Autonomous Bodies

1. Council of Scientific & Industrial Research (CSIR)

2. Consultancy Development Centre (CDC)

सत्यमेव जयते

Autonomous Bodies

1. COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH

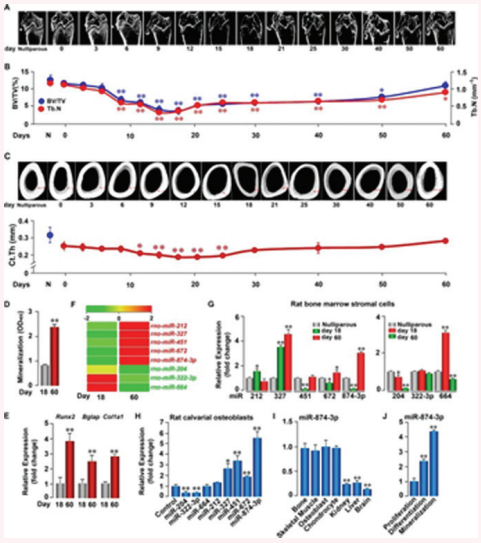
1.1 Biological Sciences

Oxidized LDL induced extracellular trap formation in human neutrophils via TLR-PKC-IRAK-MAPK and NADPH-oxidase activation

Neutrophil extracellular traps (NETs) formation was initially linked with host defence and extracellular killing of pathogens. However, recent studies have highlighted their inflammatory potential. Oxidized low density lipoprotein (oxLDL) has been implicated as an independent risk factor in various acute or chronic inflammatory diseases including systemic inflammatory response syndrome (SIRS). In the present study CSIR-CDRI investigated effect of oxLDL on NETs formation and elucidated the underlying signalling mechanism. Treatment of oxLDL to adhered PMNs led to a time and concentration dependent ROS generation and NETs formation. OxLDL induced free radical formation and NETs release were significantly prevented in presence of NADPH oxidase (NOX) inhibitors suggesting role of NOX activation in oxLDL induced NETs release This study thus demonstrates for the first time that treatment of human PMNs with oxLDL or its various oxidized phopholipid component mediated NETs release, implying their role in the pathogenesis of inflammatory diseases such as SIRS.

MicroRNA 874-3p Exerts Skeletal Anabolic Effects Epigenetically during Weaning by Suppressing Hdac1 Expression

Embryonic skeletogenesis and postnatal bone development require the transfer of calcium from the mother to the offspring during pregnancy and lactation. Therefore, bone resorption in the mother becomes elevated during these periods, resulting in significant maternal skeletal loss. There follows an anabolic phase around weaning during which there is a remarkable recovery of the maternal skeleton. However, the mechanism(s) of this anabolic response remain(s) largely unknown. CSIR-CDRI identified eight differentially expressed miRNAs by array profiling, of which miR-874-3p was highly expressed at weaning, a time when bone loss was noted to recover. CSIR-CDRI reported that this weaning-associated miRNA is an anabolic target. Therefore, an agomir of miR-874-3p induced osteoblast differentiation and mineralization. These actions were mediated through the inhibition of Hdac1 expression and enhanced Runx2 transcriptional activation. When injected in vivo, the agomir significantly increased osteoblastogenesis and mineralization, reversed bone loss caused by ovariectomy, and increased bone strength. It is speculated that elevated miR-874-3p expression during weaning enhances bone formation and that this miRNA may become a therapeutic target for conditions of bone loss.



miR-874-3p exerts bone anabolic effect

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Macrophages Promote Matrix Protrusive and Invasive Function of Breast Cancer Cells via MIP-1β Dependent Upregulation of MYO3A Gene in Breast Cancer Cells

The potential of a tumor cell to metastasize profoundly depends on its microenvironment, or "niche" interactions with local components. Tumor-associated-macrophages (TAMs) are the most abundant subpopulation of tumor stroma and represent a key component of tumor microenvironment. The dynamic interaction of cancer cells with neighboring TAMs actively drive cancer progression and metastatic transformation through intercellular signaling networks that need better elucidation. Thus, current study CSIR-CDRI planned for discerning paracrine communication networks operational between TAMs, and breast cancer cells with special reference to cancer cell invasion and dissemination to distant sites. CSIR-CDRI reported role of MIP-1β in enhancing invasive potential of metastatic breast cancer MDA-MB-231 and MDA-MB-468 cells. In addition, the poorly metastatic MCF-7 cells were also rendered invasive by MIP-1β. The MIP-1β-driven cancer cell invasion was dependent on upregulated expression levels of MYO3A gene, which encodes an unconventional myosin super-family protein harboring a kinase domain. Ex ovo study employing Chick-embryo-model and in vivo Syngenic 4T1/BALB/c mice-model further corroborated aforementioned in vitro findings, thereby substantiating their physiological relevance. Concordantly, human breast cancer specimen exhibited significant association between mRNA expression levels of MIP-1β and MYO3A. Both, MIP-1β and MYO3A exhibited positive correlation with MMP9, an established molecular determinant of cancer cell invasion. Higher expression of these genes correlated with poor survival of breast cancer patients. Collectively, these results point toward so far undisclosed MIP-1β/MYO3A axis being operational during metastasis, wherein macrophage-derived MIP-1β potentiated cancer cell invasion and metastasis via up regulation of MYO3A gene within cancer cells. This study exposes opportunities for devising potential anti-metastatic strategies for efficient clinical management of breast cancer.

Vitamin B6 Tethered Endosomal pH Responsive Lipid Nanoparticles for Triggered Intracellular Release of Doxorubicin

This study by CSIR-CDRI reports the development of Vitamin B6 (VitB6) modified pH sensitive charge reversal nanoparticles for efficient intracellular delivery of Doxorubicin (DOX). Herein, VitB6 was conjugated to stearic acid, and the nanoparticles of the lipid were formulated by solvent injection method (DOX-B6-SA-NP). Because of the pKa (5.6) of VitB6, DOX-B6-SA-NP showed positive charge and enhanced release of DOX at pH 5. Confocal microscopy illustrated that DOX-B6-SA-NP treatment kept higher DOX accumulation inside the cells than conventional pH insensitive lipid nanoparticles (DOX-SA-NP). The cationic charge of nanoparticles subsequently facilitated the endosomal escape and promoted the nuclear accumulation of DOX. Furthermore, in vitro cytotoxicity, apoptosis, cell cycle arrest, and mitochondrial membrane depolarization studies supported the enhanced efficacy of DOX-B6-SA-NP in comparison to free DOX and DOX-SA-NP. Intravenous pharmacokinetics and biodistribution investigations indicated that pH sensitive nanoparticles can significantly prolong the blood circulation time of DOX in biological system and increase the drug accumulation to tumor site. Consequent to this, DOX-B6-SA-NP also exhibited much enhanced therapeutic efficacy and lower toxicity in tumor-bearing rats compared to free DOX. The reduction in toxicity was confirmed by histological and survival analysis. In conclusion, these results suggest that the VitB6 modified charge reversal nanoparticles can be a novel platform for the successful delivery of anticancer drugs.

Diastereoselective Synthesis of 5-Heteroaryl-Substituted Prolines Useful for Controlling Peptide-Bond Geometry

A versatile diastereoselective Friedel–Crafts alkylation reaction of heteroaryl systems with

a cyclic enecarbamate for the preparation of 5-heteroaryl-substituted proline analogues in good yields has been developed by CSIR-CDRI. These heterocyclic tethered cyclic amino acid building blocks constitute important structural motifs in many biologically active molecules. The impact of the substitution on proline cis/trans isomerization was explored by carrying out solution conformational studies by NMR on 5-furanyl-substituted proline-containing peptides. Conformational analysis revealed that the peptide bond is constrained in an exclusively transconformation.

A thaumatin-like protein of Ocimum basilicum confers tolerance to fungal pathogen and abiotic stress in transgenic Arabidopsis

Plant responds to fungal pathogens by expressing a group of proteins known as pathogenesis-related proteins (PRs) which is mediated through pathogen-induced signal-transduction pathways that are fine-tuned by phytohormones such as methyl jasmonate (MeJA). CSIR-CIMAP identified a *Ocimum basilicum* PR5 family member (ObTLP1) from a MeJA-responsive expression sequence tag collection which encodes a 226 amino acid polypeptide and showed sequence and structural similarities with a sweet-tasting protein thaumatin of *Thaumatococcus danielli* and also with a stress-responsive protein osmotin of Nicotiana tabacum. Recombinant ObTLP1 protein inhibited mycelial growth of the phytopathogenic fungi, *Scleretonia sclerotiorum* and *Botrytis cinerea;* thereby, suggesting its antifungal activity. Ectopic expression of ObTLP1 in *Arabidopsis* led to enhanced tolerance to *S. sclerotiorum* and B. cinerea infections, and also to dehydration and salt stress. Thus, ObTLP1 might be useful for providing tolerance to the fungal pathogens and abiotic stresses in crops.

Fungal endophytes of Catharanthus roseus enhance vindoline content

Little information is available regarding the mechanism of endophyte-mediated induction of secondary metabolite biosynthesis in *Catharanthus roseus*. CSIR-CIMAP reported two fungal endophytes, Curvularia sp. CATDLF5 and *Choanephora infundibulifera* CATDLF6 were isolated from the leaves of the plant that were found to enhance vindoline content by 229-403% without affecting the primary metabolism. The maximum quantum efficiency of PSII, net CO2 assimilation, plant biomass and starch content of endophyte-inoculated plants were similar to endophyte-free control plants. The expression of terpenoid indole alkaloid (TIA) pathway genes; geraniol 10-hydroxylase (G10H), tryptophan decarboxylase (TDC), strictosidine synthase (STR), 16-hydoxytabersonine-O-methyltransferase (16OMT), desacetoxyvindoline-4-hydroxylase (D4H) and deacetylvindoline-4-O-acetyltransferase (DAT) were found to be upregulated in endophyte-inoculated plants. The gene for the vacuolar class III peroxidase (PRX1), responsible for coupling vindoline and catharanthine, was also up-regulated upon inoculation.

De Novo sequencing and analysis of lemongrass transcriptome provide first insights into the essential oil biosynthesis of aromatic grasses

Aromatic grasses of the genus *Cymbopogon* (Poaceae family) represent unique group of plants producing diverse monoterpenes rich essential oils. Illumina-based high-throughput sequencing, de novo transcriptome assembly and analyses of *Cymbopogon flexuosus* (lemongrass) was carried out by CSIR-CIMAP as first step toward understanding the essential oil biosynthesis. Mining of transcriptome data and subsequent phylogenetic analysis led to the identification of terpene synthases, pyrophosphatases, alcohol dehydrogenases, aldo-ketoreductases, carotenoid cleavage dioxygenases, alcohol acetyltransferases, and aldehyde dehydrogenases, which are potentially involved in essential oil biosynthesis. SSR repeats linked to terpene pathway genes including the genes potentially involved in aroma biosynthesis were also identified.

