experience higher aerodynamic thrust and high skin temperatures when launched during sorties. The process chain and technology is capable of scaling up to larger radomes of upto 1 meter height and 0.5 meter base diameter.

Commercialization Status: An expression of interest (EOI) was published online in the CSIR-CGCRI website. Three reputed companies, namely, Bharat Heavey Electrical Ltd. (BHEL), Bangalore, Larsen & Toubro (L&T), Mumbai and Prism Johnson Ltd., Pen, Maharashtra have shown interest in the technology

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Electrophoretic Deposition – A Versatile Coating Technology

Corrosion, erosion and abrasion are common problems encountered in many different industries including mining, chemical, metallurgical, oil & gas, aerospace, marine, automobile, construction, medical, biomedical, orthopaedics, dentistry, mechanical and manufacturing, electronics, transport, food and packaging, agriculture, power generation, and renewable energy, etc. Coatings and surface engineering is of great industrial importance that is often used to improve corrosion protection, minimize abrasion & wear and thereby enhance service life of components.

Ceramics, cermets and ceramic-polymer composites have shown great promise for the above applications. Conventional coatings based on CVD, PVD etc. are very effective, but prohibitive due to high cost and scale up issues related to coating of large components. In order to overcome the problem, CSIR-IMMT has developed an advanced coating technology, based on Electrophoretic Deposition (EPD) for coating of ceramics, metals, polymers, graphene, carbon nanotubes and their composites. This process works on the principle of electrophoretic mobility. When an electric field is applied to a stable suspension of charged particles in a liquid, they migrate towards the electrode of opposite polarity and gets deposited there. Coatings of any desired thickness ranging from 5 µm -1 mm can be made. The coating can be applied on all types of shapes including flat, tubular or complex shapes. The technology can be easily customized, scaled up and adapted for the specific coating needs of different industries.

Important Parameters Unique to the Development:

- Fast kinetics of coating (30 sec- 3 min);
- Easy to control the coating thickness and morpohology by simple adjustment in operating parameters like voltage, time, concentration of suspension etc.;
- No restriction in shape of the substrate (i.e., it can coat on flat, tubular or complex shapes);
- Coating can be done inside as well as outside surface of tubes;
- The process allows coating of single material, as well as multi-component, organic-inorganic hybrid materials, layered materials or functionally graded materials;

- Requires simple apparatus (e.g., DC power supply);
- Room temperature process, but may need subsequent curing/heat treatment to impart strength of coating; and
- Easy to scale-up and customize for a specific coating need.

The uniqueness of the Electrophoretic Deposition (EPD) technology lies in achieving stable suspension of the coating material in a suitable liquid to ensure high surface charge necessary as driving force for the process. The usage of the technology can address major problem of corrosion, erosion, abrasion and wear faced by most of the industries.

Impact of the Technology: Success of the technology is its ability to produce thin to thick coatings for enhanced resistance to corrosion, erosion, abrasion and wear. As an example, ceramic coatings (e.g. Al_2O_3-siloxane nanocomposite) of about 30-40 micron thickness on steel has been shown to be of excellent adhesion strength and can withstand salt spray test of more than 2000 hours in accelerated corrosion environment of 3.5 wt% NaCl, and improved wear resistance. The technology provides the following benefits:

- Enhanced performance and durability along with extended equipment life-span as a result of applying the protective coatings, which will ultimately lead to increased uptime and boosted output for the specific industry; and
- Use of this technology for coating to refurbish components offers a much faster and more affordable solution compared to replacement with expensive new parts. Moreover, there are no delays (downtime) as a result of having to wait for parts delivery.

Commercialization Status: The technology is generic and available for customization and licensing for specific coating needs of industries.

Contact: The Director, CSIR-Institute of Minerals and Materials Technology, Bhubaneswar - 751 013; Tel.- 0674-2379 401; E-mail: dir@immt.res.in

Process Development for Production of Flaky Graphite, High Purity Graphite Graphene Oxide and Graphene from Natural Graphite

Graphite is one of the most versatile non-metallic minerals in the world. It has following properties:

- An excellent conductor of heat and electricity;
- The highest natural strength and stiffness of any material;
- Maintains its strength and stability to temperatures in excess of 3,600°C,
- One of the lightest of all reinforcing agents;
- High natural lubricity; and
- Chemically inert with a high resistance to corrosion.

Graphite is used as raw material for crucible, refractory, foundry, pencils, colloidal graphite, lubricants, batteries, electrodes, graphene oxide, graphene, and expandable graphite. Grade, shape, size and purity are the determinant factors for each application. Flake content in the ore varies from 10-70% depending on the ore quality. Graphite concentrate is produced from natural ore by flotation process after grinding to particular size. During grinding of the ore, flake is ground and fine size produced in the concentrate. During grinding of the more, maximum flaky graphite breaks down to finer process. Unique process has been developed to take out the flaky graphite before grinding the ore in the ball mill by agitation technique. It helps a lot not only save the flaky graphite, the fixed carbon of the graphite concentrate improves as well as overall process cost goes down drastically by removing around 50% of clay particles. The fixed carbon in the flaky graphite varies from 92-95%. The global graphite market projected to be valued at around USD 27.03 billion by 2025.

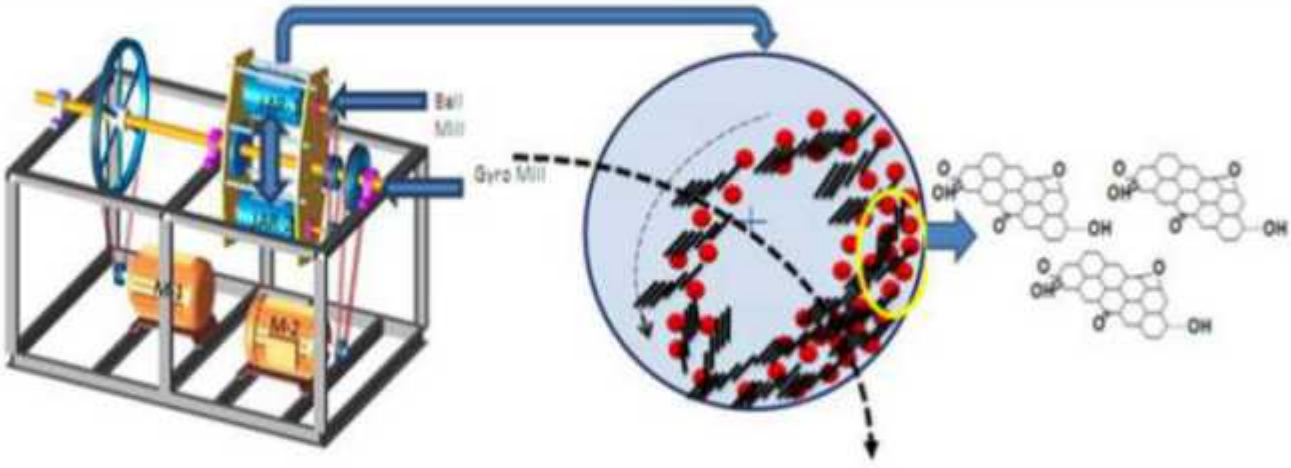
The beneficiated flaky graphite concentrate was used as feed material for high purity graphite. It could not further enhance due to the presence of fine gangue particles, gangue minerals coated by graphite and part of locked particles. Based on these reasons, it is not possible to achieve more than 95% purity of fixed carbon in the graphite concentrate only by physical beneficiation process.

High Purity graphite process was developed in combination of chemical and physical beneficiation. Lot of research has been carried out to enhance the fixed carbon value more than 99% through chemical leaching processes using different chemicals like HF/ H_2SiF_6 for removal of alumina and silicate minerals and H_2SO_4/ HNO_3/ HCl was used for removal of Ca, Mg, Na, K, Fe etc. As HF or HF related compounds are hazardous materials, NaOH/ soda ash are used for roasting/ leaching processes of graphite to remove the silica and alumina materials.

Based on CSIR-IMMT patent, the graphite is treated with alkali materials followed by mineral acid treatment with low pressure and less consumption of chemicals. Then the flotation is done to remove the locked particles and free quartz particles to achieve more than 99%. It has different applications i.e., batteries, fuel cell application, ceramic and refractory material, chemical and catalyst industries, fire resistant material, plastics and rubber additives, crucibles, carbon brushes, lubricants and

releasing agents, powder metallurgy, powder forging, raw material for graphite foil, high temperature coatings, raw material for pencil, bed material in nuclear reactor, photovolatic industry, semiconductor and LED industries and metal industry. The main attraction of graphite at present scenario is the application in Li-ion battery.

Graphene is the world's first 2-D material, available in a thin layer of tightly packed carbon atoms bonded in a hexagonal honeycomb lattice. It is thinnest, strongest, lightest and greenest material. Graphene is produced by different processes which includes micromechanical cleavage, Chemical Vapour Deposition (CVD), epitaxial growth on SiC substrates, chemical reduction of exfoliated graphite oxide, liquid phase exfoliation of graphite and unzipping of carbon nano-tubes . However each of the above methods has its own advantages as well as limitations depending on its target application.



Schematic diagram of planetary ball mill for production of GO and RGO

CSIR-IMMT has developed an improved process for preparation of graphene oxide from natural graphite by dry process using dual drive planetary ball milling process. It is a novel process for preparation of graphene oxide and graphene from high pure natural graphite using shearing action of balls in dual drive vertical swing planetary ball mill. These products are used for fuel cells, surface coating, solar cell, composite materials, DNA sequencing and biosensors, super capacitor etc.

Impact of Technology:

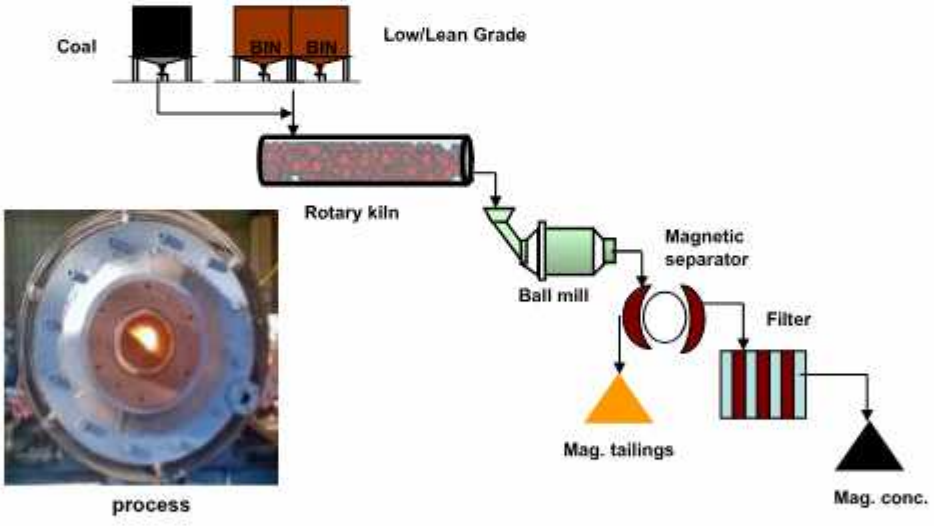
- Low cost recovery of flaky graphite comparing to the traditional method;
- Eco-friendly process for producing high pure graphite (> 99% FC); and
- Eco-friendly process for production of graphene oxide using mechanical process

Commercialization Status: Process has been transferred to M/s Tirupati Graphite PLC , Madagascar(Africa) for recovery of flaky graphite from raw graphite ore.

Contact: The Director, CSIR-Institute of Minerals & Materials Technology, Bhubaneswar - 751013, India, E-mail: dir@immt.res.in.

Maximize the Recovery of Iron Values from Lean Grade Iron Ore by Reduction Roasting and Pelletisation of High LOI and High Blaine Number Iron Ore Fines

As per the recent National Steel Policy of Govt. of India, steel production will be enhanced to 300 MTPA in 2030-31 from current production of 114 MTPA to increase per capita consumption from 65kg to 160kg against the world average of 218 kg. For the production of 300 MTPA, the country needs high-quality ore around 450 MTPA in form of calibrated ore, sinter and pellet to meet the requisite demand. The country is not endowed with high-grade requisite iron ore resources. It is, therefore, imperative to achieve the best use of available low and lean grade iron ore resources through scientific methods of beneficiation and pelletisation. As the cut-off grade has been reduced by Ministry of Mines, Govt. of India from 58 to 45% Fe, and BHQ, BGQ and BHJ are declared as ores in 2010 along with micro fines iron phase minerals present in the slimes and tailings generated from existing beneficiation/washing plants these resources are to be utilised in economical and eco-friendly process for long-term sustainability. As the lean and low grade iron ore does not respond well to conventional beneficiation process due to presence of high percentage of kaolinite, and goethite, the iron values are recovered through reduction roasting followed by physical beneficiation as shown in Figure.



Schematic diagram of the reduction roasting process

CSIR-IMMT, Bhubaneswar has developed process for recovering iron values from low and lean grade iron ore, slimes and tailings by reduction roasting followed by physical beneficiation process to produce high grade concentrate to utilise as pellet feed materials. The test work has been done on different iron ore samples in India and abroad in both laboratory and pilot scale level. The pilot scale rotary kiln was used for this purpose to feed 100kg/hr basis. In this process iron recovery value is more than 85% in case of low grade ores whereas in case of banded ore, the iron recovery is more than 90%. It will give radial change in iron and steel industries.

At present, the pelletisation plants are facing major challenges to handle high LOI and high Blaine number iron ore concentrate due to presence of kaolinite and goethite phases. After reduction roasting, the above problems will not be there. In overall high quality pellet can be produced due to concentration is magnetite and overall energy will be reduced. The pellets will be highly suitable for blast furnace and DRI for iron production.