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1-Methyl-4-propan-2-ylbenzene from Thymus vulgaris attenuates cholinergic dysfunction

Cholinergic dysfunction is manifested in a plethora of neurodegenerative and psychiatric disorders such as Alzheimer's, Parkinson's, and Huntington's diseases. An elaborate investigation was carried out by CSIR-CIMAP to study the potential of thyme oil and its individual components in curtailing cholinergic deficits. Thyme oil augments neurotransmission by modulating synaptic acetylcholine (Ach) levels and nicotinic acetylcholine receptor activity through up-regulation of genes cho-1, unc-17 and unc-50. Studies on individual components revealed para-cymene (1-methyl-4-propan-2-ylbenzene) as the active component of thyme oil, contributing its effects through upregulation of cho-1, cha-1, unc-17 and unc-50, while down-regulating ace-1 and ace-2. Thymol and gammaterpinene which although were devoid of any activity individually, exhibited significantly enhanced synaptic Ach levels and nicotinic acetylcholine receptor (nAchR) responsiveness, when administered in combination.

New plant varieties developed:

During the year 2016-17, CSIR-CIMAP has released new varieties of Vetiveria zizanioides (CIM-Samriddhi), Curcuma longa (CIM-Pitamber) and Ocimum basilicum (CIM-Surabhi and CIM-Snigddha). The characteristic of these developed varieties are as below:

CIM-Samriddhi: It is a high yielding Khusilal-rich (>30%) variety of Vetiver. This variety is able to produce 35 Kg/hectare of essential oil as compared to 25 Kg/hectare produced from the currently popular variety CIM-Vriddhi.

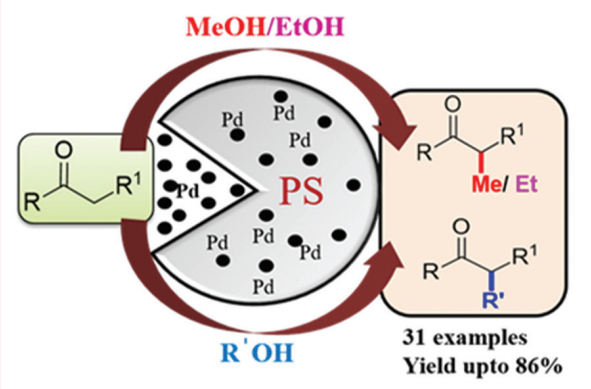
CIM-Pitamber: it is a high yielding variety of turmeric with rhizome yield potential of 60-65 tons/ha containing 12.5% curcuminoides in a relatively short duration of 180-190 days.

CIM-Snigddha: It is a methyl cinnamate-rich (78.7%) high essential oil yielding variety of O. basilicum. The potential herb yield of this new variety is 221 q/ha and oil yield of 190 Kg/ha.

CIM-Surabhi: It is a high linalool-rich, high essential oil yielding variety of sweet basil (O. basilicum).

Development of nano-composite as low cost catalyst in organic synthesis:

Polymer stabilized palladium (Pd@PS) nanoparticles (NPs) developed by CSIR-IHBT, catalyzed α-alkylation of acyclic, cyclic, and aliphatic ketones with methanol, ethanol, and long chain alkyl and benzyl alcohols. The heterogeneous catalyst, Pd@PS, was found to be highly active for most challenging small chain alkyl alcohols such as methanol and ethanol in alkylation reaction following oxidation, condensation, and reduction approaches.

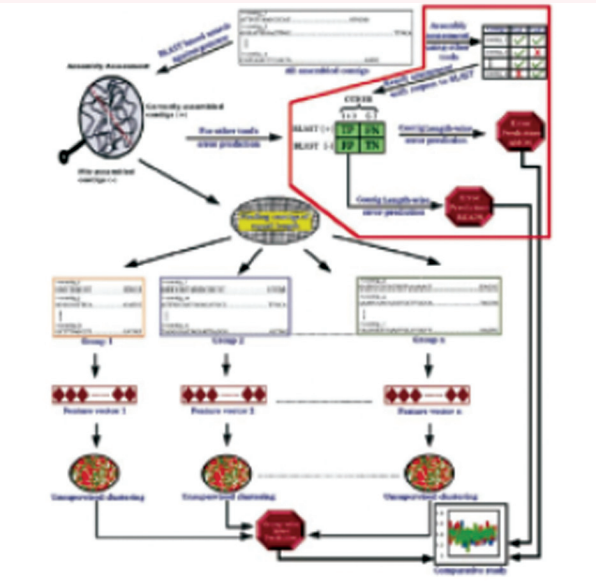


Polymer stabilized palladium nanoparticles catalyzed alkylation of ketones

Software system to identify wrong de novo genome assembly

With the advent of short-reads-based genome sequencing approaches, large number of organisms are being sequenced all over the world. Most of these assemblies are done using some de novo short read assemblers and other related approaches. However, the contigs produced this way are prone to wrong assembly. So far, there is a conspicuous dearth of reliable tools to identify mis-assembled contigs. Mis-assemblies can result from incorrectly deleted or wrongly arranged genomic sequences. In the present work, CSIR-IHBT assessed various factors related to

sequence, sequencing and assembling for their role in causing mis-assembly by using different genome sequencing data. Finally, some mis-assembly detecting tools were evaluated for their ability to detect the wrongly assembled primary contigs, the present work, proposes a simple unsupervised learning-based novel approach to identify mis-assemblies in the contigs which were performing reasonably well when compared to the already existing tools. The proposed methodology may work as a complementary system to the existing tools for enhanced accuracy.



Software system to identify wrong genome assembly

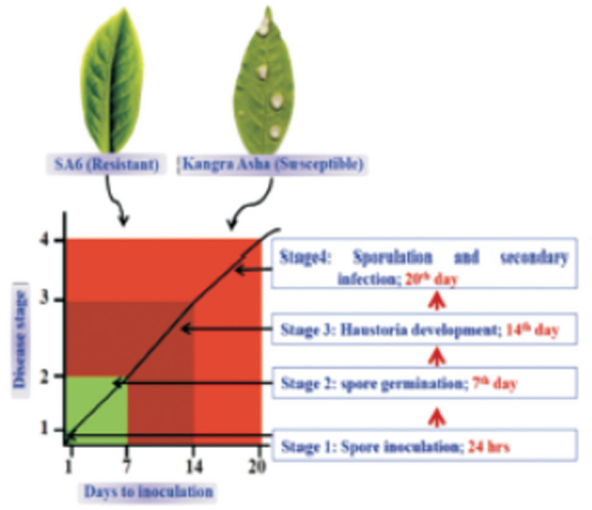
Exploration of secondary metabolites from medicinal plants of Himalayas

Studies on regulation of secondary metabolites in the medicinal plants of Himalayas, the secondary metabolite pathway in Picrorhiza kurroa was deciphered by CSIR-IHBT. Therefore, a study was undertaken to gain insights into key regulatory molecules underlying the differential regulation of picrosides by temperature. miRNA libraries were prepared from leaf and rhizome tissues of P. kurroa plants exposed to different temperatures and a total of 286 identified miRNAs. Out of these, several of bioinformatically validated miRNAs were found to belong to different biological pathways including plant hormone signal transduction, plant pathogen interaction, phenylpropanoid, stilbenoid, cysteine and methionine metabolism and pentose and glucuronate pathways. The results suggest an important role of miRNAs at different temperatures in regulating expression of the targeted genes/transcripts. Furthermore, the genome of P. kurroa was sequenced for the complete understanding of genes involved in the picroside biosynthetic pathway. Since, the information on whole genome sequence of P. kurroa is also not available in public domain, whole genome sequencing of P. kurroa was also initiated. The genomic libraries were prepared from the leaf tissues and sequenced using two NGS platforms: Illumina GA IIx and Pacific Biosciences. The assembly of draft genome sequence of P. kurroa is under way. The outcome from such studies has far reaching implications in the metabolic engineering of plant secondary metabolism and synthetic biology.

Unravelling the molecular mechanism of defense against blister blight (BB)

Blister Blight (BB) disease caused by the basidiomycetes obligate biotrophic pathogen, Exobasidium vexans Massee is amongst the most serious leaf diseases significantly affecting the commercial production of tea. Besides affecting the quality of tea significantly, it causes more than 40% total yield loss. Therefore, it is important to breed tea plants resistant to blister blight. Marker assisted breeding can be of particular importance in this regard. However, while candidate markers are required for implementation of markers assisted breeding as tea suffers from the non-availability of such markers. Therefore, a study was undertaken by CSIR-IHBT to unravel the molecular mechanism of defense against BB for combining traits in high yielding quality tea clones. In the study, key candidates were identified to analyze BB interactions with resistant and susceptible tea genotypes using

genome-wide RNA-seq during ~20-day disease cycle. From the study, approximately 69 million high quality reads were assembled de novo and 37,790 unique transcripts including 149 defense related transcripts were identified. Further, confirmation of abundant expression of well known RPM1, RPS2 and RPP13 in quantitative Real Time PCR indicated the possibility of salicylic acid and jasmonic acid mediated synthesis of antimicrobial compounds required to overcome the virulence of E. vexans. The findings can serve as important esource for unravelling the possible regulatory mechanism(s) of immunity against various biotic tresses in tea and other crops.



Molecular Mechanism of defense against Blister Blight

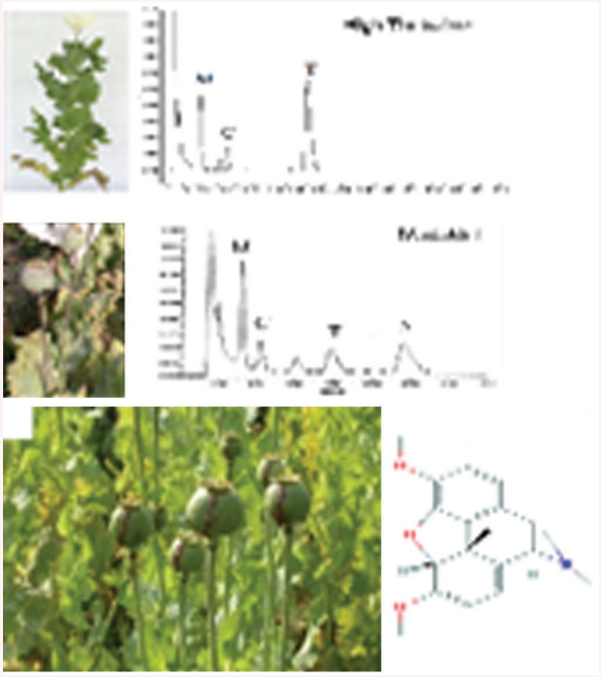
Global Burden of Disease 2015 and 2016 update program

The global burden of diseases (GBD), injuries and risk factors study is the most comprehensive effort to date to measure epidemiological levels and trends worldwide. GBD 2015 analysed 249 causes of death, 315 diseases and injuries, toll of early deaths and disability and 79 risk factors in 195 countries and territories between 1990 and 2015, published in one special issue of Lancet. At the Institute for Health Metrics and Evaluation (IHME), University of Washington in 2007 under the leadership of Prof. Christopher J.L. Murray, MD, DPhil, researchers began gathering rigorous and scientific evidence on health to launch a new era of independent, objective assessments to diagnose the world's health problems and identify the solutions to address them. Data for the project are collected, analyzed and critically reviewed by 1,870 collaborators. Role of CSIR-IITR as a GBD collaborator were providing critical feedback on data sources, providing critical feedback on methods or results and drafting the work or revising it critically for important intellectual content to prepare the final draft of GBD documents. All the studies undertaken in the GBD were published in the above document of Lancet and other issues, New England Journal of Medicine etc. The GBD data outcomes will enable to achieve the Sustainable Development Goals (SDG), through world's decision-makers and development partners like WHO, UNICEF etc and national policy makers to make the best possible decisions when determining how to allocate money, talent, and attention to combat health issues including Sustainable Development Goals (SDG) -3: Ensure healthy lives and promote well being for all at all ages.

Breeder seeds of high the baine lines of opium poppy

The Breeder seeds of high the baine lines , developed by the institute are being multiplied in isolation plots at CSIR-NBRI campus for commercialization, and performance trials of these thebaine lines were conducted at various villages of Rajasthan and Madhya Pradesh.

The analysis of sterol glycosyltransferase (sgt) gene family of Withania artificial miRNA technology in the glycosylation of secondary metabolite revealed that sterol glycosyltransferase enzyme activity of W. somnifera provides tolerance against high temperature.



Thebaine rich line of opium poppy developed by NBRI (a) Comparative HPLC profile of thebaine line and a variety (b) field view of thebaine line (c) chemical structure of Thebaine

Alpha-Cyclodextrin Interacts Close to Vinblastine Site of Tubulin and Delivers Curcumin Preferentially to the Tubulin Surface of Cancer Cell.

Tubulin is the key cytoskeleton component, which plays crucial role in eukaryotic cell division. Many anticancer drugs have been developed targeting tubulin surface. Recently, it has been shown that few polyhydroxy carbohydrates perturb tubulin polymerization. Cyclodextrin (CD), a polyhydroxy carbohydrate has been extensively used as the delivery vehicle for delivery of hydrophobic drugs to the cancer cell. However, interaction of CD with intracellular components has not been addressed before. CSIR-IICB has shown for the first time that α-CD interacts with tubulin close to the vinblastine site using molecular docking and Förster Resonance Energy Transfer (FRET) experiment. In addition, they have shown that α-CD binds with intracellular tubulin/microtubule. It delivers high amount of curcumin onto the tubulin surface of cancer cell, which causes severe disruption of intracellular microtubules. Finally, they have shown that the inclusion complex of α-CD and curcumin (CCC) preferentially enters into the human lung cancer cell (A549) compared to the normal lung fibroblast cell (WI38), causes apoptotic death, activates tumor suppressor protein (p53) and cyclin-dependent kinase inhibitor 1 (p21) and inhibits 3D spheroid growth of cancer cell.

Ultrasound assisted methods for enhanced extraction of phycobili proteins from marine macro-algae,Gelidiumpusillum (Rhodophyta)

Extraction of phycobiliproteins (R-phycoerythrin, R-PE and R-phycocyanin, R-PC) from macro-algae is difficult due to the presence of large polysaccharides (agar, cellulose etc.) present in the cell wall which offer major hindrance for cell disruption. The extraction of phycobiliproteins by using ultrasonication and other conventional methods such as maceration, maceration in presence of liquid nitrogen, homogenization, and freezing and thawing (alone andin combinations) is reported for the first time by CSIR-CFTRI. Standardization of ultrasonication for different parameters such as ultrasonication amplitude (60, 90 and 120 mm) and ultrasonication time(1, 2, 4,6, 8 and10mins)atdifferent temperatures (30,35 and 40oC) was carried out. Kinetic parameters were estimated for extraction of phycobiliproteins by ultrasonication based on second order mass transfer kinetics.. HPLC analysis was carried out in order to ensure that R-PEwas present in the extract and remained intact even after processing. Microscopic studies indicated a clear relation between the extraction efficiency of phycobiliproteins and degree of cell disruption in a given primary extraction method. These combination methods were found to be effective for extraction of phycobiliproteins from rigid biomass of Gelidium pusillum macro-algae and can be employed for down-stream processing of biomolecules also from other macro-algae.

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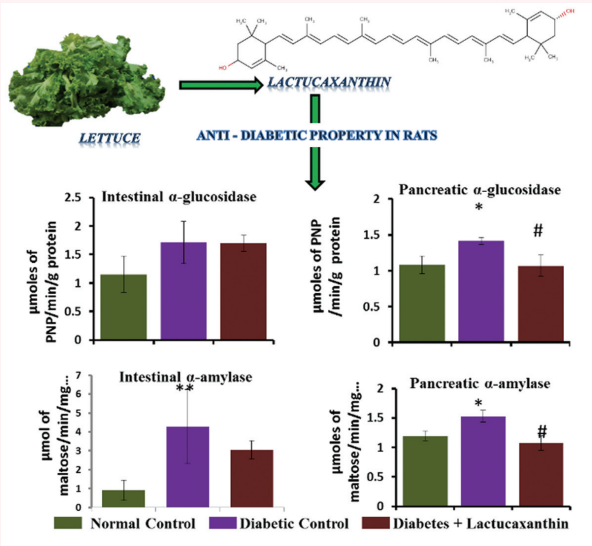
Lactucaxanthin – a potential anti-diabetic carotenoid- Food & Function

Intestinal and pancreatic α-amylase and α-glucosidase inhibitors offer an approach to lower the levels of post-prandial hyperglycemia through the control of dietary starch breakdown in digestion. This study by CSIR-CFTRI hypothesized that lactucaxanthin (Lxn) in lettuce (Lactuca sativa) inhibits the activity of α-amylase and α-glucosidase Lxn was isolated from lettuce with 96% purity confirmed by HPLC and LCMS. The in vivo results showed an increased activity for α-amylase and α-glucosidase in the intestine (4.7 and 1.30 fold, $p < 0.05$) and pancreas (1.3 and 1.48 fold, $p < 0.05$) of STZ induced diabetic rats compared to normal rats. Lxn significantly inhibited ($p < 0.05$) the activity of α-amylase and α-glucosidase and could be of medicinal and nutritional relevance in the treatment of diabetes.



Molecular Mechanism of defense against Blister Blight (BB)

Removal of nutrients and organic pollution load from pulp and paper mill effluent by microalgae in outdoor open pond.

A mixed culture of microalgae, containing two Scenedesmus species, was analysed by CSIR-CFTRI to determine its potential in coupling of pulp and paper mill effluent treatment and microalgal cultivation. Laboratory studies suggested that 60% concentration of wastewater was optimum for microalgal cultivation. A maximum of 82% and 75% removal of BOD and COD respectively was achieved with microalgal cultivation in outdoor open pond. By the end of the cultivation period, 65% removal of NO3-N and 71.29% removal of PO4-P was observed. The fatty acid composition of mixed microalgal culture cultivated with effluent showed the palmitic acid, oleic acid, linoleic acid and α-linolenic acid as major fatty acids. The results obtained suggest that pulp and paper mill effluent could be used effectively for cultivation of microalgae to minimize the freshwater and nutrient requirements.

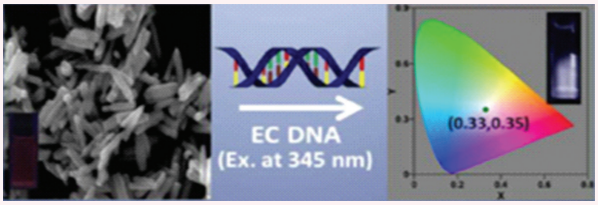
Influence of pre-treatments on post-harvest quality characteristics and shelf life extension of green tamarind fruits stored under different conditions.

An attempt was made by CSIR-CFTRI to prolong the shelf life and to preserve post-harvest quality of fresh tamarind fruits pretreated with fruit hardening chemical agents and aroma chemical compound stored under different storage (Room temperature and low temperature storage) conditions. Optimally matured (TSS 9-10°Brix) fresh and green tamarind fruits were first water washed, sorted to remove mechanically damaged and deformed ones and graded for uniform size, colour, texture and then hydro-cooled for 10 minutes, followed by the post-harvest dip treatments [T0–Control (Untreated), T1-0.25% Calcium chloride, T2-0.5% Calcium chloride and T3–500ppm Phenyl acetaldehyde] for 10 minutes. Both control and treated fruits were surface dried using mechanical driers, then packed into plastic trays with proper cushioning material and stored at RT (29±2°C, 65-70%) and low temperature (LT) conditions (4±10C,90-95% RH). These stored fruits were periodically analyzed for changes in various physiological and physico-chemical quality attributes. The results on LT and RT storage studies indicated that tamarind responded

very well to fruit hardening salt, calcium chloride at 0.50% in terms of retention of fruit firmness, fruit color and total phenolic, apart from reduction in physiological loss in weight, effective shelf life of tamarind fruits in fresh form up to 28 days at LT and 16 days at RT storage conditions as against 16 days and 8 days respectively in untreated controls when stored under same conditions.

Selective Binding of Genomic Escherichia coli DNA with ZnO Leads to White Light Emission: A New Aspect of Nano–Bio Interaction and Interface

For the first time, a novel and intriguing application of deoxyribonucleic acid (DNA) in the area of optics by demonstrating white light emission by tuning the emission of a nanomaterial, ZnO rods, exhibiting surface defects, in the presence of genomic Escherichia coli DNA with comparatively high quantum efficiency. In order to understand the DNA specificity, CSIR-IICB also studied the interaction of ZnO with CT, and ML DNA, ss EC DNA, synthetic polynucleotides and different mononucleosides and bases. The studies unequivocally confirmed that the concentration and the nature of DNA and ZnO together plays a crucial role in obtaining CIE coordinates (0.33, 0.33) close to white light. The much enhanced melting temperature (Tm) of EC DNA and the energetics factors confirm enhanced hydrogen bonding of ZnO with EC DNA leading to a new emission band. Our experimental observations not only confirm the selective binding of ZnO to EC DNA but also open a new perspective for developing energy saving light emitting materials through nano-bio interactions.

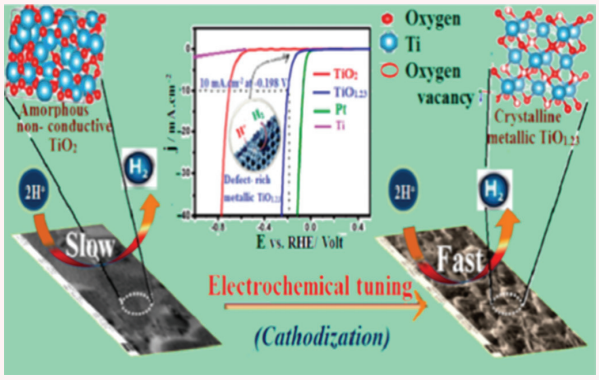


A New Aspect of Nano–Bio Interaction and Interface

1.2 Chemical Sciences

Defect-Rich Metallic Titania (TiO1.23) - An Efficient Hydrogen Evolution Catalyst

A promising alternative to platinum for hydrogen evolution electro-catalyst, earth-abundant "titania" has investigated by CSIR-CECRI wherein electroinactive titania has been surmounted by exploiting defect engineering as a tool, which tailors the local atomic structure of nonconductive titania via electrochemical cathodization strategy. These findings suggest that by tuning oxygen vacancies in the lattice and its concomitant cumulative strained configuration, reduced titania can be an effective Hydrogen Evolution Reaction (HER) electro-catalyst for electrochemical water splitting.