Important Parameters unique to the Development:

- Increases 15-10% extra yield;
- Increases grade of the concentrate;
- Reduces the grinding energy minimum 30%;
- Maximise the recovery of process water by filtration for both concentrate and tailings;
- Handling of the reject is easy and it does not require tailings pond;
- Productivity of the process will be high because there is no clay effect;
- Transportation through pipeline is easy;
- Ease to make pellet and reduced 20-30% energy consumption in the palletisation process due to exothermic reaction for conversion from magnetite to hematite;
- Improve the pellet quality from magnetite concentrate;
- Reduces the consumption of ores per tonne of production of concentrate;
- Reduces the tailings generation; and
- Ores having more than 40% Fe can be processed.

Commercialization Status: A MoU has been signed with M/s FL Smidth India (Pvt) Ltd, Chennai for commercial implementation of the process. But discussions are going on with M/s BMM Ispat Ltd, Bengaluru, and M/s Jindal Steel & Power Limited, Tensa, Odisha for using this process for recovery of iron values from BHQ and low grade iron ore respectively. The tentative production cost per tonne of concentrate has been estimated around ₹ 2800/-.

Contact: The Director, CSIR-Institute of Minerals & Materials Technology, Bhubaneswar - 751013, India, E-mail: dir@immt.res.in.

Non-Cytotoxic Bacterial Melanin (NCBM) for Biomedical Applications

Melanin is a complex biological pigment found in all forms of life from bacteria to mammals. In Humans, it gives a dark color to the skin and renders protection from UV rays. The present invention includes a sponge-associated bacteria which secrete non-cytotoxic melanin with antioxidant properties and the procedure for the extraction of melanin.

Non-Cytotoxic Bacterial Melanin

Advantages: The laboratory studies showed that the Non-Cytotoxic Bacterial Melanin (NCBM) are non-cytotoxic to animal cells (L929 mouse fibroblast cells) and brine shrimp up to a concentration of 200 and 500 ppm respectively. The bacterial melanin showed antioxidant activity (ABTS radical scavenging activity) at a very low concentration (IC_{50}- 9.0 ppm) and protected animal cells from UV-induced intracellular reactive oxygen stress at 50 ppm. Since it is a compound of biological origin, the side effects associated with continuous use of conventional sunscreen cosmetics containing UV protective chemical are not expected.

Market Applications: The NCBM is a potential biological alternative to UV protective chemicals in cosmetics. The application of sunscreen is wider in Europe, America and Canada where the incidence of skin cancer is relatively higher. The recent reports indicate positive growth in the skincare market in India also. UV protecting agents such as titanium oxide, trisiloxane, dometrizole etc are the main ingredients of sunscreens. In some products, fruit extracts are also used. Since NCBM is non-cytotoxic and has high antioxidant and a broad photo-absorption property, it can be incorporated in lotions for topical application. Also, it has the advantage of being biological origin.

Commercialization Status: The technology has been transferred to M/s Greenle Life Sciences Private Ltd under nonexclusive license for commercialization. The technology is available for further licensing.

Contact: The Director, CSIR-National Institute of Oceanography, Dona Paula, Goa, India, E-mail: director@nio.org

Production of Tungsten (W) Powder from Scraps: Shortest & Cheapest Recycling Technology

Tungsten (W) is an important metal both strategically & industrially. Global tungsten resources are limited and highly localized and the supply is primarily dominated by China (84%). Indian tungsten demand (~1200 MT/y) is mostly met through imports as India doesn't have any economic tungsten ore deposits. Indigenous recycling of tungsten scraps is highly important to meet the strategic needs of the country and lessen the import burden.

Presently only few tungsten scrap recyclers operate in India, mostly due to high capital cost of recycling technologies, fluctuating global tungsten prices and dependency on imported raw materials.

Important Parameters Unique to the Development:

The recycling technology developed at CSIR-NML is a global one, i.e. it recycles variety of tungsten bearing scraps / secondary materials such as heavy alloy scraps, WC-hard metal scraps, W-Cu boring dusts and tungsten containing metallurgical sludge. The advantages of this technology over the existing scrap recycling technologies are:

- Higher overall W extraction efficiency (>98% Vs 90% by existing technologies);
- Reduced CAPEX/OPEX; almost half of the existing technologies;
- Target recovery of other valuable metals such as Co, Ni, Cu, etc. with equal efficiency;
- Substantially higher ROI (>50%) over the existing technologies (20 – 30%); and
- Produce little or no dischargeable effluents.

The uniqueness of this technology is that it targets selective removal of impurities from the scrap materials, instead of extracting the tungsten content which is the major portion (higher than 80%) of such scraps. This led to substantial decrease in chemical/reagent demand; avoid sophisticated separation techniques such as solvent-extraction/ion-exchange etc. for getting the desired purity; and higher recovery efficiency of tungsten.

Technology Impact & Commercialization Status: The cotemporary technologies that have been deployed for recycling of WC-hard metal and other hard and soft scraps can be categorized into the following two: (i) Molten zinc process, and (ii) alkali based processes, wherein the main product is ammonium para-tungstate (APT). The molten zinc process uses molten zinc bath to selectively dissolve WCs, leaving the impurities as residues/slag; whereas the alkali base process selectively dissolves W either by alkali fusion or by high temperature pressure processes. The dissolved tungsten is re-extracted by various means (such as solvent extraction, ion-exchange, crystallization, physical processing etc.) to get the recycled products (WCs, APT, YTO, W-powder). Both these recycling technologies are cumbersome, lengthy and above all CAPEX/OPEX intensive. They are viable only for large scale recycling facilities. In contrast, the present technology target dissolution of impurities from the pre-treated scraps, thereby producing a residue containing tungsten compound in purest from. Most of the W-bearing scraps are rich in tungsten (containing 80 – 90%W) and less amount of impurities, therefore targeting impurity dissolution consumes less chemical (thus generate less effluent), requires less number of process steps and overall less expensive.

100 Kg/day scale tungsten recycling pilot plant at CSIR-NML & Tungsten (W) powder produced in large scale

This technology has been commercialized by three start-ups (M/s Wolfram MetChem Pvt. Ltd., Nagpur; M/s Minestone Minerals Ltd., Mangalore and M/s Bharat Futuristic Corporation, Bengaluru) with total installed capacity of 220 MT/y tungsten powder/YTO. These factories created about 40 direct employments.

WC-recycling commercial plants of M/s Minestone Minerals and M/s Wolfram MetChem Pvt. Ltd.

Technology for Manufacturing of ADI Components for Mining Application

In mining industry sharp digger teeth are being used for ground penetration, enabling the excavator to dig with the least possible effort. At present digger teeth are manufactured from cast steel material which wears out very fast. To address this problem, CSIR-CMERI has developed process technology for manufacturing of Austempered Ductile Iron (ADI) components for mining application. Excavator digger teeth made with developed ADI technology has superior wear resistant properties and offers good combination of low cost and a high strength to weight ratio. Durability of Digger Tooth would increase which reduces operational cost.

Digger Teeth developed with ADI technology

Important Parameters Unique to the Development:

- Superior wear resistant properties;
- Offers good combination of low cost and a high strength to weight ratio; and
- Higher durability which reduces operational cost

Major Application(s): Mining components such as digger teeth of different Excavator models (L&T, BEML, TATA Hitachi, JCB, Volvo, TEREX).

Impact of the Technology: The technology has been demonstrated on L&T CK - 300 Excavator machine at Eastern Coal Field Limited. The Excavator Teeth made of ADI material performed better than the normal one.

Commercialization Status: Technology has been transferred to M/s Mahalaxmi Auto Industries, Jamshedpur, Jharkhand for commercialization on non-exclusive basis. The technology is available for licensing.

Contact: The Director, CSIR-Central Mechanical Engineering Research Institute, Mahatma Gandhi Avenue, Durgapur - 713209, West Bengal Tel.- 0343-2546749, Fax.- 03432546745; E-mail: director@cmeri.res.in

Ecology, Environment, Earth & Ocean Sciences and Water Theme

Ecology, Environment, Earth & Ocean Sciences and Water Theme

Zero Wastewater Discharge Technology for Leather Industry

In the state of Tamilnadu, the zero wastewater discharge was made mandatory by the High Court of Madras. The tanneries had resorted to Reverse Osmosis (RO) based zero discharge system. Technically this strategy could provide scope for achieving zero wastewater discharge; there are many shortcomings that render this route not sustainable. The tanneries in other parts of the countries too are looking forward to sustainable solution to the issue of wastewater management.

CSIR-CLRI has developed a zero wastewater discharge process technology based on Electro-oxidation (EO) for both the pre-tanning processes and post tanning processes. The translation of this zero wastewater discharge technology would enable the tanneries to attain zero wastewater discharge and thereby ensure sustainability. The present technology appropriately fulfills the imminent requirement of the tanning industry not only in India but also in other major leather making countries.

Important Parameters Unique to the Development:

- No discharge of wastewater from tanneries. The present discharge is about 24 billion liters of wastewater per annum;
- The possible reduction of cost will be about ` 96 million per annum from reduction in the cost of wastewater treatment;
- This technology does not result in generation of sludge (about 160 tons sludge per annum); and
- As there is no discharge of wastewater including sulfide bearing stream, the average annual fatalities due to release of H_2S of about 10 per annum in India could be avoided.

Impact of the Technology: About 800 kilotons of raw hides and skins are processed annually in India. This leads to the generation of wastewater of volume about 24 million m^3 The environmental impacts associated are very significant and the cost of treatment is quiet high. This technology provides foolproof solution to the problem of wastewater from leather industry with much minimum capital and operational cost. This technology would bring about the environmental impact caused by the leather industry to a minimum level and ensure the sustainable growth of the industry.

Commercialization Status: The technology has been transferred to:

- M/s Jasper Concepts, Bangalore;
- M/s Leayan Global Pvt Ltd, Banthar, Unnao, Kanpur;
- M/s A N leathers Pvt Ltd, Mathura, Uttar Pradesh;
- M/s Royal Tanners, Jajmau, Kanpur; and
- M/s Ruksh International, Kanpur

CSIR-CLRI is partnering with an NGO, Solidaridad for wide translation of the technology in the tanneries in India. Efforts are made to collaborate with Leather Industry Development Institute (LIDI), Ethiopia for translating the technology in Ethiopian tanneries with the consent of Ministry of Industry, Ethiopia. Presently, commercial scale demonstration of the technology in Ethiopian tanneries is being carried out. A business proposal for translating the technology in Ethiopian tanneries has been submitted to the Government of Ethiopia. Ministry of Industry and Commerce (MoIC), Sri Lanka has expressed willingness to implement the technology in all the tanneries in Sri Lanka. Technology is available for licensing.

Contact: The Director, Central Leather Research Institute, Adyar, Chennai - 600020; Tel.- 044-24910897, 24910846; E-mail: directorclri@gmail.com

Domestic Iron Removal Filter

In India, groundwater of many locations is highly contaminated with iron (exceeding the WHO limit 0.3 ppm) and because of its bad tastes and stains clothes, containers and skin, village people rejects this water and return to surface water for drinking. This can result in disease especially for young children.

To address these problems, CSIR-CMERI has designed and developed a domestic/household type iron removal filter of ~2 L/hr capacity which is suitable for a family of 4-5 members It removes iron concentration from groundwater below the WHO limits (0.3 ppm). The filtration unit can also remove foul odour, bad taste of iron water.

Domestic Iron Removal Filter

Important Parameters Unique to the Development

- Design is simple & compact, requires less space (table top);
- Naturally available/low cost materials used;
- No electric power requirement;
- No chemicals are being used;
- Flow rate: 3 L/hour (approx.);
- Storage capacity: ~ 9 L;
- Cost of the iron filter unit (SS make): ₹1800 -2000/- (approx.)
- No replacement of adsorbent;
- Backwashing facility is available;
- Estimated filtration ability of filter medium (backwashing time) is around 40 days (for 7 ppm iron concentration) assuming average consumption of 8L of water per day for a family;
- Water quality of the treated/filter water comply the IS: 10500:2012; and
- Removes iron concentration from groundwater below the WHO limits (0.3 ppm)

Major Application(s): Rural areas of India where groundwater is contaminated with iron.

Impact of the Technology: Provision of an adequate supply of safe drinking water is a basic necessity for the well-being and socio-economic development of any country. In India, groundwater of many locations (22 states) is highly contaminated with iron (exceeding the WHO limit 0.3 ppm) and because of its bad tastes and stains clothes, containers and skin, village people rejects this water and return to surface water for drinking. The users will get safe iron free drinking and can avoid disease especially for young children.

Commercialization Status: Technology has been transferred to M/s Bargachiya Cluster of Metal Product, Bargachiya, Howrah on non-exclusive basis. The technology is available for licensing.

Contact: The Director, CSIR-Central Mechanical Engineering Research Institute, Mahatma Gandhi Avenue, Durgapur - 713209, West Bengal; Tel.- 0343-2546749, 9434022951; Fax.- +91-343-2546745; E-mail: director@cmeri.res.in

Gas Sensor for Environmental Monitoring

The focus of Indian government's Swachh Bharat Abhiyan (Clean India Mission) is to provide clean environment to the society. This is possible only if the correct estimate of the pollutants in environment is made. CSIR-CEERI has developed an Internet of things (IoT) enabled platform system for NH_3, CO and H_2S sensing, which enables us to monitor the gas levels at desired location. Developed systems include indigenously developed metal oxide MEMS gas sensors, electronics and smart algorithms. This is one step towards the vision of smart cities. Readout and control electronics are indigenously developed and interfaced with in-house developed gas sensors The baseline correction and detection algorithm are implemented and tested for the detection of three gases.

NH_3, CO and H_2S Gas Detection Systems

Micro-gas sensors are realized using mass reproducible micro-electronics unit processes while an electronic component assemble unit is required to realize control electronics.

Gas sensor chip and its package

Important parameters unique to the development

- Versatile platform; alarm levels can be tuned based on the application;
- Baseline correction, threshold detection algorithm and electronic interface for readout and control; and
- In-house developed low power rugged micro gas sensors

Salient Features:

- Response time is < 1 min;
- Sensor Power consumption < 200 mW;
- Overall system power consumption: System with sniffer mechanism 2.5 watt and System without sniffer (small) 1 watt;
- Systems enabled with IoT can detect ammonia and log data at central server;
- Industry friendly 4-20 mA interface;
- Easy sensor replacement; and
- Flexibility to tune the alarm threshold as per the need.

Major Application(s): Three individual systems have been developed to detect NH_3, CO and H_2S. Ammonia sensor finds application in toilet cleanliness monitoring as well as in chemical industries, fertilizer industries, cement plants, refrigeration plants, etc. CO is considered as a silent killer hence, CO detector has indoor applications as well as outdoor applications. CO and H_2S detectors can also be used for manhole gas detection. These three detectors are also useful in outdoor air quality monitoring as these are identified as air pollutants.

Impact of the Technology: Ammonia, carbon monoxide and hydrogen sulphide are hazardous gases and have severe health hazards, if inhaled above Permissible Exposure Limit (PEL). Very high concentration of these gases can lead to sever health hazards or even death. Hence, the developed gas sensor systems can save lives, as well as can help to reduce the air pollution, in the areas where the hazard of these gases exists.

Commercialization Status: Lab prototype of three gas detection systems has been demonstrated at various platforms including CSIR-CEERI Technology Day-2018, Indian Science Congress-2019 etc. The technology is available for licensing.

Contact: The Director, CSIR-Central Electronics Engineering Research Institute, Pilani - 333031 (Rajasthan); Tel.- 01596-242111; E-mail: director@ceeri.res.in

Coal Dust Collecting and Briquetting System

Haul and transport roads are the major generating source of particulate matters for an opencast mine. These particulate matters not only create environmental problem but also pose health hazards. It is pertinent to collect the dust from mine roads and put it to alternative use not only for reducing air pollution but also for improving the health of local populace. CSIR-CIFMR has developed Road dust collecting system.

Important Parameters Unique to the Development:

- The system is specially developed for collecting huge quantity of coal dust being accumulated on uneven road of mines and industrial areas;
- The system utilizes of waste coal dust as domestic fuel after converting into coal briquettes; and
- The system has applications in mines and coal washeries as well as thermal power plants, steel plants, cement plants and other industrial areas.

Impact of the Technology: The system controls air pollution in mining and industrial areas, which reduces health problem related to air born dust in mining and industrial areas. Significant number of employee will be engaged in manufacturing and operation of the system in mines and other industrial areas.

Commercialization Status: CSIR-CIMFR has transferred the patented technology to M/s Tata Motors Limited, Mumbai on non-exclusive basis. Field trial of road dust collecting system has been carried out in 2 mines of Jindal Saw Limited, Bhilwada, Rajasthan and Hindustan Zinc Limited. The technology is available for licensing.

Contact: The Director, CSIR-Central Institute of Mining & Fuel Research, Barwa Road, Dhanbad - 826015; Tel.- 0326-2296023, 2296006; E-mail: director@cimfr.res.in

An Electronic Device for Online Drinking Water Disinfection- Oneer™

Water is one of the most essential requirements of the life. Rapid industrialization and over-abstraction led to water reserves shrinkage and contamination of natural water resources with a number of undesirable toxic substances making it unfit for human consumption. As per WHO estimate, nearly 80% of diseases are caused directly or indirectly by scarcity of safe water and sanitation. In India, there is 15-20% infantile mortality due to gastroenteritis.

CSIR-IITR has developed Oneer™ which is useful for the continuous treatment of water. It is an innovative technology that eliminates all disease causing pathogens such as virus, bacteria, fungi, protozoa, and cyst to provide safe drinking water to communities as per National and International standards prescribed for potable water (BIS, WHO and EPA.).

Salient features of the Technology:

- An innovative modular design enables purification and disinfection of water;
- Pre-filters as per the water quality allows removing particulate impurities, bad odors, colors and other contaminants;
- High disinfection efficiency of >8 Log reduction of bacteria;
- Inbuilt smart sensor systems provide real time information on operational steps, self-clean mode and automatic tank filing to ensure 24x7 availability of safe drinking water. The unique disinfection process retains the natural essential minerals;
- The running cost of the device is ~ 2 paisa/litre;
- High capacity option for communities with 450 LPH of treated water. The unique modular design allows for scaling up of the process from 5000 to 1 lakh L/day and more; and
- Oneer™ is maintenance and membrane free "Safe Water & Save Water" technology.

The device is based on the principle of anodic oxidation. Active oxygen species are produced in water under the influence of modulated / pulsating constant DC current through specially designed SS electrodes immersed in water where the electrical energy is changed to chemical energy. The oxidants produced due to electron reaction and ion migration mechanism have an extra high potential and act on bacteria and other microorganisms more effectively as compared to other oxidant producing agents such as chlorine, hypochlorite, UV and gamma radiation, Ozonation etc. commonly used for drinking water disinfection.

On an average four persons/family require approximately 30-50 liters of potable drinking water/day. Thus, a single unit will cater to approximately 100-125 families or 400-500 people of a community. This could be expanded by installing multiple units of the Oneer™.Smaller version provides 10 Litres of safe water per batch suitable for house hold and small establishments and can also be operated on a solar powered battery. Bigger version can continuously supply 450 Litres of water/ hour for communities.

The cost of purifying water of the Online Water Disinfection System is only 1.5 paisa per litre against competitive technologies of Ultra Violet (UV), Reverse Osmosis (RO), Ultra Filter (UF), Total Dissolved Solids (TDS), and silver which have per litre costs ranging from 5 paisa to 30 paisa.

Commercialization Status: Technology has been transferred to M/s SS Maser Technology Private Limited, Lucknow and M/s Bluebird Pure Private Limited, New Delhi for commercialization on non-exclusive basis. The technology is available for licensing.

Contact: The Director, CSIR-Indian Institute of Toxicology Research, Mahatma Gandhi Marg, Lucknow - 226001; Tel.- 0522-2621856, 2613357; E-mail: director@iitrindia.org

Hollow Fiber Membrane Based High Flux Domestic Filter for Water Clarification and Disinfection

Water pollution is a very serious problem in our country. Even though 88% of Indian population has access to water sources, only 32% of population gets treated potable water. It is estimated that over 70% of all of India's surface water and many of the groundwater reservoirs have been contaminated due to biological and industrial pollutants. Between 0.5 to 1.5 million children under the age of five die every year from contaminated water related diseases in India. Safe drinking water for common man has emerged as one of the major challenges of this century. HF ultrafiltration membrane process is one of the most efficient processes in the treatment of turbid water with pathogens and other microorganisms.

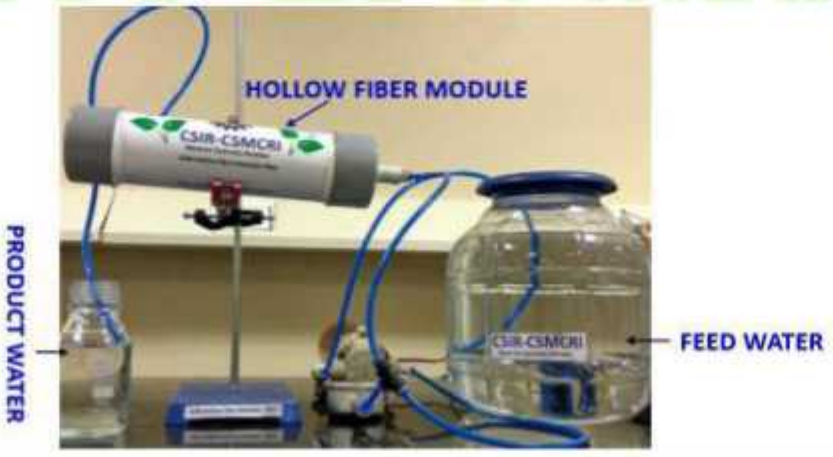
Important Parameters Unique to the Development:

- Hollow Fibre (HF) membranes with 2-3 times higher productivity over the current membrane developed by CSIR-CSMCRI and other HF membranes available in the market;
- HF membrane based high-flux domestic water filter which can be driven by simple gravity-assisted separation without any electricity for water clarification and disinfection producing water free of pathogens and suspended particles; and
- The Domestic filter has been designed which contains micron and carbon filters as pre-filters of HF modules using optimized hollow fibers. It needs simple backwash with water for every 1.5 months for disinfection of supply tap water and backwash for every 2 weeks in case of treating highly contaminated water (~10^7cfu/ml).

Major Application(s): The CSIR HF domestic filter will be cheaper in comparison with the commercial water purifier available in the market without compromising product quality and has prospects of commercial success of HF domestic water filter both in urban areas and villages because of its high productivity, compactness and easy maintenance and low cost.

Impact of the Technology: Hollow fiber ultrafiltration membrane process is one of the most efficient processes in terms of productivity because of its high water permeability particularly in the treatment of turbid water containing suspended particles, pathogens and other harmful microorganisms. The novel CSIR HF domestic filter will have direct impact to the society by meeting the drinking water need of the mass with the initiative of Government and NGOs; improving peoples' lifestyle and good health particularly in rural sector where potable water availability is still a problem; likelihood of start-up/ spin-off company; and licensing technology to the entrepreneurs

Commercialization Status: M/s Rinzai Hydratech Pvt. Ltd., Ahmedabad has been consulted and negotiation for transfer of technology is in process. A patent is under consideration on the process of manufacturing high-flux hollow fiber membranes and module fabrication. Technology is available for licensing.



Lab-scale Hollow fiber module testing system

Domestic Hollow Fiber Filter

Contact: The Director, CSIR-Central Salt and Marine Chemicals Research Institute, Gijubhai Badheka Marg, Bhavnagar - 364002, Gujarat; Tel.- 0278-2567760 / 2568923/ 2565106; Fax.- 0278 - 2567562 / 2566970; E-mail: director@csmcri.res.in

Water Quality Monitoring Watchdog Pod

The 'looming water crisis' is becoming a major issue on the world's agenda for the 21st Century. The World Water Council reported that 1.2 billion people or one-fifth of the world population do not have access to safe drinking water, while half of the world population lacks adequate sanitation. Further, growing cities, burgeoning industries, and rapidly rising use of chemicals in agriculture have undermined the quality of many rivers, lakes, and aquifers and pollutants are accumulating in groundwater. Furthermore, with existing analytical techniques, it is not easy to monitor and follow groundwater quality evolution worldwide or at regional level due to error in sampling, its frequency and unavailability of portable and online sensor systems. Therefore, it is of immense importance to unlock various techniques and technologies to monitor and maintain groundwater quality to make its effective use in affected regions of the country and maintain its quality utilizing sensors and software solutions.

CSIR-CSIO has developed water quality monitoring system for detecting hazardous pollutants including nitrate, fluoride and arsenic.

Important Parameters Unique to the Development:

- Field deployable Integrated optical system for arsenic, nitrate and fluoride; and
- Low cost integrated system with an approximate cost of ₹ 20,000-50,000/unit.

Integrated Water Quality Monitoring System

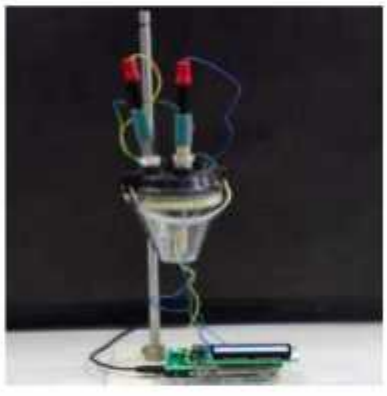
Major Application(s): Water quality monitoring is in terms of hazardous pollutants including nitrate, fluoride and arsenic. The system can be deployed for online monitoring of rivers for these pollutants, with a sampling setup.

Impact of the Technology: In India, water safety and security is a major issue. More than half the population does not have access to safe drinking water. However, systematically testing the microbial and chemical quality is expensive and complicated. The standard reference methods used in laboratory are cumbersome and time consuming. By the time water quality analysis is completed and results indicate that the water is not safe to drink, thousands of people may have consumed that water putting them on risk. According to a report, 37.7 million Indians are affected by water borne diseases annually, 1.5 million children are estimated to die of Diarrhoea alone and 200 million working days are lost due to water borne diseases. The resulting economic burden is estimated at ₹ 36,600 Crore every year. Furthermore, it is estimated that the equipment market related to water technologies is worth approximately ₹200 - 300 million and expected to have double-digit growth rates every year. Indigenization of water related technologies will decrease the import, increase the export, and create employment through startups and entrepreneurship development and thus impacting the GDP.

Commercialization Status: The Knowhow has been transferred to M/s Ambtek Innovations Pvt. Ltd, Saha Industrial area, Ambala (Haryana). Technology is available for Licensing

Fluoride Detection System

Nitrate Detection System



Arsenic Detection System

Contact: The Director, CSIR-Central Scientific Instrumrnts Organisation, Chandigarh; Tel.- 0172–2657190; E-mail: director@csio.res.in

Civil Infrastructure and Engineering Theme

Civil Infrastructure and Engineering Theme

Building Products using Kota Stone Cutting and Slurry

Processing of Kota stone generates about 10-12 million tons of stone waste annually. This stone waste generally discharged into local convenient place which poses major environmental and ecological problems besides occupying a large area of land for their storage or disposal.