Defect-Rich Metallic Titania as electro catalyst for electrochemical reaction

Developing abiotic stress (salt and/or drought) tolerant crops for sustainable agriculture:

The majority of agricultural crops grown nowadays are glycophytes (salt sensitive), and their productivity becomes commercially non-viable with an increase in salinity in the 4–8 dS/m range. Salinity and drought both adversely affect photosynthesis, metabolic pathways and physiology. Consequently, this retards plant growth. In Gujarat, salinity is emerging as a major constraint for profitable production of crops like cumin, ground-nut etc. Halophytes are considered as a rich source of salt responsive genes that play an important role in engineering stress tolerance

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into glycophytes. Salicornia brachiata is an extreme halophyte that thrives in salt marshes and requires salt for growth. Adaptation to extreme salt conditions makes Salicornia a potential candidate for stress responsive genes. An expressed sequence tag (EST) database from S. brachiata subjected to salt stress has been developed by CSIR-CSMCRI. Some important genes like SbNHX-1, SbpAPX, SbASR etc. have been cloned and transformed to Tobacco (model plant), Cumin, Jatropha and Groundnut. These transgenic plants were first characterized under laboratory conditions and thereafter tested under containment facility (green house) as per bio-safety guidelines of DBT, Govt. of India. Transgenic plants have showed enhanced salt tolerance and also stable gene integration.

Transgenic salt tolerant plant varieties

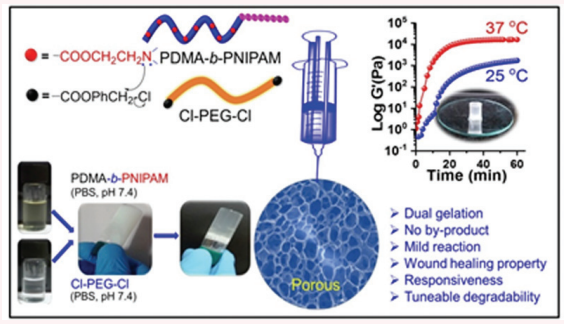
Sustainable and efficient process for the preparation of polyethylene-polystyrene interpolymer based anion exchange membrane by in situ chloromethylation for electrodialytic applications

CSIR-CSMCRI has worked on the preparation of efficient and stable anion exchange membranes (AEMs) from the inter-polymer of polyethylene and polystyrene-co-polydivinylbenzene. The chloromethylated moiety in the interpolymer film was incorporated by in situ Friedly Craft reaction followed by quaternization with trimethylamine. This process dispensed the direct use of hazardous and carcinogenic chloromethyl ether which is required for functionalization of interpolymer films. The electrochemical properties such as membrane resistance, ionic conductivity and transport number have also been determined. The oxidative stability of the membrane has been verified by treatment with 3% Fentons reagent at room temperature. The performance of the membrane, in terms of water desalination by electrodialysis and ultrapure water production by electrodeionization process, has been evaluated and compared with polyethylene-poly4-methyl styrene interpolymer based membranes and two other commercial membranes (Lonsep and Fujifilm).

Block copolymer and injectable hydrogels for sustained delivery applications

Rapid gelation, low heat generation, biocompatibility, biodegradability, avoiding the use of small molecular weight gelator and high gel fraction are essential criteria for successful biomedical application of an injectable hydrogel. CSIR-CSMCRI has developed series of dually crosslinked injectable hydrogels of PEG and poly[2-(dimethylamino) ethyl methacrylate]-b-poly(N-isopropyl acrylamide) through extremely simple chemistry. Sequential reaction between PEG containing reactive termini and the copolymer provided chemically crosslinked hydrogels with gel fraction as high as 97-99% with gelation time 1-4 min in the physiological conditions. The gelation occurred with ca. 1°C rise in temperature/g of the injectable solution, avoids formation of by-products and can be performed at temperature range of 20-37°C. The hydrogels undergo hardening at physiological temperature as confirmed by the rheological experiments. The gelation time, water swelling, mechanical properties and the degradability of the hydrogels depend on the PEG to copolymer ratio in the injectable solution. Rheological behavior of the fully hydrated hydrogels showed desirable mechanical property for soft tissue regeneration. The hydrogels exhibited blood compatibility and retained the viability of HepG2 cells with time.

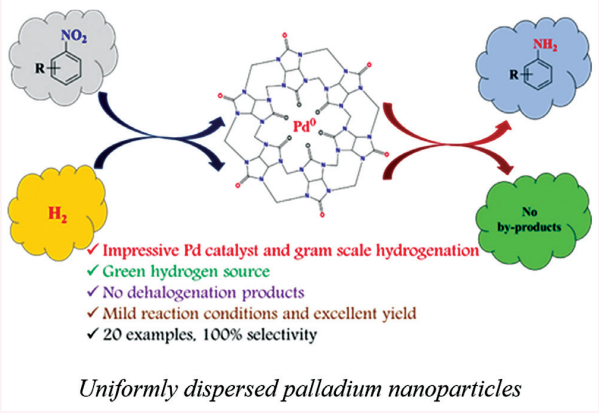
Platelets adhesion and aggregation followed by fibrinogen adsorption ability makes these hydrogels suitable for wound healing application.



Crosslinked injectable hydrogels of PEG and poly [2-(dimethylamino) ethyl methacrylate]-b-poly (N-isopropyl acrylamide)

Development of material/metal complexes for diversified applications

The luminescent property of DNA like double helical molecules incorporating europium and terbium(III) ions have been employed for the detection and determination of AMP in the blood and urine. The nanocrystalline (001) faceted anatase TiO_2 photocatalyst selectively oxidized non-activated aliphatic/cyclic alcohol to corresponding aldehyde/ketone. The first asymmetric synthesis of N-chiral amine oxides via dynamic kinetic resolution of unsymmetrical a-hydroxy tertiary amines (up to 91:9 er) has been achieved by CSIR-CSMCRI using a bimetallic titanium complex. The chiral macrocyclic CrIII salen complexes with various chiral collar catalyzed the asymmetric aminolysis of aromatic ester epoxides with various anilines to prepare the β-amino-α-hydroxyl esters in very good yield with high diastereo- and enantioselectivity. The detection of nitroaromatic explosives through fluorescence quenching in aqueous phase has been achieved using syntheses hydrolytic stable MOFs. The uniformly dispersed palladium nanoparticles supported on cucurbit [6]uril (CB[6]) has resulted in chemoselective hydrogenation of substituted nitrobenzene to aniline with excellent activity and selectivity (up to 100%) under mild reaction conditions.



Uniformly dispersed palladium nanoparticles

Porous polymer scaffold for on-site delivery of stem cells.

Protects from oxidative stress and potentiates wound tissue repair Wound healing by cell transplantation techniques often suffer setbacks due to oxidative stress encountered at injury sites. A porous polyethyleneglycol–polyurethane (PEG–PU) scaffold that facilitates cell delivery and boosts tissue repair was developed by CSIR-IICT through semi-interpenetrating polymer network approach. The key physico-chemical properties assessed confirms these polymeric matrices are highly thermostable, barostable, degrade at an acidic pH (5.8), biodegradable, cytocompatible and possess excellent porosity. Mechanism of cellular penetration into porous polymer networks was evident by a ≥6 – fold increase in gene expression of MMP-13 and MMP-2 via activation of Akt and Erk. H2O2-induced apoptosis of mouse bone marrow stem cells (BMSCs) was abrogated in presence of polymer networks indicating a protective effect from oxidative stress. Transplantation of BMSC + PEG–PU at murine excisional splint wound site depicted significant increase in fibroblast proliferation, collagen deposition, anti-oxidant enzyme activities of catalase, SOD and GPx. Furthermore it significantly decreased expression of pro-inflammatory cytokines (IL-1β, TNF-α, IL-8, etc) with a concomitant increase in anti-inflammatory cytokines (IL-10, IL-13) at an early healing period of day 7. Finally, immunostaining

revealed an enhanced engraftment and vascularity indicating an accelerated wound tissue closure. This pre-clinical study demonstrates the proof-of-concept and further necessitates their clinical evaluation as potential cell delivery vehicle scaffolds.

Engineered Asymmetric Composite Membranes with Rectifying Properties:

Asymmetric composite membranes with rectifying properties were developed by CSIR-IICT grafting pH-stimulus-responsive materials onto the top layer of the composite structure, which is prepared by two novel block copolymers using a phase-separation technique. This engineered asymmetric composite membrane shows potential applications in sensors, filtration, and Nano fluidic devices.

Polymer nanocomposites:

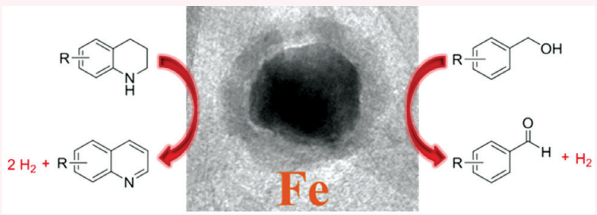
Graphene is the 2D nanomaterial discovered during the past decade that has attracted outstanding research interest across several disciplines. The modification of graphene with hydrophilic/hydrophobic entities is pursued to broaden its application in several areas of nanoscience and technology. A process has been developed by CSIR-IICT for the preparation of graphene polymer nanocomposites with improved adhesion properties. Hybrid nanocomposites with conjugated polymers has been developed for improved optoelectronic properties.

Natural product derived new molecules were synthesized and evaluated as anticancer agents Mito-esculetin

CSIR-IICT has synthesized a novel mitochondria-targeted esculetin (Mito-Esc) and found that mito-Esc has a great potential to inhibit atherosclerotic features and age-delaying properties in ApoE-/- mice. Based on these results, we have filed a patent application on the 'synthesis and usefulness of Mito-Esc in the treatment of atherosclerosis', a major cardiovascular disorder. This patent entitled "An antioxidant compound having anti atherosclerotic effects and preparation thereof" has been recently approved by the USPTO (notice of allowance has been issued, 20160244470A1). Similarly patent applications on the above aspect have been filed in India (0478DEL2015), and UK (1602960.8). To take this lead forward, we will have to now perform dose-response efficacy of Mito-Esc in regressing both angiotensin-II- and high fat diet-induced atherosclerosis in ApoE-/-mice. Along with this, we will have to carry out thorough DMPK analysis in different rodent species. In parallel, we will have to synthesize Mito-Esc in large scale (at least 10-50 g) and study various analytical properties of the molecule.

Green chemistry by heterogeneous catalysis

The key research objective was to convert homogeneous catalytic reactions into heterogeneous versions (replacement of precious metal catalysts by first-row transition elements) through the attachment of catalytic sites on stable supports. CSIR-NCL carried out thermal decomposition of a molecular complex of a metal on a carbon support to obtain supported robust nanocatalyst and have designed several environmentally benign catalytic reactions, in particular acceptorless dehydrogenation and related reactions based on developed nanocatalysts. It has replaced an expensive noble metal catalysts with an inexpensive, benign, and sustainable nanoscale iron catalyst for the efficient acceptorless dehydrogenation of N-heterocycles and alcohols with liberation of hydrogen gas.