Tiles, Paver blocks, Wall tiles & Lightweight blocks using Kota stone wastes

A technology has been developed for recycling and utilization of solid and slurry wastes in making tiles, paver blocks and cellular blocks by CSIR-CBRI. The developed items meet the requirements of Indian Standard Specifications. The utilization of high volumes of Kota stone slurry waste in lightweight concrete leads to higher strengths than that of normal lightweight blocks.

Important Parameters Unique to the Development:

- Products meet IS specifications;
- Dimensionally Stable;
- Comparatively High Performance Factor of CLC Blocks;
- Better Mechanical Strength of Tiles;
- Excellent Thermal Resistance of CLC Blocks;
- Cost Effective & Durable;
- Green Building Materials;
- Sustainable Construction; and
- Supports 'Swachh Bharat Abhiyan

Major application(s):

- Floor tiles- Light traffic loads & heavy traffic conditions;
- Paver blocks- Non traffic to Heavy traffic conditions; and
- CFC blocks- Infill material & brick replacement

Impact of the Technology: The technology would help Kota Stone Industry of Rajasthan in disposing off the huge waste generated economically without effecting the environment besides employment generation through setting of industry and saving of natural resources through waste utilization.

Commercialization Status: The technology has been transferred to Rajasthan State Pollution Control Board, Jaipur for mass deployment on exclusive basis. India's first start-up plant (based on CSIR-CBRI's developed technology) was set up by Pashan Welfare Foundation, Kota for Kotastone waste management in June 2018. This plant has been recognized by Central and State government under Start-up Policy - 2017, Waste to Wealth and Swachh Bharat Abhiyan. The plant has the capacity to manufacture 8,000 flooring tiles, 3,500 rough paver blocks and 5,000 bricks daily from the slurry. It can use up to 100 ton Kota stone waste per day.

Contact: The Director, CSIR-Central Building Research Institute Roorkee, Uttarakhand Tel.- 01332-283323; Fax.- 01332-272272; E-mail: director@cbri.res.in

Boring Machine based on Trenchless Technology

Trenchless construction limits the amount of excavation and the surface repairs needed after digging. Available imported machines are very expensive as they are of large capacities and suitable for big projects. No such machine is being manufactured indigenously.

To address this gap, CSIR-CBRI has developed boring machine based on trenchless technology. The developed machine can bore up to 14 m length and 160 mm diameter holes under the roads and buildings for laying sewer/ pipe lines and cables. The developed machine is affordable and can be used by small/middle class contractors. It is light in weight, portable and requires low maintenance and suitable for both wet and dry boring.

Developed boring machine inside the Pit

Important Parameters Unique to the Development:

- Indigenous and an Initiative under 'Make in India' programme;
- Can bore 160 mm diameter holes up to 14 m length at a depth of 1m from the surface level;
- Light in weight and portable;
- Easy to assemble and dismantle at the site;
- Requires a very small pit just on the side of road/ building; and
- Low maintenance and suitable for both wet and dry boring.

Major Application(s): The machine can bore up to 14 m length and 160 mm diameter holes under the roads and buildings for laying sewer/ pipe lines and cables under trenchless construction.

Impact of the Technology:

- Traffic jam due to open cut trenches will be reduced; and
- During boring operation under the ground, pollution due to dust in atmosphere will be minimized

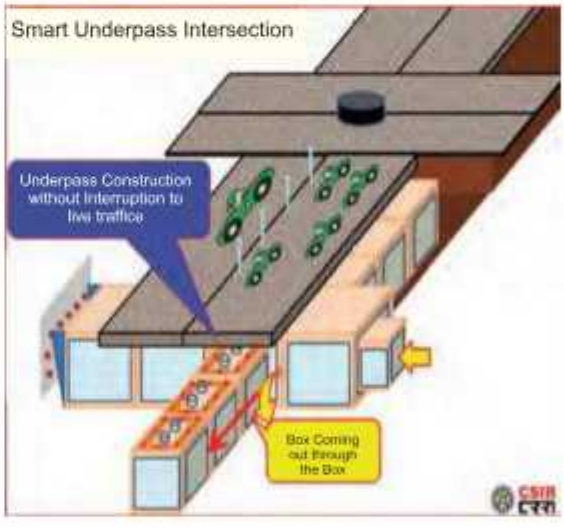
Commercialization Status: The technology has been transferred to M/s Techno Industrial Marketing, Dehradun on non-exclusive basis. Technology is available for licencing.

Contact: The Director, CSIR-Central Building Research Institute Roorkee, Uttarakhand; Tel.- 01332-283323; Fax.- 01332-272272; E-mail: director@cbri.res.in

Soil Nailing Technique for Stabilization of Soil Slope for the Construction of Underpass Intersection Below Live Road Traffic Conditions

The rapid growth in population, industries and infrastructure development in country has led to shortage of land space in the metropolitan cities and also resulted in tremendous increase in traffic volume and congestion on roads. Often, further widening of road or provision of flyovers is not feasible due to many constraints. The underpass is the only viable solution in such situations. Today, precast RCC segments are gaining popularity in underpass construction due to many advantages. The shallow underpasses can be constructed by pushing pre-cast boxes under live loading and traffic conditions. However, due to soil instability problems, often the idea of construction of underpass is dropped.

To address the aforesaid, CSIR-CRRI has developed Soil Nailing Technique by which underpass construction becomes simple, easy, safe, time-saving, economical and user friendly in live loading condition. A stepwise de-stabilisation and stabilisation of Soil Nailing Technique for construction of underpass below live road/rails has been patented in India and abroad.



Important Parameters Unique to the Development:

- User friendly construction methodology of Underpass below live loading;
- Safe and secure soil stabilization method for collapsible soil;
- Safe and economical technology for Civil engineering construction Industry;
- Fast construction of Underpass with live loading condition; and
- Environmental protection of greenery at ground level.

Major Application(s): The technique can be used for fast construction of underpass with live loading condition. The technique will be useful for road construction agencies such as PWD, Railway, NHAI, BRO, Construction Companies, Municipal Corporations and private developers.

Impact of The Technology: Many situations where underpass projects were dropped due to instability problems, those projects can be taken up with this technology. Underpass at shallow depth will be possible in live loading condition. Small-small pedestrian underpass will be possible without disturbing the surface traffic flow and Open road cuts can be avoided by using the trenchless Box pushing technique of underpass construction.

Commercialization Status: Three projects namely (Yamuna Bazar, Apsara Border and Sahibabad) underpass had been successfully completed using Soil Nailing Technique with box jacking/Box pushing below live traffic. The technology is available for licensing.

Contact: The Director, Central Road Research Institute, Delhi - Mathura Road, P.O. CRRI, New Delhi - 110025 Tel.- 011-26848917, E-mail: director.crri@nic.in

Cement Grouted Bituminous Mix (CGBM) for Urban Roads

India has the second largest road network with heterogeneous traffic conditions. However, at times, it is observed that the flexible/rigid pavements, especially in urban areas, are unable to sustain the traffic conditions. Hence the prime objective of the study is to develop and demonstrate composite surfacing wearing course for pavements using grouted high void bituminous mix in order to support the urban traffic and to study the performance of cement grouted bituminous mix under moderate loading conditions for the durability and optimised operations.

View of pouring of grout and squeezing on high voids bituminous mix

CSIR-CRRI has developed a technology with Cement grout bituminous mix, which is a semi flexible type of pavement comprising of open graded aggregates in the bituminous mix resulting in high air void content in the mix. The voids in the bituminous mix are filled with cement grout. Cement grouted bituminous mixes have advantages in both flexible and rigid pavements. This hybrid mixture provides good rut resistance and a surface highly resistant to fuel and oil spillage.

Important Parameters Unique to The Development:

- More durable than the commonly used flexible and rigid pavements;
- A prime solution to overcome moisture induced damages/ fuel spillage related problems;
- Pavements with CGBM is expected to have less temperature susceptibility; and
- Joint less and impermeable wearing course.

Major Application(s): Situation wherein roads pavements cannot be taken up for frequent maintenance/rehabilitation and also where good skid resistance and more durable surfacing are the prime requisites.

Impact of The Technology:

- The laying of Cement Grouted Bituminous Mix on urban road will give high resistance to permanent deformation and will be more durable to withstand heavy load condition. The laying of such pavement will lower temperature susceptibility and reduce the fuel spillage related problem as faced under flexible and rigid pavements; and
- The CGBM will be free of crack surface so that no water gets percolated i.e. it is completely impermeable and will be absolutely joints free. The upper layer will provide adequate skid resistance.

Commercialization Status: Based on laboratory evaluation and design of CGBM, two trial sections were laid in Surat city roads by CSIR-CRRI. Development of specifications of CGBM for Indian roads is in progress in consultation with Indian Road Congress. Technology is available for licencing.

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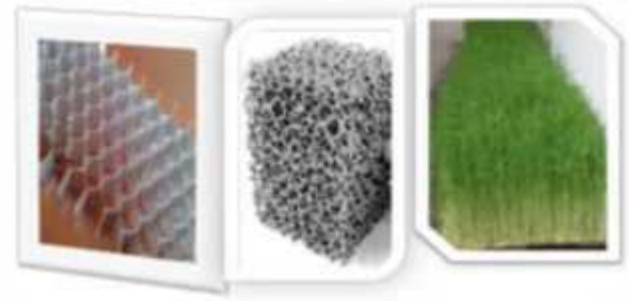
Noise Barrier based on Different Frequencies

The commonly used noise barriers are made of rockwool fibrewool of different densities and thickness as inside material and Aluminum perforated sheets front and back of the panel as outside material. Globally noise barriers are not designed based on their disturbing frequency. Frequency based noise barrier design gives highest reduction of noise compared to all existing designs at the same cost.



High Frequency based NB Material | Middle Frequency based NB Material | Low Frequency based NB Material

CSIR-CRRI for the first time in the world has designed and developed frequency based noise barriers which can arrest three frequencies of sound waves - low (<200Hz), medium (200-1k Hz); and high (1k-20k Hz). These noise barriers would drastically reduce noise level (about 38 decibel) and improve quality of life in noise affected areas. The noise barriers can be easily mounted on flyovers, traffic intersections etc. where the level of sound pollution and high frequency sounds are extremely high.

Important Parameters Unique to The Development:

- Designed based on the disturbing frequency i.e Low frequency (<200Hz); Middle frequency (200-1k Hz); and High frequency (1k-20k Hz); and
- Highest reduction of noise compared to all existing designs at the same cost.

Major Application(s): Noise barriers can be used to reduce noise levels alongside high speed expressways, rural highways, flyovers and urban area. Indian Railway, Metro Rail Corporations, PWDs, Urban Development authorities like MMRDA-Mumbai, MSDRC-Mumbai, HMDA-Hyderabad, NHAI, Pollution Control Boards etc. are the potential users.

Impact of the Technology: Transport infrastructure development in the past two decades has resulted in increased noise levels in cities and regional corridors. Communities living in the close vicinity are exposed for longer durations to noise levels above prescribed limits. Increased exposure to transport noise has resulted in health hazards like hearing loss, sleep disturbances, hypertension etc. The developed noise barriers would drastically reduce noise level (about 38 decibel) and it is useful to improve quality of life in noise affected areas

BR Ambedkar Road Flyover Mumbai-2016 (Fitted with noise barrier designed and developed by CSIR-CRRI)

Commercialization Status: CSIR-CRRI has transferred the technology to M/s Technocrats Kohlhauer Infrastructure Pvt Limited, Mumbai on non-exclusive basis. The technology is available for licensing.

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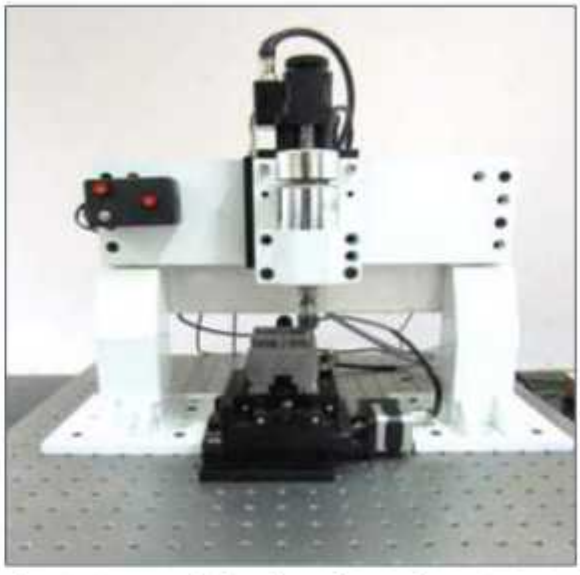
Indigenous 4-axis Controller for Multi-process Micro Machine

Micro machines are not indigenously manufactured and needs to be imported from foreign countries. It becomes difficult for small-scale industries and educational institutions / engineering colleges to procure such systems for machining and skill development respectively due to high cost. To address the same, CSIR-CMERI has developed a low cost micro machine test bed which houses an indigenously developed controller, software and graphical user interface that can conduct four micromachining operations i.e. micro turning / micro milling / micro drilling / micro patterning in a single desktop system (60 cm X 60 cm).



Prototype of the developed system

Important Parameters Unique to the Development

- The micromachining test bed houses indigenous controller card, software and graphical user interface (GUI);
- The controller card houses only low cost microcontrollers as compared to expensive FPGAs and ASICs found in commercial micro machines;
- The controller architecture and communication protocol is novel from technological perspective;
- The entire test bed, controller and software could be manufactured in about ₹ 2 lakh; and
- As the cost of the system is less, it can be used for skill development (machine operation training) at educational institutes.

Major Application(s): The developed system can be used by small and medium scale micro-machining industries such as Surgical tool industries, Jewellery making industries etc. besides skill development in engineering colleges for imparting training on CNC machine operations.

Impact of the Technology:

- The development bears tremendous impact in terms of promotion of micro machining in Indian industrial sector as it is of low cost and can be used in micro machining applications; and
- The developed system has societal impact too as it can be used for skill development activities especially in engineering colleges for imparting training on CNC machine operations.

Commercialization Status: Technology has been transferred to NHIT, Durgapur and Manbhum Pvt. ITI, Purulia on non-exclusive basis. The technology is available for licensing.

Contact: The Director, CSIR-Central Mechanical Engineering Research Institute, Mahatma Gandhi Avenue, Durgapur - 713209, West Bengal; Tel.- 0343-2546749, Fax.- 0343—2546745; E-mail: director@cmeri.res.in

Graphene Based Aqueous Lubricant

Graphene oxide is extensively used in energy storage devices, polymer composites, desalination of water, conducting ink, aqueous lubrication, nano-coolant, additive for phase change materials, etc. The cost of commercially available graphene oxide is very high and thus it is very difficult to use it in the aforesaid areas. Therefore, scaled-up production of graphene oxide at reasonable cost without compromising the quality is a challenging task. CSIR-CMERI has developed a technology for production of graphene oxide starting from natural flake graphite (200 g/batch) without pre-treatment. It can be used for production of graphene based aqueous lubricant to replace graphite-based imported lubricant extensively used in hot-forging industries. The developed lubricant is affordable and has minimum wastage with no nozzle clogging and almost no deposit on the shop-floor. No extra additive or preservative is required for storing the lubricant and it can be stored as solid powder and require only mixing before use. It is not affected by bacterial attack or bad odour due to temperature change.

Important Parameters Unique to the Development:

- Scaled-up graphene oxide production technology (10 kg/month);
- 0.1 wt% of graphene oxide dispersed in water show the friction co-efficient of 0.04 as compared to 0.12 for commercial graphite lubricant (1.5 wt% concentration);
- No extra additive or preservative is required for storing the lubricant;
- Can be stored as solid powder and require mixing before use; and
- No bacterial attack or bad odor due to temperature change

Graphene Based Aqueous Lubricant

Major Application(s): Graphene oxide has several applications in the areas of energy storage and conversion, automotive and aerospace composite materials, coatings and corrosion, biomedical and structural engineering, defence, sensors, electronics, etc. Graphene-based lubricant can be used as hot-forging lubricant.

Impact of the Technology: Graphene lubricants can be used as a substitute for imported lubricants and thus would result in saving of foreign exchange.

Commercialization Status: The scaled-up graphene production technology (200g/batch) has been transferred on non-exclusive basis to M/s Auropol Pvt. Ltd., Kolkata, West Bengal. The technology is available for licensing.

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Intelligent and Powered Wheel Chair

Affordable, intelligent and powered wheel chairs have been designed and developed by CSIR-CMERI. It is a differentially driven model where two of the central wheels are used for power and rear wheels have active suspension mounted casters. The design provides enhanced mobility and stability and capability to turn full 360 degrees in any narrow corridor. It can also go up slant pavements, maintaining stability. It offers high degree of manoeuvrability to navigate smoothly on ups and downs. Its light weight components (main body and seating) decreases the overall weight without compromising on safety. It has fully electronic soft touch control, infrared based safety warning and safety belt, collapsible and foldable foot rest, interchangeable seating with on board charging facility and better night vision capability. It can easily be disassembled into parts for traveling and transportation

Important Parameters Unique to the Developed

- Differentially steered, six-wheel configuration;
- Fully electronic soft touch control;
- LH/RH interchangeable Joystick based command;
- Infrared based safety warning and safety belt;
- On board charging facility;
- Active suspension on rear wheels;
- Collapsible and foldable foot rest;
- Interchangeable seating; and
- Endurance (8-10 hrs for intermittent running)

Major application(s): Mobility vehicle for Physically challenged, old age population and movement aiding for health centres.

Impact of Technology: The market value of the commonly available powered wheel chair is ranging between ₹90,000/- to ₹3,00,000/-. The envisaged cost of the developed technology/product is approximately ₹35,000/- to ₹40,000/-. Simultaneously the system has immense societal value for the physically challenged people, old age population for mobility and rehabilitation purpose.

Commercial Status: The technology has been transferred to M/s S.S. Udyog, Kolkata for commercialization on non-exclusive basis. The technology is available for licensing.

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Glass Textile Reinforced Concrete Crash Barrier System

As of today, the most popularly used crash barrier is made up of reinforced concrete, which has high rigidity but poor energy absorption. When a vehicle collides with such crash barrier, the vehicle is seriously damaged and occupants may be fatally injured due to the impact of the collision.

GTRC Crash Barriers

Keeping in mind the safety of road users, a ready to use pre-fabricated Glass Textile Reinforced Concrete Crash Barrier System has been designed and developed by CSIR-SERC. Methodology has also been developed for connecting the pre-fabricated glass textile reinforced concrete crash barrier to ground and to the side barriers to maintain integrity in the event of collision. The developed crash barriers are lighter in weight, flexible and elastic with ability to absorb the energy of vehicle impact.

Important Parameters Unique to the Development:

- Glass Textile Reinforced Concrete Crash Barrier System (GTRC CRABS) – is a first of its kind application using textile reinforced concrete;
- GTRC CRABS is flexible and absorbs more energy during a vehicle impact;
- Lesser section dimensions and lighter in weight;
- Non-corrosive and highly durable;
- Possibility of customization for target impact resistance and energy absorption;
- Robust connection method to maintain the integrity in the event of collision; and
- Adaptable for use in narrower spaces in interior roads.

Major Application(s): As Crash Barrier/Median in road Highways

Impact of the Technology: The technology would provide improved safety to the vehicle passengers and result in less damage to the impacting vehicles.

Commercialization Status: Technology is available for licencing.

Contact: The Director, CSIR-Central Mechanical Engineering Research Institute, Mahatma Gandhi Avenue, Durgapur - 713209, West Bengal; Tel.- 0343-2546749, 9434022951; Fax.- +91-343-2546745; E-mail: director@cmeri.res.in

Precast Ferrocement Toilet Core Unit (Prefer Toco)

Swachh Bharath Mission aims at promoting cleanliness and sanitation coverage for improving the quality of life in the rural areas. Sustainable sanitation practices can be inculcated through awareness and providing necessary facilities. Quality and speedy construction of the toilets are essential to meet the massive demand. Keeping this in mind, CSIR-SERC has developed a Precast Ferrocement Toilet Core Unit (Prefer Toco) technology as a solution for quality and speedy construction of toilets which are required on a massive scale, especially to promote the Swachh Bharat Mission. The developed toilet units are modular and portable and requires minimum site work. The developed technology improves the speed of construction, quality and durability to overcome the deficiencies in masonry and plastic toilet structures. It would provide column heads for load transfer, natural day light and ventilation to overcome the deficiencies in existing precast/prefabricated ferrocement toilet units and suitable for making cluster of toilet which is not in practice. The cluster toilets developed with common centre wall reduce the cost of toilet units about by 22%.

Single toilet core unit

Multiple toilet core Unit

Important Parameters Unique to the Development:

- Light weight precast panels;
- Dry joints with specially designed concealed connector;
- Ferrocement panels with galvanized meshes - Corrosion resistant;
- Reinforced concrete ribs for strength and bolted connection;
- Suitable for manual / industrialized production;
- Strong, durable and sustainable;

- Modular and portable;
- Speedy construction;
- High quality prefabricated units with minimal site work; and
- Easy installation with minimal lifting equipment / manual

Major Application(s): The technology can be used at rural panchayats/ municipalities, Schools and colleges, Public toilets and Bus stands / railway stations.

Impact of the Technology:

- Addresses Swachh Bharat Mission objectives;
- Caters to the needs of 800 million under privileged population;
- Apt solution for solving basic need of toilet units; and
- Sanitation coverage for improving the quality of life.

Commercialization Status: Technology has been transferred on non-exclusive basis to three firms namely, M/s Laxmi Srinivas Engineers, Hyderabad; M/s Fractal Enterprise, Vishakhapatnam and M/s Natural Waste Management Technologies, Gollapalli, Nuzvid (Mandal) Krishna Dist, AP. The technology is available for licensing.

Contact: The Director, CSIR-Structural Engineering Research Centre (CSIR-SERC) CSIR Campus, TTTI Taramani, Post Box No. 8287, Chennai, Tamil Nadu; Tel.- 044-22542139; Fax.- 22541508; E-mail: director@serc.res.in

Cost Effective Water Tanks using Flowable Cement Mortar

Water tank is an essential need for every house to store water for domestic purposes. CSIR-SERC has developed ferrocement water storage tanks using ferrocement plates of 25- 30 mm thick. This water tank is prepared by a simplified process in modifying the cement mortar as flowable in nature without compromising on its strength properties so that the process will eliminate the requirement of highly skilled person of artisan type and also would be highly cost effective compared to all other water tanks commercially available. The structures are as strong as steel plates and are completely waterproof. Tanks can be made in various sizes with the regular construction tools and its environmental friendly. The water tank can be constructed using this precast concrete panels and assembled in 30 minutes. Further, no machinery is required for lifting the tank.

Important Parameters Unique to the Development:

- Cost-effective compared to commercially available tanks;
- Easy-to-build, durable and safe in storing water;
- Weight of the tank is relatively less when compared to RCC and masonry tanks;
- Viable alternate to plastic tanks;
- Water tank can be constructed using thin precast concrete panels and assembled in 30 minutes; and
- No machinery required for lifting the tank constructed using thin precast concrete panels

Major Application(s): Residential use for storage of water particularly for rural housing sector and also for all residential applications.

Impact of the Technology: Use of cost-effective water tanks will help rural people to improve their living conditions by properly saving and using potable water in hygienic conditions. Tanks can be constructed in various sizes with the regular construction tools and its environmental friendly.

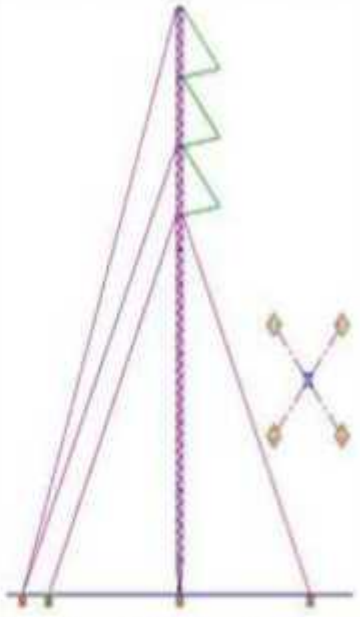
Commercialization Status: Technology has been transferred to M/s. Lakshmi Srinivas Engineering, Hyderabad on non-exclusive basis. The technology is available for licensing.

Contact: The Director, CSIR-Structural Engineering Research Centre (CSIR-SERC) CSIR Campus, TTTI Taramani, Post Box No. 8287, Chennai, Tamil Nadu; Tel.- 044-22542139; Fax.- 22541508; E-mail: director@serc.res.in

Emergency Restoration System for Power Lines (ERS)

In the event of failures of transmission line tower, permanent restoration may take several weeks. Emergency restoration system enables retrieval of the power within very short span i.e. 2-3 days. The permanent restoration can be taken up afterwards or simultaneously. The technology on Emergency Restoration System (ERS) for power lines is first-of-its-kind attempt in the country by CSIR-SERC to develop an import-substitute product. The system provides an alternative solution for transmission of power in the aftermath of failure of the transmission power lines during a cyclone. The system has light weight modular structural panels, which are used as temporary support structure to restore the power within few days. The system is designed as reusable and to facilitate quick fabrication with minimum hardware by way of introduction of innovative simple connections and compatible ready-to-construct foundation systems.

Typical 132 kV TL tower



Equivalent ERS for 132 kV TL Tower

Important Parameters Unique to the Development:

- Simple to fabricate, requires less hardware with innovative connection system;
- It is easy to plan, erect and use at any location;
- Further, this system is compact and yet economically affordable;
- Usage of lightweight materials makes it easy to transport at remote locations;
- The modular system is easy to assemble and flexible enough to develop various configurations of towers for different voltage class TL systems;
- Easy to construct foundation system suitable to all type of soils;
- Scalable system, can be used for 33 to 800 kV transmission lines; and
- Suitable for Industrial production.

Major Application(s):

The developed emergency restoration system can be used for quick restoration of power lines during tower failure events. This technology can be adopted by the Power Ministry to improve the power transmission during failures.

Impact of Technology: The deployment of emergency restoration system will ensure minimal power cuts at the time of tower failures and hence the industries will run smoothly, thus bringing down the businesses interruption losses. Further, since power will be made available in short span of time, use of fossil fuels for temporary power generation and the associated pollution can be minimized. The developed technology contributes in a major way to achieve a disaster resilient society.

Commercial Status: The technology is available for licensing.