Iron-based nanocatalyst for the acceptorless dehydrogenation reactions

Field emission properties of highly ordered low aspect ratio carbon nanocup arrays

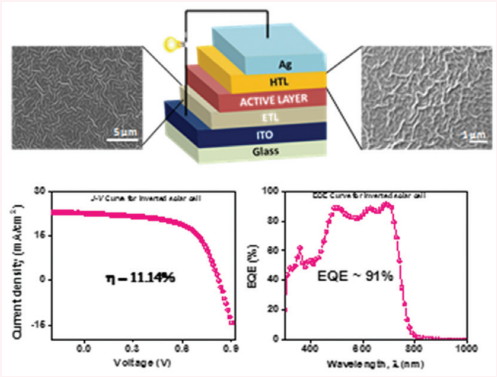
A high performance field emission of cup-stacked carbon nanotubes (CSCNTs) was designed and developed by CSIR-NCL. These 3D high-aspect ratio carbon nanocup structures were synthesized by a combination of anodization and chemical vapor deposition techniques. The morphological analysis revealed that CSCNTs have low-aspect ratio structures with a cup diameter of ~50 nm and length of ~100 nm. The enhanced field emission behavior observed for the CSCNTs is attributed to a high field enhancement factor of 1645, high field emission current density of 1 μA/cm^2 and low turn-on field 2.30 V/μm with better emission current stability. The enhancements observed in CSCNTs arrays is attributed synergic effect of high aspect ratio, atomically sharp diameter of the cups, uniform distribution of the emitters over the whole area of specimen and lower screening effect of the CSCNTs. These obtained results provide new information about the effect of the stacking carbon layers on their electronic properties and open up possibilities to integrate new morphologies of graphitic carbon in nanotechnology applications.

Removal of arsenite and arsenate metal ions from wastewater using TFA and TAFA resins:

In this study by CSIR-NCL, tanninformaldehyde (TFA) and tannin-anilineformaldehyde (TAFA) resins were synthesized and utilized successfully for an adsorptive removal of arsenite [As (III)] and arsenate [As (V)] metal ions from the contaminated water. A computational intelligence CI) based hybrid strategy was employed by CSIR-NCL to model and optimize the resin-basedadsorption of arsenite and arsenate metal ions for securing optimal reaction conditions. This strategy first uses an exclusively reaction data-driven modelling strategy, namely, genetic programming (GP), to predict the extent (%) ofarsenite/arsenate adsorbed on the TFA/TAFA resins. Finally, the sets of theoptimal reaction condition variables provided by the GP-GA hybrid method were verified experimentally. The verification results indicate that the optimized conditionshave led to 0.3% and 1.3% increase in the adsorption of the arsenite and arsenate ionson the TFA resin. More significantly, the optimized conditions resulted in an improvement of 12.77% in the adsorption of arsenate on the TAFA resin. The GP-GA based strategy introduced here can be gainfully utilized for modeling and optimization of similar type of contaminant-removal processes.

Developing Nanoengineered Charge Selective Intermediate Layers for Organic Photovoltaics

The performance and shelf-life of a solar cell strongly depends on the constituent materials and their transport (both bulk and interfacial) properties. From the engineering point of view, controlled processing of these materials that have better compatibility with cell fabrication techniques offers a significant value addition. A suitable screening tool that can be quickly optimized for an individual molecular system will have tremendous impact in developing practical OPVs. In CSIR-NIIST, has developed a solution processing method for fabricating inorganic intermediate materials that are compatible with the organic components in an OPV. Previously these materials were typically fabricated using inconvenient vacuum techniques. These specially designed layers offer huge advantage in terms of device stability and shelf-life. Also, the band positions can be chemically tuned to match operational

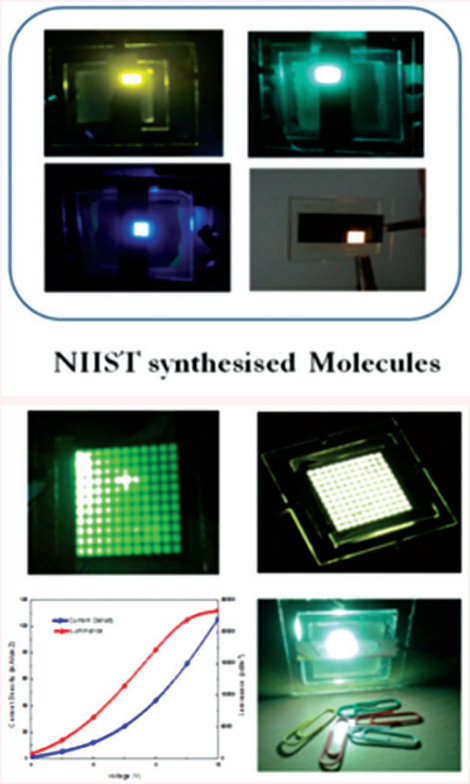


Charge selective intermediate layers for organic photovoltaics

requirements of the novel molecules. Owing to the higher thermal and chemical stabilities of these layers and due to fact that they offer a protection to the underlying organic components, even the air-processed solar cell offer much higher stability compared to the standard techniques.

Organic Light Emitting Diodes (OLEDs)

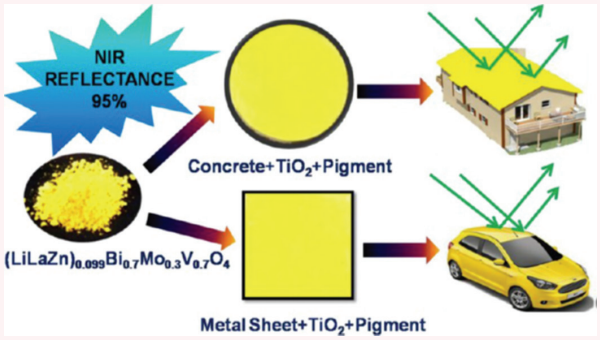
Organic light emitting diodes (OLEDs) are the next generation lighting sources whose aesthetic appeal and the resemblance to the natural light make it more suitable for lighting application. In line with the developments in OLEDs worldwide. White OLED with brightness more than 20000 cd/m^2 has been developed in CSIR-NIIST. These have maximum current efficiency of 40 cd/A and max power efficiency of 26 lm/w. At 10000 cd/m^2 the values are 38 cd/A and 16 lm/w. Further, CSIR-NIIST developed a light extraction technique which when applied improved the performance to 62 cd/A and 48 lm/w. At 10000 cd/m2 brightness the values are 52 cd/A and 24 lm/w.



Light emitting diodes

Enhanced Near Infrared Reflectance with Brilliant Yellow Hues inScheelite Type Solid Solutions, (LiLaZn)1/3MoO4–BiVO4 for EnergySaving Products:

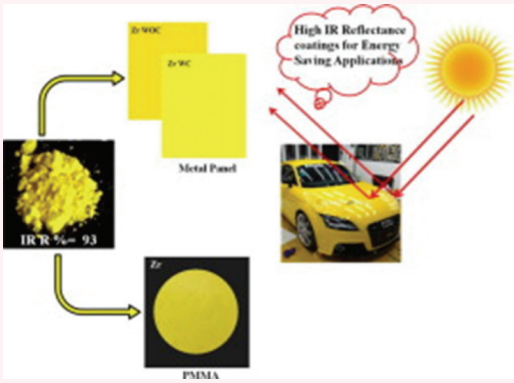
CSIR-NIIST has synthesized enhanced near infrared (NIR) solar reflectance with interesting yellow hues in a new series of scheelite-type solid solutions, $[(LiLaZn)x/3Bi1-x][MoxV1-x]O_4$ (x = 0, 0.1,0.2, 0.3, 0.4) via conventional solid state reaction (SSR) method and planetary ball milling assisted solid state reaction (PBM) method. The solid solutions undergo a phase transformation from a monoclinic to a tetragonal phase. The compounds exhibit strong absorption in the UV and blue regions of the visible spectrum displaying high NIR reflecting intense yellow shades ranging from reddish to greenish. The yellow hue and NIR reflectance is enhanced by the morphological modifications through PBM method. Typically, the pigment $[(LiLaZn)0.099Bi0.7][Mo0.3V0.7]O_4$ displayed intense yellow color (b* = 86.63) with NIR reflectance of 95% much better values than the commercial sicopal yellow. The applicability studies of these pigments on concrete cement block and metal sheet imparts good coloring performance with high NIR solar reflectance. Chemical and light resistance tests indicate their durability in the extreme weathering conditions. Thus, the prepared compositions consisting of less toxic elements demonstrate sustainable use of the present pigments in exterior surface coating applications as energy saving products.

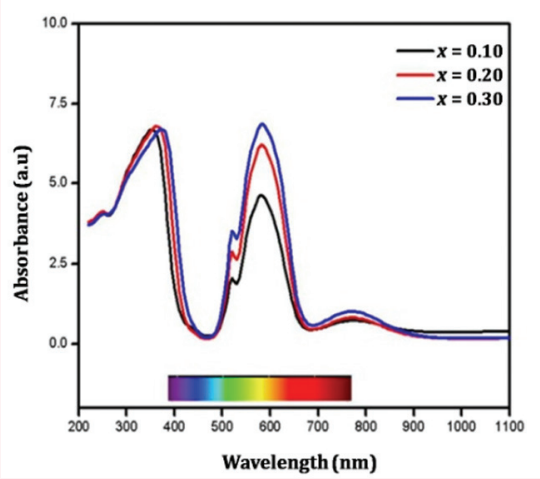


Multifunctional inorganic pigments

Terbium doped Sr2MO4 [M = Sn and Zr] yellow pigments with high infrared reflectance for energy saving applications:

A new class of environmentally benign and high infrared reflective inorganic yellow pigments, Sr2M1 – xTbxO4 (M = Sn and Zr; x = 0, 0.2 and 0.4) were synthesized at CSIR-NIIST by a solid-state route. The substitution of terbium in Sr_2MO_4 hosts produces visible light responsive compounds by shifting the absorption edge to higher wavelength side. The pigments exhibited good yellow hue ($b^* = 53.4$) with high NIR spectral reflectance of 95%. The coloring performance of the synthesized pigments was investigated in polymer matrix and on metal plates for potential applications. These results demonstrate the synthesized pigments as promising NIR reflective yellow colorants for cool roof and surface coating applications.

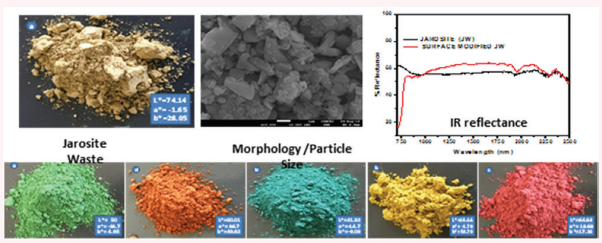




Pigment with high infrared reflectance

Ceramic Colorants from Inorganic Industrial Solid Waste, 'Jarosite': A low cost Corrosion Resistant Pigment for Paints and Coatings:

Processing of automobile grade Zn alloys from zinc ore through hydrometallurgy route discharge voluminous amount of inorganic waste named Jarosite. In India, a typical zinc alloy processing plant annually produced 0.25 million ton jarosite which is chemically a sodium and sulphate containing iron silicate. Jarosite solid residue is expressed as [M $(Fe_3(SO_4)(OH_6)]$ where M= Na+,K+,NH4+). Jarosite being a natural yellow pigment has >60% IR reflectivity. A chemical modification strategy is first employed by CSIR-NIIST for achieving hydrophobic surface that eventually prevent the leaching of hazardous impurities. A hydrophobic contact angle of 108° is seen over the chemical modification. Such surface engineered jarosite was found to offer exceptional adsorption to range of inorganic stains and hence it is examined to prepare series of 'adsorptive-pigments' to produce green, yellow, orange and brown colors. The newly developed colorants were systematically characterized for color index, particle size, morphology and NIR reflectance property. Subsequently, the hydrophobic, NIR reflective jarosite colorants were coated on traditional tile bodies to obtain cool-tiles. Further it is also investigated for the anticorrosion property over metallic iron sheet. This work describes an innovative process for obtaining high-value, mineral-pigment from the highly economical source, jarosite, for the first time.