Contact: The Director, CSIR-Structural Engineering Research Centre (CSIR-SERC) CSIR Campus, TTTI Taramani, Post Box No. 8287, Chennai, Tamil Nadu; Tel.- 044-22542139; Fax.- 22541508; E-mail: director@serc.res.in

Chemicals (including Leather) and Petrochemicals Theme

Chemicals (including Leather) and Petrochemicals Theme

Technology of Double Fortified Salt (DFS) Composition Containing Iron and Iodine to Control Both Deficiencies

Iron and iodine are essential elements for the human body. Iodine deficiency disorder (IDD) and iron deficiency anaemia (IDA) are caused by insufficient intake of iodine and iron, respectively. These have serious detrimental effects on human physiology and eventually adversely contribute to the economic and social development of entire populations. Globally 1.88 billion people are at risk of Iodine deficiency disorders (IDD) due to insufficient iodine intake and 2 billion people suffer from iron deficiency. Over 71 million people in the country are suffering from Goitre and other iodine-deficiency disorders. As per the National Family Health Survey, India (NFHS-3) report 24% men, 56% women and more than 50% children in 10 states are anaemic.

An innovative and cost effective process for iodine and iron containing double fortified salt (DFS) exhibiting white colour and retaining micronutrient concentration for a prolonged period has been developed. Process scale up has been done for production up to 0.5 ton/day DFS. A multi-centre field survey for anaemic and iodine deficient clusters were conducted. Large scale community-based comparative trial of CSIR-CSMCRI DFS for long term safety, and improvement in iron and iodine status in Bhavnagar and Vadodara district have been successfully competed.

Important Parameters Unique to the Development:

- Fortified with iron in form of Fe^{3+} which is more stable form of iron and white in colour;
- The stability of Fe^{3+} and that of iodine are excellent;
- The free flow ability and aesthetic appearance are excellent;
- The cost of fortification for fortifying salt to contain 1000 ppm of iron and 30 ppm of iodine works out to be ₹2 per kg of salt; and
- The additional nutrition that one gets out of this salt is magnesium. Magnesium is very important nutrient in the body that helps in preventing mellitus diabetes.

Major Application(s): The DFS technology will help in improvement of nutrition and health status by employing cost effective, simple nutritional and technological solution. This technology also has the tenacity to reach and serve the common masses of lower or lower-middle income of Indian population who are in iron and iodine-deficient zones.

Impact of the Technology: Iodine and iron deficiency leads to poor life quality during early fetal development and young children may compromise on their IQ and cognitive development. Growth faltering in malnourished children also hampers intelligence and physical capacity. These in turn lead to slowing down socio-economic growth, reduces productivity and increased poverty and therefore economic cost of malnutrition becomes very high. School age is a very crucial period of life. There is a transition between childhood to adolescence, a stage where rapid growth occurs. In this stage group, nutritional deficiencies may hinder the expected growth and will challenge growth at physical, physiological and mental fronts.

The DFS technology will help in improvement of nutrition and health status by employing cost effective, simple nutritional and technological solution. It will also eradicate severe malnutrition and also reduce the incidence of micronutrient deficiencies, which are often not visible, but can severely impede the development of the child and women.

Commercialization Status: CSIR-CSMCRI DFS has been tested and evaluated by Regional Food Laboratory, Rajkot which conformed that the DFS prepared adheres with Food Safety and Standards (Food Products Standards and Food Additives) Regulation, 2011, Food Safety Standards Act, 2006, rules and regulation made there under. Further it is pertinent to mention that the CSIR-CSMCRI DFS complies largely with BIS specification of DFS IS-16232-2014.

MoU has been signed with Bhavnagar Municipal Corporation (BMC) to provide DFS in mid-day meals for 55000 angandwadi children of Bhavnagar district after ensuring safety via large scale efficacy trial. There are prospective market opportunities to transfer DFS to small / medium scale edible salt manufacturers/ salt refineries. The technology will therefore be transferred at affordable price to large number of small and medium scale manufacturers. The DFS manufacturer will supply to the public distribution system (PDS) at prices fixed by the Government for the benefit of people living below the poverty line. Commercialization of CSMCRI-DFS in the form of supply to government-aided programmes would be feasible and would be an appropriate model. Technology is available for licensing.

Contact: The Director, CSIR-Central Salt and Marine Chemicals Research Institute, Gijubhai Badheka Marg, Bhavnagar - 364002, Gujarat; Tel.- 0278-2567760/ 2568923/ 2565106; Fax.- 0278-2567562 / 2566970; E-mail: director@csmcri.res.in

Membrane Based Process for Commercial Production of Biomolecules

Bioactive molecules have great potential in world market of drug and pharmaceutical, cosmetics, food and textile industries. Oxyresveratrol is used as an anti-aging, cardio-protective, anti-cancerous, treatment of tape-worm infestation, neuro degradation in Alzheimer's disease and skin brightener. Natural dyes are used as food/cloth colorant and in cosmetics. As per UPICO's survey report, in India the total requirement of raw materials of natural dye is 33730 tons and the quantity of natural dyes used is 675 tons. Membrane based process for separation and purification of biomolecules is less energy intensive and a low cost process for production of high purity biomolecules and have great market potential. The project envisaged the development of knowhow for commercial production of Oxyresveratrol and Natural dyes.

Important Parameters Unique to The Development:

- Membranes for separation and purification of Oxyresveratrol and Natural dyes; and
- Process technology for production of Oxyresveratrol and Natural dyes (99%).

Major Application(s): The technology has application in the drug and pharmaceutical, dye, food and textile, cosmetics and membrane manufacturing industries

Impact of the Technology: The North Eastern Region of India possesses large plant resources, only little has been exploited so far. The unique opportunity of the technologies is that it is a membrane based separation processes which is economical, safe and eco-friendly. Development of indigenous membranes for specific applications with improvements in productivity, durability, separation efficiency etc. is the key point of this technology. The membrane based process for commercial production of Oxyresveratrol and Natural dyes reduces the overall production costs to meet the "National Need" as tons of these compounds has been imported from foreign countries including China. Generation of entrepreneurship and employment is another major impact of this technology.

Commercialization Status: The technology for commercial production of Oxyresveratrol has been developed and patent filed. Technology for production of Natural Edible dye: Deep Pink Colour has been transferred to M/s Nabarun Enterprise, Guwahati on non-exclusive basis. Technology is available for further licensing.

Flat sheet membrane module

NEIST Oxyresveratrol

Hollow Fibre Membrane module

NEIST Natural dye: Deep pink colour

Technology on "Process for production of Natural Edible Dyes: Deep Pink Colour" transferred to M/s Nabarun Enterprise, Assam

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Novel Cost Effective Process for High Purity Solar Salt Production with Reduced Contents of Carbon, Iodine, Suspended Solids and Sulfate Content Directly in Solar Salt Fields from High Sulfate Containing Brines (Particularly for Rajasthan Inland/Lake Brines)

CSIR-CSMCRI has patented a process for high purity salt production. The technology deals with improvement in salt purity and whiteness through chemical treatment of brine in Rajasthan, which typically contain high amounts of carbonates, bicarbonates, suspended impurities and micro algae. Thus, the salt is upgraded from edible to industrial grade and will meet the requirements of chlor-alkali industry in the adjacent areas.

The developed process has been validated at pilot scale in the solar salt works of a private salt manufacturer supplying salt to the chlor-alkali industries. The process has resulted in upgradation of solar salt quality as per the desired specifications of chlor-alkali industries.

Process for high purity solar salt production

Important Parameters Unique to the Development:

- Cost effective process for converting edible grade salt to industrial grade salt; and
- Demonstration and transfer of process to chlor alkali industries operating in vicinity of Rajasthan.

Major Application(s): The technology finds application in chlor-alkali, soda ash and detergents etc.

Impact of the Technology: Rajasthan is the 3rd largest salt producer state in India after Gujarat and Tamil Nadu and produces nearly 25 lakh tons of salt every year. The salt produced in Rajasthan is of edible grade due to unique composition of brine available in Rajasthan. The salt manufacturers in Rajasthan are facing difficulties in selling their salt for chlor alkali industries therefore this technology will be very helpful for them in upgrading the salt quality.

Upgraded quality salt will be obtained directly in solar salt fields and be suitable for industrial applications. Small and medium scale solar salt manufacturers will be able to sale salt for industrial purpose at higher price. It is expected to uplift the livelihood of small salt manufacturers.

Commercialization Status: The processes for high purity salt production developed at CSIR-CSMCRI (US Patent No. 8,282,690 B2; EP 1928569 B1 and US patent No.

8,021,442 B2) is further improved to address the difficulties of impurities in solar salt fields from high sulfate and other impurities containing subsoil/lake brines in Rajasthan. Prototype salt unit for validation of results has been constructed and is ready for demonstration of process to user industries. Experiments at semi-pilot scale are validated and reproduced. The process has been perfected and implemented on large scale in Rajasthan at M/s. Bharat Salt Company, Nava. Industrial partners (M/s. Grasim Industries Ltd., Nagda & Sambhar Salts Limited, Nawa and DCM Shriram Consolidated Ltd. Kota), Lord Alkalies & Chemicals Ltd. have been involved for participation and validation of end product. Salt samples have been sent to different industries for testing, analysis and suitability. Feedbacks have been obtained from the user industries. As per feedback, the salt meets the required specifications. Efforts are being made to transfer the process to salt manufacturers of Rajasthan. Technology is available for licensing.

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A Linalool Rich Cold Tolerant *Ocimum* Chemotype

The essential oil of Indian basil from leaves or whole aerial biomass of the plant is used to flavor foods, dental and oral products, fragrances, social/religious rituals and traditional medicines. The essential oil has also been shown to contain biologically active constituents that have insecticidal, nematicidal, fungistatic or antimicrobial properties. Linalool is used in the aroma, cosmetic, perfumery, pharmaceutical and flavour industries for formulating value added novel industrial products. India is importing linalool from China. The estimated annual demand of linalool is about 700-900 tons. The market rate of natural linalool is ₹1500-1700/kg. However, the rate of synthetic linalool is ₹600-700/kg.

Development and evaluation of unique chemotypes having more linalool content in basil is a very novel work. Intensive breeding techniques and selection process have been undertaken at CSIR-CIMAP, to develop a variety of *Ocimum basilicum* named 'CIM-Surabhi' having 70-75% (-) linalool with 99.14% purity and quality.

CIM-Surabhi

Important Parameters Unique to the Development:

- CIM-Surabhi is morphologically distinct from other *Ocimum basilicum* varieties and clearly identifiable by its broad, medium green leaves and light green stem;
- The variety has a unique feature and advantage of better survival in winter season in comparison to other *O. basilicum* strains/varieties;
- Essential oil extracted from this variety contain higher amount of linalool content (70-75 %) with low amount of linalool acetate (8.50 %); and
- Variety is also suitable for rain-fed cultivation (March-December).

Major application(s): Small farmers, essential oil, aroma, cosmetic, perfumery, pharmaceutical and flavour industries will be benefited by this variety and they may utilize the product/variety in order to develop entrepreneurships.

Impact of the Technology: The new variety can be an economical source of (-) Linalool used in aroma, cosmetic, perfumery, pharmaceutical and flavour industries. Besides the premium price of linalool, the variety will also provide additional income to farmers as it would be a high herb and essential oil yielding variety with 70-75 % (-) linalool. A farmer can get an income of ₹50,000/- to ₹55,000/ha per annum. This variety requires low input and gives high returns within a period of about 90 days. The farmers may be benefited with 30-35% additional profit. The socio-economic condition of the farmers will be improved due to their income enhancement. This will definitely boost economic impact of farmers in North Indian plains.

Commercialization Status: For commercialization of the knowhow, CSIR-CIMAP has put in place its model of large scale cultivation at farmers' fields and buyback arrangement with industry. The seeds of CIM-Surabhi were provided to farmers for commercial cultivation and oil to different oil trading companies to find out the acceptability of the oil by different industries. The oil samples were provided to private industries like Ultratech International, Nishant Aroma and Ajmal to assess the acceptability of oil in the industry and thereby to ensure the sale of the oil produced by the farmers. The traders have shown willingness to purchase the oil from the farmers. This year the new variety has been planted in the fields of 5 farmers and oil produced by them will be sold to traders / industry.

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Continuous Dinitration for Manufacturing of Pendimethalin

Indian agriculture needs pendimethalin, an herbicide, for managing weeds for several crops (viz. cotton, soybeans, rice, barley, beans, alliums, vines, tobacco, ornamentals and orchards of fruit and nut trees). The conventional process of pendimethalin manufacturing uses large quantities of mixed acids and solvents for reactions carried out for several hours. There are more than 10 manufacturers of this product across India (viz. UPL India Ltd., Rallis India Ltd., GSP Crop Sci. Pvt. Ltd., Meghmani Agrochemicals Ltd., Deccan Chemicals Ltd., etc.) and a large fraction of the product is exported. On an average India manufactures 50 – 80 tons of pendimethalin every day from season to season.

CSIR-NCL has developed an intensified continuous process for the synthesis of pendimethalin using only nitric acid and very low quantities of the solvents when compared to the conventional process.

Figure: (Left) Molecular structure of pendimethalin, (Middle) Various commercially available pendimethalin formulation brands from India (taken from internet), (Right). The continuous pilot plant established at CSIR-NCL for synthesis of pendimethalin at 50 kg/day.

Continuous dinitration process with complete conversion of the substrate at optimal concentration of the nitrating agent has been established. Significantly lower quantity of solvent in the reaction helps to accelerate the reaction rates and reduced solvent handling. Two different types of continuous flow reactors (Pinched tube reactor and high shear dispersion reactor, both help to maintain excellent liquid-liquid dispersion in the reactor while giving large heat transfer area) are used and demonstrated at a scale of 50 kg/day that meet the requirements for the next step of denitrosation.

Salient Features of the Technology:

- A patent has been filed on the technology based on using a high shear dispersion reactor for this process; and
- A detailed BEP is ready for technologies based on two different reactors to be implemented at commercial scale (0.5 to 2 TPD).

Impact of the Technology: Overall the process is highly energy efficient, environment friendly, modular and encourages decentralized production due to very less chemical footprint (at least by 50%). The process is continuous and hence automated making it compatible for remote monitoring as needed in Industry 4.0. Basic Engineering Package Document of the process is ready for production of 0.5 to 2 TPD.

Commercialization Status: CSIR-NCL has signed a technology transfer agreement with M/s GSP Crops, Ahmedabad on non-exclusive basis. The technology transfer agreements with other two companies are in advanced stage. Technology is available for licensing.

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Waterless Chrome Tanning - A Game Changing Technology

Leather industry is extremely under pressure due to stringent environmental regulations specifically with respect to discharge of wastewater. Use of huge quantity of water in the leather manufacture and generation of substantial volume of wastewater are major concerns to reckon with. The bio toxicity of chromium has been a subject of major concern. In view of the potential toxicity of chromium, the environmental regulatory norms stipulate the discharge of chromium from industrial wastewaters in the range of 0.3–2.0 ppm. Such strict norms demand technological interventions to minimize the discharge of chromium within the specified levels.

Chromium is the most sought after tanning agent with about 2.0 billion sq. ft. of leather being made in India. About 20 thousand tons of chrome tanning agent is discharged in the wastewater. In order to overcome the problem, CSIR-CLRI has developed waterless chrome tanning technology. Significance of this technology is that a) it completely eliminates two processes before and after tanning, b) eliminates the use of water in tanning, c) reduces the total dissolved solids in wastewater from this process by 20% and also d) brings down the usage of chromium by 15-20%, resulting in material saving.

Important Parameters Unique to the Development:

- No pickling, basification, and rechroming;
- The fullness and roundness of the wet-blue leathers are much better than the conventionally processed leathers, thus providing ample scope for the reduction of syntans during wet-finishing;
- Due to the increased fixation of chromium, the dye uptake is higher. Therefore, there is a scope for the reduction of dye used in the process;
- Handling of 380 tons of dangerous sulphuric acid is averted per annum;
- Savings of ₹120 crores per annum;
- Overall up gradation and better cutting value; and
- A simple process suitable for all kinds of skins/hides.

The uniqueness of the waterless chrome tanning technology lies in achieving irreversible chromium binding without process water, high exhaustion of chromium during tanning, elimination of rechroming as well as eliminating the emission of many pollutants. The usage of the chrome tanning technology for wet blue manufacturing would provide significant reduction in TDS and chromium loads. This addresses the major problem faced by the leather industry to comply with the environmental regulations.

Leather industry provides employment to nearly 2.5 million people in India. More than 90% of the leathers manufactured globally contain chromium through the use of chrome salts for tanning. The leather industry with its enormous socio-economic background suffers from environmental issues resulting from the tannery wastewaters. The implementation of waterless chrome tanning assures near zero chromium emission. This would make the leather industry sustainable with the emergence of new units thereby the employment for the people depending on this industry will be secured and boosted in the future.

The waterless tanning technology has now found PAN INDIA acceptance with tanners in all clusters enrolling for its adoption. The technology has been put to use in about 60 tanneries in the country. Several countries including Ethiopia, South Africa, The Netherlands, New Zealand, Vietnam and Brazil have evinced interest in this CSIR technology and are in the process of seeking it from CSIR. The technology was dedicated to the Nation on September 26, 2018 by Hon'ble President of India.

Commercialization Status: Commercialized in 60 tanneries on non-exclusive basis, many more are in the offing. Further, technology is available for licensing.

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Technology for making High Grade Gelatin from Raw Hide and Skin Trimming Wastes

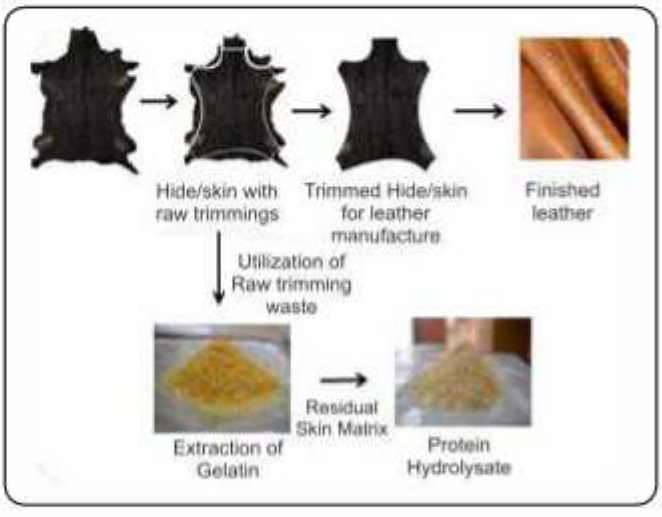
Huge volume of raw skin/hide trimmings wastes is generated during leather manufacture. Raw skin or hide trimmings contain high value proteins especially collagen and keratin, which could find applications in different fields. Currently, these trimming wastes are underutilized and in many cases these are dumped as solid wastes.

Gelatin is widely used in the pharmaceutical industry to make capsules for drugs as well as in the food industry to make jelly candies, ice cream, and as thickening agent in cakes and soups. In India, high grade gelatin is manufactured from animal bones, which does not meet the requirements of domestic consumption and India annually imports more than US$ 50 million dollars' worth of high grade gelatin, which are mainly for making capsules in pharma industry. Global gelatin and collagen peptide market was valued at US$ 3,614.1 Million in 2016 and the same is expected to reach US$ 9,860.2 Million by 2025 expanding at a CAGR of 10.90% from 2017 to 2025.

CSIR-CLRI has developed technology for making high grade gelatin from waste material-trimmings of raw hide. The technology developed by CSIR-CLRI is towards complete utilization of proteinous constituents present in the trimmings.

Important Parameters Unique to the Development:

- Simple, innovative and cost effective technology;
- Wealth from waste technology;
- Holistic and a closed loop process for the extraction of gelatin;
- High grade gelatin with high gel strength >250 g;
- Complete utilization of trimming waste to make high value products; and
- Zero discharge technology



Major Application(s): High grade gelatin can be used as raw material for food, pharma and laboratory applications. The protein hydrolysates developed too have multiple usages; they can be used in leather manufacture, animal feed applications and in agriculture as fertilizer.

Impact of the Technology: Every year, Indian tanneries process about 700,000 tons of raw materials for leather manufacture, which results in the generation of about

50,000 tons of trimming waste. The availability of raw trimmings and the developed technology presents a scope to make about 7000 - 8000 tons of high-grade gelatin presenting a strong case of import substitution to the tune of US$ 40 million every year. While the tanneries are finding it tough to manage the disposal of these wastes, this technology opens a new paradigm to derive high value products out of these wastes. Translation of this technology paves way for creating start-ups leading to value and employment creation.

Commercialization Status: The technology is exclusively licensed at a cost of ₹ 1.0 Crore to M/s Anipro Manufacturing Company for making gelatin and protein hydrolysate within India. The technology is available for licensing abroad.

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Synthesis of 5-Hydroxymethyl Furfural from Saccharides

Renewable biomass (cellulose) derived 5-Hydroxymethyl furfural (5-HMF) via formation of glucose and fructose is considered as a major platform chemical, which is also reported by DOE. It is a starting chemical for the synthesis 2,5-furandicarboxylic acid (FDCA), a potential bio-renewable replacement for terephthalic acid to make bio-derived polymers (PEF) like PET. PEF has several advantages over PET in terms of moisture, O_2 and CO_2 permeability and thus it can be used in food packaging. Several industries are looking into this aspect. In spite of worldwide enormous efforts for 5-HMF synthesis from glucose on commercial scale, no process is known and thus efforts are put in this direction.

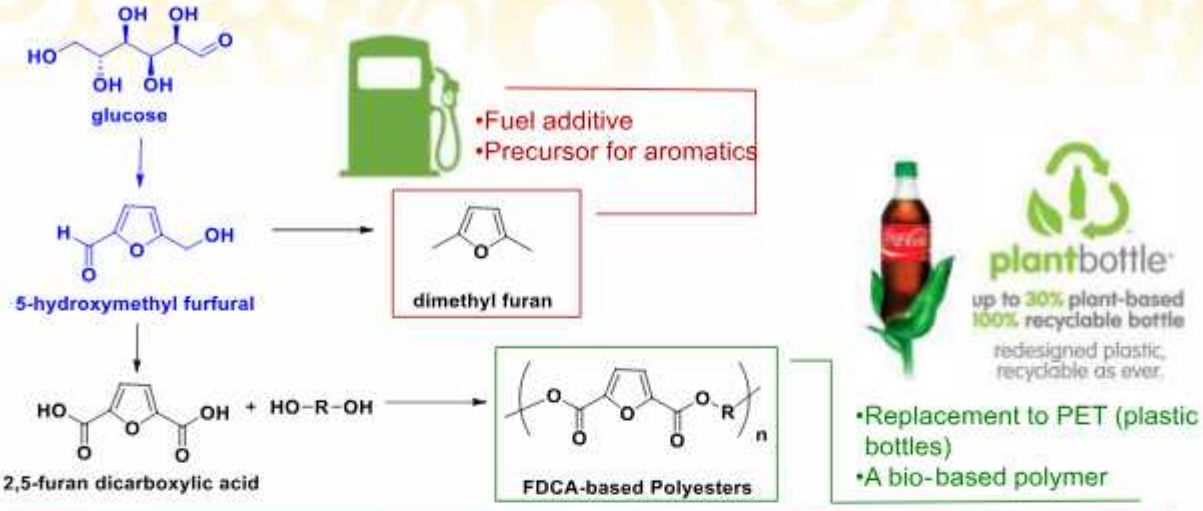
Considering above, it is required to develop methodologies for the synthesis of HMF from glucose [since it is available in plenty (especially with India from crop waste can be derived) – through hydrolysis of cellulose] instead of fructose (its availability is relative to glucose is minimal and is costlier than glucose). However, the challenge is to overcome several equilibrium reactions such as ring opening of glucose, isomerization of glucose to fructose and dehydration of fructose to 5-HMF. Overcoming all the challenges, CSIR-NCL has developed a technology for the conversion of glucose into 5-HMF.

Important Parameters Unique to the Development:

- India specific with global relevance: Availability of glucose and fructose in India has been checked with industry and as per the suggestions received, glucose is primarily chosen as a substrate to synthesize 5-HMF;
- Designing the recyclable catalysts with dual functionality: One-pot isomerization and dehydration reactions with high yields;
- Energy efficient methodology: Use of high concentration substrate solutions to make process economically viable in terms of cost of 5-HMF with a consideration to develop green process;
- Lower solvent usage: High substrate concentration (~12-16wt %) makes use of lower solvent quantity which enhances the rate of reaction. Further mix of organic solvents gives better extraction of 5-HMF; and
- First of its kind for 5-HMF from glucose: It would be world's first commercial process to synthesize 5-HMF from glucose.

Major Application(s):

- 5-HMF will serve as major platform chemical as described in US DOE report on biomass derived top value added chemicals;
- 5-HMF is used to synthesize 2,5-furan dicarboxylic acid (FDCA) which has a potential to replace terephthalic acid to prepare bio-derived PEF, an analogue to PET. This polymer is used in bottles and food storage containers;
- 5-HMF up on hydrogenation gives 2,5-dimethyl furan (DMF), which is a good gasoline additive; and
- 5-HMF is a starting chemical for Levulinic acid, alkyl levulinate, GVL etc. which are other important renewable platform chemicals.



Gas permeability data - PEF performs better than PET

Gas	Method	PEF	PET
CO_2	MOCON Permatran	4.449	10.154
O_2	MOCON Oxtran	0.095	0.891

- The Tg of PEF is 86°C compared to the Tg of PET of 74°C
- The Tm of PEF is 235°C compared to the Tm of PET of 265°C

Impact of the Technology: Developed technology would be a step towards making bio-derived PEF type polymers which has properties better than PET in terms of preserving food for longer time. The polymer also last in the environment for shorter time than the conventional PET based polymer.

Commercialization Status: Technology is available for licensing.

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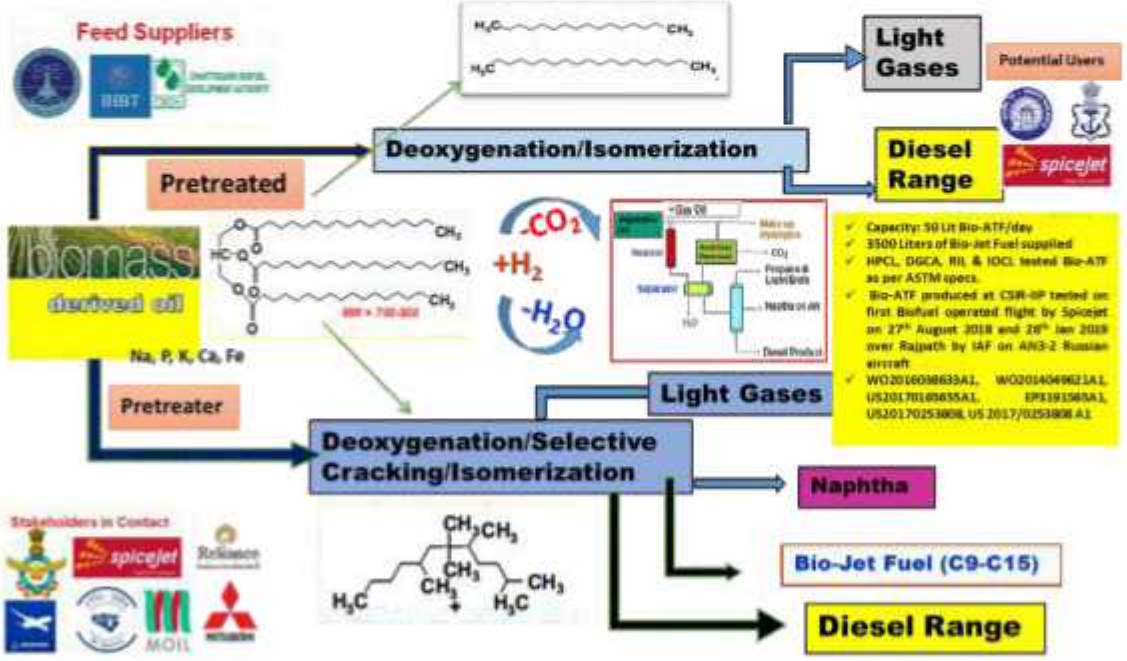
Technology Demonstration and Process Flexibility for Production of Bio-Aviation Fuels

Air transport is completely dependent upon liquid hydrocarbon fuels. The technical approval of the 50% biofuel / kerosene mix for aviation fuel (ASTM D7566), in June, 2011 has resulted in a noticeable rapid increase in interest and investment on biojet fuel. Through the project, the existing pilot unit for bio-jet fuel and renewable diesel production was revamped to strengthen the existing technology economics.