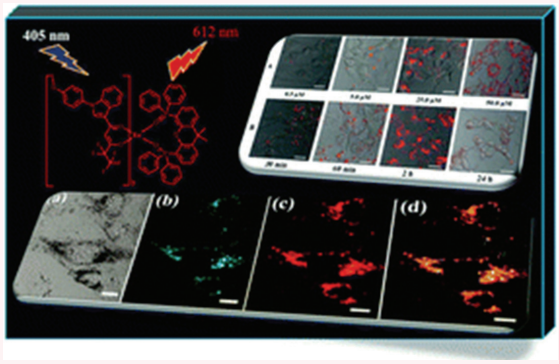


Jarosite Colorants via adsorption

सत्यमेव जयते

A lysosome targetable luminescent bioprobe based on a europium β-diketonate complex for cellular imaging applications

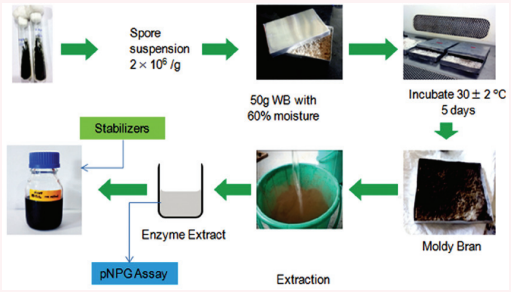
CSIR-NIIST has developed a novel lysosome targetable luminescent bioprobe derived from a europium coordination compound, namely $Eu(pfphOCH_3IN)_3(DDXPO)$ 4 [where HpfphOCH3IN = 4,4,5,5,5-pentafluoro-3-hydroxy-1-(1-(4-methoxyphenyl)-1H-indol-3-yl)pent-2-en-1-one and DDXPO = 4,5-bis(diphenylphosphino)-9,9-dimethylxanthene oxide]. Notably, the newly designed europium complex exhibits significant quantum yield ($\Phi_{overall}$ = 25 ± 3%) and $^5D_0$ excited state lifetime (τ = 398 ± 3 μs) values under physiological pH (7.2) conditions when excited at 405 nm. Hence the developed europium complex has been evaluated for live cell imaging applications using mouse pre-adipocyte cell lines (3T3L1). Colocalization studies of the designed bio-probe with commercial Lysosome-GFP in 3T3L1 cells demonstrated the specific localization of the probe in the lysosome with a high colocalization coefficient (A = 0.83). Most importantly, the developed bioprobe exhibits good cell permeability, photostability and non-cytotoxicity.



luminescent bioprobe

Scaling up of Beta Glucosidase (BGL) production from Aspergillus niger

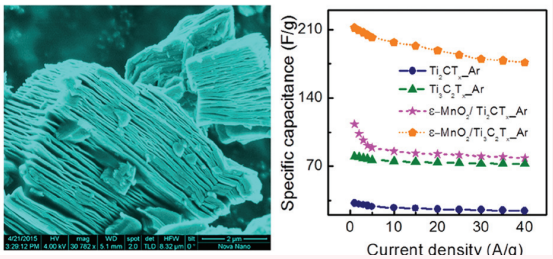
BGL is a critical component in biomass hydrolyzing enzymes and addition of it can improve the efficiency of acid cellulases used in textile industry and can upgrade them to biomass hydrolyzing enzymes. CSIR-NIIST has a process for production of BGL using the fungus Aspergillus niger and developing this into a full-fledged technology for commercial deployment full performance data in blends with all leading cellulases for biomass hydrolysis, and with the techno-economic data.



Process flow for Scaling up of Beta glucosidase (BGL) production

Metal Oxide/Mxene Composite Electrodes for High Performance Supercapacitors

Transition metal carbides (MXenes) are an emerging class of two dimensional (2D) materials with promising electrochemical energy storage performance. In CSIR-NIIST, nanocrystalline ε-MnO_2 whiskers were formed on MXene nanosheet surfaces (ε-MnO_2/Ti2CTx and ε-MnO_2/Ti3C_2Tx) to make nanocomposite electrodes for aqueous pseudocapacitorsn by direct chemical synthesis. The ε-MnO_2 nanowhiskers increase the surface area of the composite electrode and enhance the specific capacitance by nearly three orders of magnitude compared to pure MXene based symmetric supercapacitors. Combined with enhanced pseudocapacitance, the fabricated ε-MnO_2/MXene supercapacitors exhibited excellent cycling stability with ~88% of the initial specific capacitance retained after 10000 cycles which is much higher than pure ε-MnO_2



Nanocrystalline ε-MnO_2 whiskers formed on MXene nanosheet

based supercapacitors (~74%). The proposed electrode structure capitalizes on the high specific capacitance of MnO_2 and the ability of MXenes to improve conductivity and cycling stability

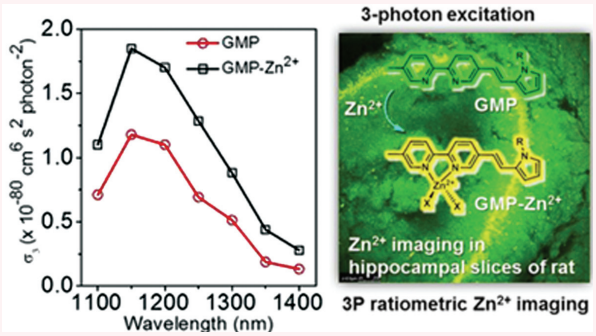
Supercapacitors Based on Two Dimensional VO_2 Nanosheet Electrodes in Organic Gel Electrolyte

VO_2 is a low band-gap semiconductor with relatively high conductivity among transition metal oxides, which makes it an interesting material for supercapacitor electrode applications. In CSIR-NIIST, two-dimensional nanosheets of VO_2 are prepared by the simultaneous solution reduction and exfoliation from bulk V_2O_5 powder by hydrothermal method. The performance of VO_2 as supercapacitor electrode in organic electrolytes is being determined for the first time. A specific capacitance of 405 Fg^{-1} is achieved for VO_2 based supercapacitor in an organic electrolyte, in three electrode configuration. The symmetric capacitor based on VO_2 nanosheet electrodes and the liquid organic electrolyte exhibits an energy density of 46 Wh kg^{-1} at a power density of 1.4 kW kg^{-1} at a constant current density of 1 Ag^{-1}. Furthermore, flexible solid-state supercapacitors are fabricated using same electrode material and Alumina-silica based gel electrolyte. The solid-state device delivers a specific capacitance of 145 Fg^{-1} and a device capacitance of 36 Fg^{-1} at a discharge current density of 1 Ag^{-1}. Series combination of three solid state capacitors is capable of lighting up a red LED for more than 1 minute.

- CVs of solid state device measured at different angles (inset shows the schematic for the measurement of the bending angles and the optical image of the flexible supercapacitor device)
- Optical images displaying lighting up of an LED using three flexible supercapacitors connected in series

Three-Photon Active Organic Fluorophore for Deep Tissue Ratiometric Imaging of Intracellular Divalent Zinc

Deep tissue bioimaging with three-photon (3P) excitation using near-infrared (NIR) light in the second IR window (1.0–1.4 μm) could provide high-resolution images with an improved signal-to-noise ratio. In line with this CSIR-NIIST have developed a photostable and nontoxic 3P excitable donor-π-acceptor system (GMP) having 3P cross-section (σ_3) of 1.78 x 10^{-80} cm^6 s^2 $photon^{-2}$ and action cross-section ($\sigma 3\eta 3$) of 2.31 x 10^{-81} cm^6 s^2 photon-2, which provides ratiometric fluorescence response with divalent zinc ions in aqueous conditions has been. The probe signals the Zn^{2+} binding at 530 and 600 nm, respectively, upon 1150 nm excitation with enhanced σ_3 of 1.85 x 10^{-80} cm^6 s^2 $photon^{-2}$ and $\sigma 3\eta 3$ of 3.33 x 10^{-81} cm^6 s^2 $photon^{-2}$. The application of this probe is demonstrated for ratiometric 3P imaging of Zn^{2+} in vitro using HuH-7 cell lines. Furthermore, the Zn^{2+} concentration in rat hippocampal slices was imaged at 1150 nm excitation after incubation with GMP, illustrating its potential as a 3P ratiometric probe for deep tissue Zn^{2+} ion imaging.



Zn^{2+} imaging in hippocampal slices of rat

1.3 Engineering Sciences

Soil Nail as Remedial Measures:

A series of laboratory pull-out tests were conducted by CSIR-CBRI to investigate the pull-out behaviour of helical soil nails in different conditions. Comparisons have been made between helical and driven and grouted soil nails. It was found that in all the cases performance of helical soil nails is always superior than conventional soil nails. Hence application of helical soil nails for slope stabilization is a better option than conventional nails.

सत्यमेव जयते

Development and Fabrication of Innovative Mini Water–Mist fire Tender:

The design details for the development and fabrication of an innovative Mini Water–Mist fire Tender out of the condemned mini bus has been finalized, for combating the large-scale fires efficiently and effective in water scarce fire situations as well as firefighting skill development in the water scarce situations. The water-mist fire tender is procured as a product/technology for IPR and Tech. Transfer for socital benefits.

Revalidation of CFD modeling results of interaction of water mist fire suppression system under fire condition:

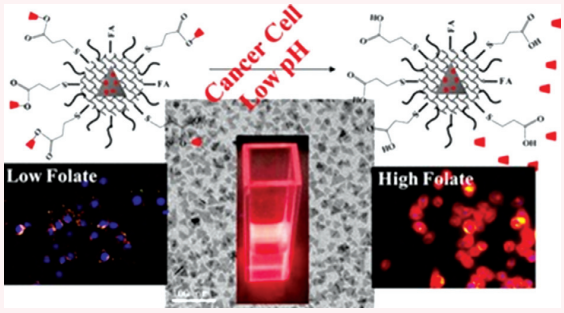
The CFD Modeling of interaction of water mist fire suppression system with 2.45 m, 2.50 m and 2.55 m ceiling heights were repeatedly carried out for revalidating the experimental fire suppression time of 10 to 15 seconds with 100% fire suppression efficiency by bringing down the fire temperature in the range of 90 to 100 deg. C with fire control time from 5 s to 10 s.

Development of a Novel Method for Evaluation of Seismic Earth Pressures on Retaining Wall

An analytical model is developed by CSIR-CBRI for the evaluation of seismic earth pressures on retaining wall. Developed theory is consistent with dynamic centrifuge experimental results. This can be used for safe and economic design of soil retaining structure considering wave propagation in the earthquake prone areas. Proposed method has immense potential for the inclusion in the standard codal provision, which is a step ahead of state of the art.