Important Parameters Unique to the Development:

- Single-Reactor Catalytic Process;
- Integrable with current global production and supply chains;
- Cheap multifunctional catalyst - Deoxygenations, Isomerization, Selective cracking, Aromatization, Cyclization reactions;
- Better Fuel Economy;
- Renewable Fuel; and
- Reduced Pollution – SOx, COx, Particulate Matter – Environment Friendly



Major Application(s): The development has application in the aviation fuel as well as road transport fuel sectors for civil and strategic needs.

Impact of the Technology: Inedible oil to aviation fuel is expected to add to economic and industrial growth and streamline the waste cooking oil/inedible oil sector. Use of bio-aviation fuel and renewable diesel will reduce carbon footprint.

Commercialization Status: CSIR-Indian Institute of Petroleum (CSIR-IIP) has developed process as well as catalyst to produce jet fuel based on biomass-derived non-edible oils such as jatropha oil. The technology is protected through patents. The bio-jet fuel matches all the major specifications for aviation fuels such as petroleum derived jet fuel. The process developed is very similar to refinery processes and hence can be integrated into the current refinery infrastructure. The technology was showcased at Republic Day 2019 through flight of an Air Force carrier aircraft. Earlier in August 2018, a test flight was conducted with Spicejet when a commercial flight from Dehradun to Delhi was flown with the bioaviation fuel in one of its engines.

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Adsorption Based Technology for the Production of Ultra Low Sulfur Diesel Meeting BS VI Specification

There is worldwide concern on the harmful effects of vehicular emissions on environment and public health resulting from use of high sulphur transportation fuels. Stringent fuel quality standards are being imposed for control of such emissions. Recently Government of India has proposed switchover to BS VI (10 ppm S) by April 2020.

The conventional technologies to produce ultra-low sulfur diesel are capital and energy intensive and rely on hydrogen treating. There is a need to design a low-cost technology to produce ultra-low sulfur diesel, implementation of which will concomitantly lead to a decrease in the level of greenhouse gas emissions from within the refinery. In this context, CSIR-IIP has developed a vapor phase adsorptive process to reduce the sulfur levels in diesel to meet BS VI specifications. The developed process can remove refractory sulfur from transportation fuel to meet the targeted specifications.

Important Parameters Unique to the Development:

- A fixed bed vapor phase adsorption process that can bring down sulphur level to <10 ppm meeting BS VI diesel specifications using commercial BS IV diesel as feed;
- Adsorbent is thermally regenerable with minimum temperature swing between adsorption and regeneration step;
- Operating pressure of the adsorptive desulfurization process is lower (3-8 bar) compared to conventional HDS (30-110 bar) to produce ultra-low sulphur gasoline and diesel;
- Effluent streams can be handled within existing refinery treatment facilities;
- H_2 consumption is lower (up to 20% of diesel HDS) leading to reduced CO_2 footprint;
- Substantial savings in costs for adsorber and separator vessels are envisaged due to low pressure operation; and
- The process can be integrated as a polishing step with conventional hydro desulfurization unit.

Major Application(s): The developed process has strong potential for application both in an operating refinery as well as at several locations in India in the natural gas processing industry or in small refineries where limited hydrogen availability prevents application of conventional hydro-treating technology. Commercialization of this technology in the refining sector is expected to bring benefits both economic as well as social as it will make production of "clean fuel" cheaper and it will be a step towards better environment management with respect to emissions control for the refinery with reduced CO_2 foot print.

Pilot scale Adsorptive Desulfurization Unit at CSIR-IIP

Impact of the technology: Consumption of vehicular transportation fuel particularly diesel in urban areas in India is quite significant. Benefits of the technology for fuel desulphurization will be in terms of improving urban air quality. There is thus a potential for positive impact on the health of urban population.

Commercialization Status: The bench scale developed process has been validated at pilot scale using commercial BS IV diesel as feed. The adsorbent formulation was scaled from gram scale to kg scale successfully and the desulfurization performance of the scale up adsorbent was found to be reproducing the lab scale desulfurization data.

A demonstration unit with 10 LPH diesel throughput was designed in-house and commissioned at CSIR-IIP. The in-house developed adsorbent formulation was successfully scaled up from gram to kg scale. The adsorption and regeneration parameters were optimized to produce diesel product meeting BS VI specifications. The pilot scale desulfurization results exceeded the performance at the bench scale operation under the same set of operating conditions. The product diesel conforms to the BSVI specifications for diesel.

HMEL has shown interest for a feasibility study for reducing the total 'S' of HMEL's VGO feed from ~50 ppm to <10 ppm total 'S' and also for a proof-of-concept study for reducing of HMEL's LCO feed from ~500 ppm to maximum extent possible. CSIP-IIP has submitted a techno-commercial proposal to HMEL which is currently under consideration.

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Demonstration and Process Validation of Laboratory Scale Vacuum Swing Adsorption (VSA) Process for Biogas Up-gradation to Pipeline Quality Fuel from Raw Biogas

Biogas is one of the renewable energy sources with favourable CO_2 balance. It can be formed by biological transformation of large variety of organic wastes. It primarily consists of methane (CH_4), carbon dioxide (CO_2) and small amounts of hydrogen sulphide (H_2S). The raw biogas is generally saturated with moisture (H_2O). The typical compositional range of raw bio-gas depending on feedstock is CH_4: 55-65%; CO_2: 35-45%; H_2S: 50-40000 ppm; Moisture (Saturated). The bio-gas needs to be upgraded to increase its calorific value (Bio-gas: 21.5 MJ/m^3 *vis a vis* Natural gas: 35.8 MJ/m^3) and also to remove toxic and corrosive H_2S. The upgraded bio-gas can be used as fuel for gas engines, boilers, fuel cells, vehicles etc.

CSIR-IIP has developed a Vacuum Swing Adsorption (VSA) based process for upgrading raw biogas to high purity bio methane which can be used as a replacement to natural gas for power generation, as piped natural gas equivalent fuel (bio PNG) for domestic and industrial heating or as compressed biogas for vehicular fuel application (CBG).

Important Parameters Unique to the Development:

- Simple VSA cycle configuration;
- Designed to operate at low pressure considering availability of biogas at low pressure; and
- The upgraded biogas composition conforms with BIS specification (IS-16087) for pipe line quality biogas.

Major Application(s): The process will find applications in upgradation of biogas which can be used as a fuel in small and medium scale industries, as bio CNG for vehicular transport, for power generation and as fuel for community kitchens/residential fuel.

Impact of the technology: As the upgraded biogas with high calorific value will find more applications as an efficient fuel for combustion, transportation and electricity generation, the technology adoption is expected to have wider acceptance from local communities. This will lead to better living conditions, employment generation and better connectivity with the urban areas.

Commercialization Status: The process has been demonstrated at raw biogas throughputs in the range of 150-500 m^3/day. The raw biogas was sourced from a municipality owned anaerobic digester which uses kitchen wastes sourced from hotels as feed to the digester. Upgraded biogas could meet BIS specification (IS-16087) for pipe line quality bio-methane.

	CH_4 (vol%)	**CO_2** (vol%)	**O_2** (vol%)	**H_2S** (mg/m^3)	**Moisture** (mg/m^3)
Compositions of Raw Biogas	55-65	35-45	0.5-1	500-1600	Saturated
Compositions of Upgraded Biogas	94-97	1-4	0.1-0.5	0-20	≤5

As per the preliminary estimates, the PNG grade bio-methane can be produced by this process @ ` 11-18/ m3 of bio-methane depending on the scale. Considering the current PNG price of ` 29/m3, implementation of the process is thus financially viable. There will also be employment generation of 2-3 semiskilled and 1 skilled operator per plant. On these lines, as per the preliminary estimates producing CBG (which involves compressing bio-methane to 250 bar pressure) will also be attractive owing to the higher selling price of CBG (` 48 inclusive of GST). The estimated cost of CBG for a 2 TPD plant will be ~ ` 19/ kg and it will attract higher margins than PNG.

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Setting up 1 TPD Pilot Plant for Converting Waste Plastics to Diesel

The rapid increase in the consumption of plastics has resulted in the simultaneous generation of enormous amount of waste plastics. The plastics are non-biodegradable and hence their increased utilization is also simultaneously resulting in increased generation of plastic wastes. The present methods of disposal of waste plastics like land filling and incineration have inherent drawbacks such as turning enormous amount of land into waste and emission of toxic gases. Hence there is a strong need to find a viable solution for utilization of these waste plastics. Also, the process should be environment friendly, simple and suitable for small as well as large scale units.

CSIR-IIP in collaboration with GAIL (India) developed a novel process by which polyolefinic waste plastics like polyethylene and polypropylene can be converted exclusively into any one of the products, viz, gasoline or diesel or aromatics along with simultaneous production of liquefied petroleum gas (LPG). The process after being developed at the laboratory scale has been successfully revalidated at the continuous bench scale unit (7-10 Kg per day). A 1 ton per day (TPD) pilot plant has been set up along with GAIL (India) Ltd for converting sorted waste polyolefins, available from MSW, into diesel. Setting up of 1 TPD plant together with feed pre-treatment facilities would facilitate commercialization of this technology.

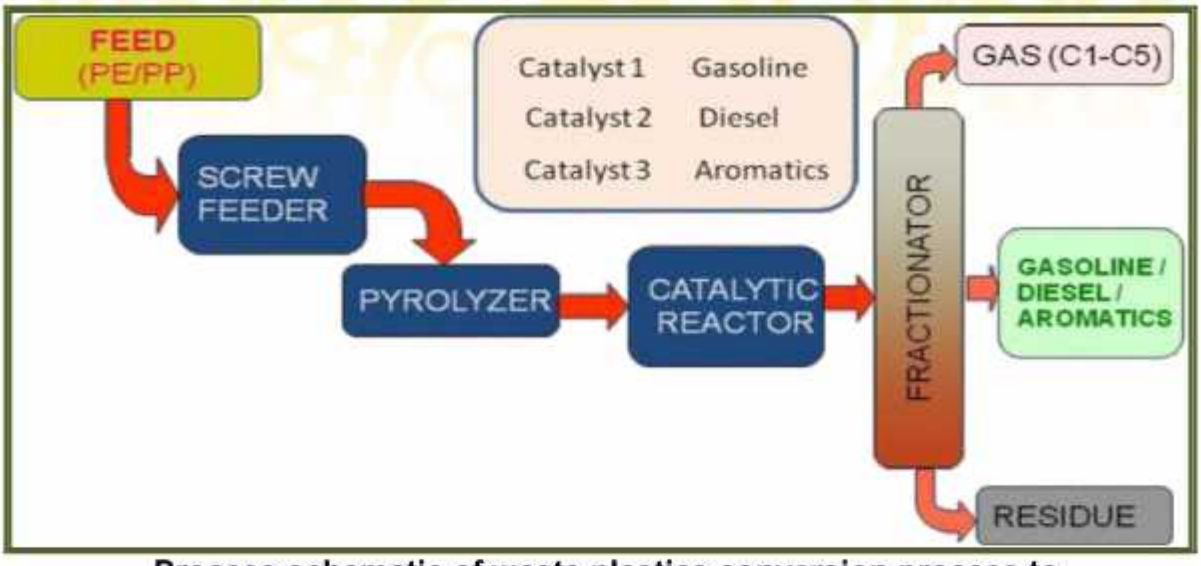
Important Parameters Unique to the Development:

- Exclusive production of any one of the products viz. gasoline or diesel or aromatics along with LPG;
- The liquid fuel (gasoline/diesel) meeting Euro IV specifications. These have been tested on a passenger car and their performance is comparable to commercial automotive fuel;
- The uncondensed gases utilized for internal consumption in the plant; and
- The process is completely environment friendly as no toxic gases are evolved.

Major Application(s): Setting up of commercial plants based on this technology for utilization of waste plastics available from municipal solid waste (MSW) at various locations across India.

Impact of the technology: The process has the potential to solve the problem of plastics of waste plastics disposal in an economical and environmental friendly way. The plant based on this process can be set up at various capacities ranging from 1 TPD (skid mounted) to larger scale. It can augment the supply of fuel and chemicals.

Commercialization Status: Technology for converting waste plastics to automotive grade (Euro IV/VI diesel) has been developed at bench scale. A pre-treatment set up has also installed for treating waste plastics obtained from MSW. A 1 TPD plant has been set up at CSIR-IIP for converting waste plastics to automotive grade (Euro IV/VI) diesel.



Process schematic of waste plastics conversion process to value added products

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