Surface-Engineered Multifunctional Eu:Gd2O3 Nanoplates for Targeted and pH-Responsive Drug Delivery and Imaging Applications

The synthesis of surface engineered multifunctional Eu:Gd2O3 triangular nanoplates with small size and uniform shape via a high-temperature solvothermal technique. Surface engineering has been performed by a one-step polyacrylate coating, followed by controlled conjugation chemistry. CSIR-CGCRI modified the drug molecules with terminal double bond and ester linkage for the easy conjugation of nanoparticles. The nanoparticle surface was further modified with free thiols to specifically attach the modified drug molecules with a pH-responsive feature. High drug loading has been encountered for both hydrophilic drug daunorubicin (~69% loading) and hydrophobic drug curcumin (~75% loading) with excellent pH-responsive drug release. These nanoparticles have also been used as imaging probes in fluorescence imaging. A detailed fluorescence imaging study has confirmed the efficient delivery of drugs to the nuclei of cancer cells with a high cytotoxic effect. Synthesized surface-engineered nanomaterials having small hydrodynamic size, excellent colloidal stability, and high drug-loading capacity, along with targeted and *pH*-responsive delivery of dual drugs to the cancer cells, will be potential nanobiomaterials for various biomedical applications.

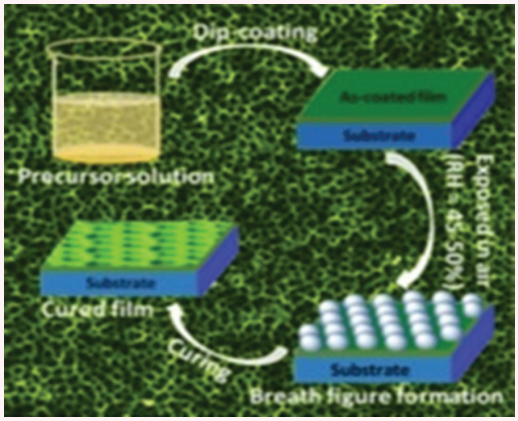


Gd2O3 Nanoplates for Targeted and pH-Responsive Drug Delivery and Imaging Applications

Hierarchically Structured Macro with Nested Mesoporous Zinc Indium Oxide Conducting Film

Fabrication of homogeneously distributed (HD) macropores by breath figure process is an active research area. Adopting the process, for the first time, CSIR-CGCRI report the fabrication of HD macro with nested meso (hierarchical) porous nanocrystalline zinc indium oxide conducting

sol–gel thin film on glass by dip-coating at 45–50% room relative humidity (RH) from a solution in ethanol-2-butanol (1:1, w/w) medium with a 1:1, Zn:In ratio. In this process, solution composition and RH are found to play key roles on HD macropore generation. The film is highly promising toward visible-light-driven photoelectrochemical water splitting.



Zinc Indium Oxide Conducting Film

Nanostructured Conducting Polymers for Energy Applications: Towards a Sustainable Platform

Recently, there has been tremendous progress in the field of nanodimensional conducting polymers with the objective of tuning the intrinsic properties of the polymer and the potential to be efficient, biocompatible, inexpensive, and solution processable. Compared with bulk conducting polymers, conducting polymer nanostructures possess a high electrical conductivity, large surface area, short path length for ion transport and superior electrochemical activity which make them suitable for energy storage and conversion applications. The current status of polymer nanostructure fabrication and characterization is reviewed in detail. The present review includes syntheses, a deeper understanding of the principles underlying the electronic behavior of size and shape tunable polymer nanostructures, characterization tools and analysis of composites. Finally, a detailed discussion of their effectiveness and perspectives in energy storage and solar light harvesting is presented. In brief, a broad overview on the synthesis and possible applications of conducting polymer nanostructures in energy domains such as fuel cells, photocatalysis, supercapacitors and rechargeable batteries is described.

Indian Highway capacity Manual - The main hypothesis behind conceiving the project was that Indian traffic

CSIR-CRRI study on Alignment Road from Sasoma to Saser Brangsa -The main objective of study is to carry out a detailed investigation to realign the existing alignment from KM 41.50 to KM 48.80 and propose suitable new alignment from KM 48.80 to KM 54.7. To achieve the stated objectives a study methodology was devised. The study team of CRRI carried out the required investigations to improve and realign the existing road from KM 41.5 to KM 48.8 and propose the most appropriate alignment from KM 48.8 to KM 54.7. The major activities included topographical data collection, geometric design, geotechnical characterization and slope stability analysis and suggestion of remedial measures. Topographical data was collected from different sources namely Survey of India (SOI), Stereo Satellite data. Site investigation reports from various organizations and relevant literature were also collected. A detailed topographic survey was conducted using LiDAR technology on the study alignment.

The collected data was analyzed and geometric design and slope stability analysis were carried out. Finally Design Drawings (submitted in the month of November 2016) including horizontal, vertical alignment and cross section, remedial measure drawings were prepared and remedial measures were suggested. Final Report was submitted in December 2017.

Utilisation of Municipal solid waste in road construction/ emabankment.

A detailed study was carried out by CSIR- CRRI to investigate the possibility of utilizing the Municipal Solid Waste (MSW) collected from Ghazipur,

East Delhi as an embankment fill material. The MSW is proposed to be utilized in the widening of NH-24 (Delhi-Meerut Expressway) from the existing 4 lane to 14 lane. The construction would be carried out by National Highway Authority of India (NHAI) under the supervision of CSIR-Central Road Research Institute. About 200 tons of Municipal Solid Waste was collected from three different locations on the landfill site, based on its age. These materials were dried and then segregated into different sizes in the existing compost plant. The different fractions were studied for their suitability for use in embankment construction. A segregation methodology was proposed in the study to arrive at a final material to be used in the embankment. This Municipal Solid Waste (MSW) was also studied for the presence of heavy metals by carrying out leachate studies. The segregated MSW is then characterised for its Geotechnical characteristics. Stability and Settlement analysis was also carried out to investigate its feasibility for embankment construction. It was concluded that ;

- About 65-75% of segregated Municipal Solid wastes can be used for embankment construction.
- Leachate studies indicate that MSW is a non hazardous material as concentration of heavy metals is within the permissible limit.
- Typical design cross sections with MSW embankment have been arrived for experimental test track construction along the Delhi-Meerut expressway. The MSW embankment would be instrumented and monitored over a period of 2 years before recommending the material for large scale field applications.

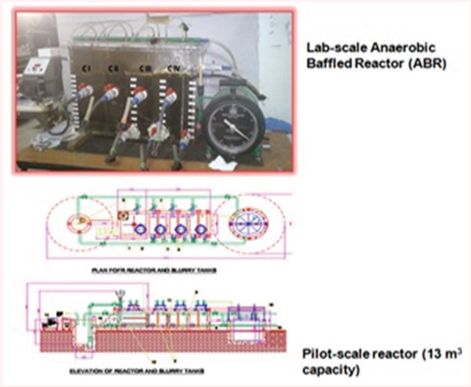
Environmental bacteria that could detect mercury and respond to presence of mercury by color change

CSIR-NEERI has Identified microbiome of foam and lake water from Bengaluru that produces high levels of biosurfactant. Efforts are towards developing bacterial consortia for bioremediation of mercury contaminated soil and control of foam formation in lake environment employing biological systems.

Microbiome of foam bacteria that can detect mercury by color change

Anaerobic baffled reactor (ABR) for vegetable/ kitchen

CSIR-NEERI has developed anaerobic baffled for biomethanation. The reactor demonstrated superior performance owing to longitudinal separation of acidogenic and methanogenic phases. This resulted in segregation of the microbial communities as per their respective roles in reactions of anaerobic digestion (viz., hydrolysis, acidogenesis, acetogenesis, methanogenesis) indicating efficient phase separation. The ABR also showedm high stability to organic and hydraulic shock loads with high sludge retention time leading to high efficiency and robustness. Further it was observed that the ABR supported hydrogenotrophic methanogenesis resulting in consistent 60% methane production.



Lab scale reactor & Pilot scale reactor

Development of Zero waste technology for processing and utilization of thermal coal

Technology developed by CSIR-NML for dry beneficiation of thermal coal. Validated the developed technology at pilot scale (5-10tph). Wet Processing Scheme developed for recovering the combustibles from rejects of dry circuit. Developed technology through geopolymerisation for making bricks at a pilot scale. Technology developed for making geopolymer cement from high iron containing fly ash(1 tpd). Developed a process for making geopolymer concrete using bottom ash (10 kg scale).

Hot Dip galvanizing simulation

Installation of Hot Dip Process Simulator at CSIR-NML. Development of Galvanizing and Galvannealing process for IFHS grade of steel. Optimization of thermal cycle for DP 590 grades of AHS steels using HDPS. Development of processes for Galvanizing of DP 590 and DP 780 grades of AHS steels.

Reduction of silica in slimes of limestone washing plant (LSWP) by conventional & column flotation and utilization slurry waste for value added products

A process based on froth flotation technique using suitable reagents was developed for the recovery of calcium carbonate from limestone washing plant (LSWP) slimes. It mitigates the problems associated with handling of large quantities of slimes presently being lost as tailings; while recovering carbonate values by more than 50% by mass. A conceptual flow sheet was developed for implementation at plant scale of 140 tonnes per hour. Slurry waste with 40 to 50% solids generated from limestone washing plant has been utilized for the development of cost effective value added products such as tiles/pavers at laboratory scale. A conceptual flow chart for product making was also developed.

1.4 Information Sciences

Climate Change Informatics programme at CSIR-NISCAIR

The Climate Change Informatics programme at CSIR-NISCAIR has developed three facilities for Geospatial, Biospatial and Environmental studies as part of the VACCIN project. As a result India emerged as the pioneering leader to have studied for the first time the impact of climate variability and biogeography migration of marine living organisms on the top predator populations like tuna fishery in the northern India Ocean.

As part of the CSIR Knowledge Gateway (KNOWGATE) project, CSIR-NISCAIR developed a web portal including federated searching for knowledge resources, a Virtual Union Catalogue using open source software, a CSIR Cloud Module to enhance computing power for data intensive research and applications hosting for KRCs and CSIR Trend Module for analysing research and technological data.

A scenario based approach to seismic hazard assessment:

Current computational resources and physical knowledge of the seismic waves generation and propagation processes allow for reliable numerical and analytical models of waveform generation and propagation. From the simulation of ground motion it is easy to extract the desired earthquake hazard parameters. Accordingly, a scenario-based approach to seismic hazard assessment has been developed by CSIR-4PI, namely the neo-deterministic seismic hazard assessment (NDSHA), which allows for a wide range of possible seismic sources to be used in the definition of reliable scenarios by means of realistic waveforms modeling. Such reliable and comprehensive characterization of expected earthquake ground motion is essential to improve building codes, particularly for the protection of critical infrastructures and for land use planning. The first ever neo-deterministic seismic hazard map of India was given by CSIR-4PI in 2003 by

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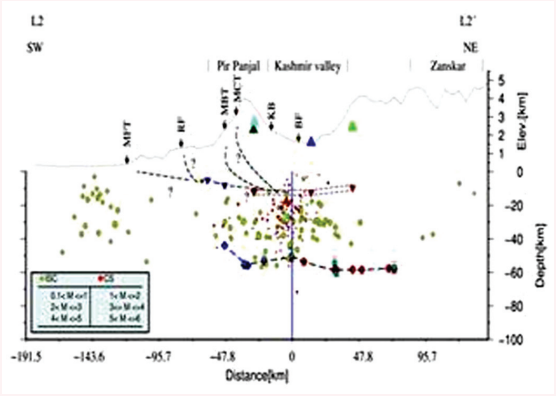
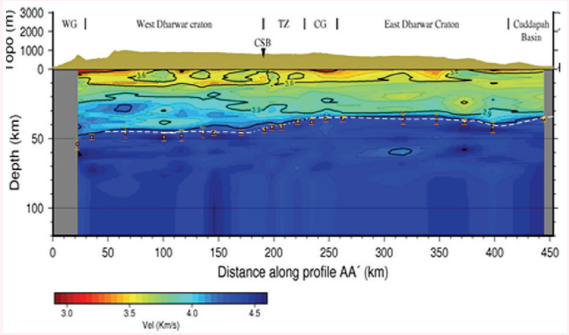
computing synthetic seismograms with input data set consisting of structural models, seismogenic zones, focal mechanisms and earthquake catalogues. The seismic hazard, expressed in terms of maximum displacement (Dmax), maximum velocity (Vmax), and design ground acceleration (DGA), has been extracted from the synthetic signals and mapped on a regular grid over the studied territory.



Scenario based seismic hazard assessment

Velocity image along a transact in Dharwar Craton

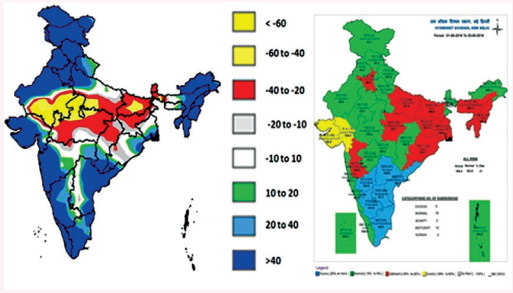
CSIR-4PI generated velocity image along a transact in Dharwar Craton (from Talkaveri to Cudapah) using 22 broadband station data. This provides crustal structure beneath the transact which is helpful to understand the transition zone between Western and Eastern Dharwar, the geodynamics of the region and the velocity structure. It can also be used to precise the earthquake locations, simulation of ground motion for earthquake hazard assessment.



Transition zone between Western and Eastern Dharwar

High resolution long-range dynamical forecasting of Indian monsoon 2016:

The first outlook of high resolution long-range forecast of the Monsoon 2016 was made available by CSIR-4PI in the middle of April, 2016. The date of onset of monsoon over Kerala, the seasonal (JJA) as well as monthly rainfall anomalies are forecasted using the variable resolution general circulation model (GCM). These forecasts are based on an ensemble (5 member) consisting of information on the atmospheric state (initial conditions) from 15th March 2016 to 15th April 2016. The forecasts are also presented in the pre-season meeting organized by IMD in mid-April; IMD acknowledged these forecasts. For 2016, the CSIR-4PI forecast of the date of Onset of Monsoon was June 02, while that of IMD was 8th June. The post season validation of the spatial distribution of monthly and seasonal rainfall anomalies show good agreement of the forecast with observation over many regions of the country.



The monthly scale validation of rainfall anomaly for June 2016

The relationship between antecedent soil moisture and monsoon rainfall over the Indian region through observational analysis.

Understanding the relationship between gradually varying soil moisture (SM) conditions and monsoon rainfall anomalies is crucial for seasonal prediction. Though, it is an important issue, very few studies in the past attempted to diagnose the linkages between the antecedent SM and Indian summer monsoon rainfall. CSIR-4PI examined the relationship between spring (April-May) SM and June rainfall using observed data during the period 1979-2010. The Empirical Orthogonal Function (EOF) analyses

showed that the spring SM plays a significant role in June rainfall over the Central India (CI), South India (SI) and North East India (NEI) regions. The composite anomaly of the spring SM and June rainfall showed that excess (deficit) June rainfall over the CI was preceded by wet (dry) spring SM. The anomalies in surface specific humidity, air temperature, and surface radiation fluxes also supported the existence of a positive SM-precipitation feedback over the CI. On the contrary, excess (deficit) June rainfall over the SI and NEI region were preceded by dry (wet) spring SM. The abnormal wet (dry) SM over the SI and NEI decreased (increased) the 2m-air temperature and increased (decreased) the surface pressure compared to the surrounding oceans which resulted in less (more) moisture transport from oceans to land (negative SM-precipitation feedback over the Indian monsoon region).

1.5 Physical Sciences

Design and development by CSIR-CEERI.

CSIR-CEERI has designed and developed ion controller based Fluid-FET concept for micro reactor; unique passive particle separator-cum-counter chip for WBC, RBC & plasma from blood; micro-viscometer based on dielectric property of fluids.

Designed Application specific instruction set processor (ASIP) and mixed signal sensor interface electronic circuits with patented auto-calibration technology.

Voltametric methods for multisensor systems to authenticate various liquids, such as, milk, fruit juices, wine, soft drinks, teas and bottled water. Customizable Terahertz Tags have been developed for the detection of fake Currency/Document.

Under the Umbrella MOU signed between CSIR-NGRI and AMD to conduct Heliborne Geophysical Surveys in the parts of Kaladgi, Bhima, Satpura (MP) and Chhattisgarh blocks for Uranium Exploration, a total of 20939 LKM was covered over both Chhattisgarh and Satpura basins in the year 2016-17.

The Peak ground acceleration map of the central part of the Indo Gangetic plains shows the areas closer to the epicenter had relatively higher ground motion accelerations than the others. The violet region in the figure is the area where the maximum damage to built in environment occurred as well as the loss of life in comparison to the regions where the ground motion accelerations were less than 0.06 g.

Full waveform inversion, the most advanced technique to image subsurface, has been able to resolve complex structures (circled) and BSR (a marker due to presence of gas-hydrate) and minute changes in velocity due to the presence of gas hydrate.

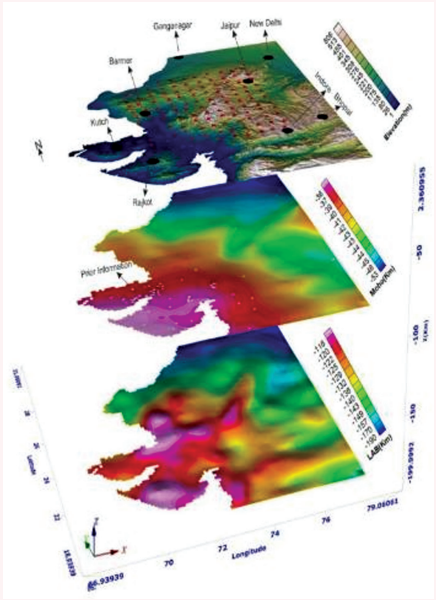


Image of gas-hydrate (future potential energy resource) bearing marine sediments in Krishna Godavari offshore basin.

Ablation and chemical alteration of cosmic dust particles during entry into the earth`s atmosphere

Most dust-sized cosmic particles undergo ablation and chemical alteration during atmospheric entry, which alters their original properties. A comprehensive understanding of this process is essential in order to decipher their pre-entry characteristics. The purpose of the study is to illustrate the process of vaporization of different elements for various entry parameters. The numerical results for particles of various sizes and various zenith angles are treated in order to understand the changes in chemical composition

that the particles undergo as they enter the atmosphere. Particles with large sizes (>few hundred Mu m) and high entry velocities (>16 km^{-1}) experience less time at peak temperatures compared to those that have lower velocities. Model calculations suggest that particles can survive with an entry velocity of 11 km^{-1} and zenith angles (ZA) of 30°-90°, which accounts for ~66% of the region where particles retain their identities. Our results suggest that the changes in chemical composition of MgO, SiO_2, and FeO are not significant for an entry velocity of 11 km^{-1} and sizes <300 Mu m, but the changes in these compositions become significant beyond this size, where FeO is lost to a major extent. However, at 16 km^{-1} the changes in MgO, SiO_2, and FeO are very intense, which is also reflected in Mg/Si, Fe/Si, Ca/Si, and Al/Si ratios, even for particles with a size of 100 Mu m. Beyond 400 Mu m particle sizes at 16 km^{-1}, most of the major elements are vaporized, leaving the refractory elements, Al and Ca, suspended in the troposphere.

Relict olivines in micrometeorites: Precursors and interactions in the earth`s atmosphere

Antarctica micrometeorites (~1200) and cosmic spherules (~5000) from deep sea sediments are studied using electron microscopy to identify Mg-rich olivine grains in order to determine the nature of the particle precursors. Mg-rich olivine (FeO <5wt%) in micrometeorites suffers insignificant chemical modification during its history and is a well-preserved phase. We examine 420 forsterite grains enclosed in 162 micrometeorites of different types-unmelted, scoriaceous, and porphyritic-in this study. Forsterites in micrometeorites of different types are crystallized during their formation in solar nebula; their closest analogues are chondrule components of CV-type chondrites or volatile rich CM chondrites. The forsteritic olivines are suggested to have originated from a cluster of closely related carbonaceous asteroids that have Mg-rich olivines in the narrow range of CaO (0.1-0.3wt%), Al_2O_3 (0.0-0.3wt%), MnO (0.0-0.3wt%), and Cr2O3 (0.1-0.7wt%). Numerical simulations carried out with the Chemical Ablation Model (CABMOD) enable us to define the physical conditions of atmospheric entry that preserve the original compositions of the Mg-rich olivines in these particles. The chemical compositions of relict olivines affirm the role of heating at peak temperatures and the cooling rates of the micrometeorites. This modeling approach provides a foundation for understanding the ablation of the particles and the circumstances in which the relict grains tend to survive.

Inhibition of mixed-layer deepening during winter in the northeastern Arabian Sea by the West India coastal current

Though the deep mixed layers (MLs) that form in the northeastern Arabian Sea (NEAS) during the winter monsoon (November–February) have been attributed to convective mixing driven by dry, cool northeasterly winds from the Indian subcontinent, data show that the deepest MLs occur in the northern NEAS and the maxima of latent-heat and net heat fluxes in the southern NEAS. We use an oceanic general circulation model to show that the deep MLs in the NEAS extend up to ~20°N till the end of December, but are restricted poleward of ~22°N (~23°N) in January (February). This progressive restriction of the deep mixed layers within the NEAS is due to poleward advection of water of lower salinity by the West India Coastal Current (WICC). The deep MLs are sustained till February in the northern NEAS because convective mixing deepens the ML before the waters of lower salinity reach this region and the wind stirring and convective overturning generate sufficient turbulent energy for the ML to maintain the depth attained in January. Though the atmospheric fluxes tend to cool the ML in the southern NEAS, this cooling is countered by the warming due to horizontal advection. Likewise, the cooling due to entrainment, which continues in the southern NEAS even as the ML shallows during January-February, is almost cancelled by the warming caused by a downwelling vertical velocity field. Therefore, the SST changes very little during December-February even as the ML

shallows dramatically in the southern NEAS. These deep MLs of the NEAS also preclude a strong intraseasonal response to the intraseasonal variability in the fluxes. This role of horizontal advection implies that the ML depth in the NEAS is determined by an interplay of physical processes that are forced differently. The convective mixing depends on processes that are local to the region, but the advection is due to the WICC, whose seasonal cycle is primarily forced by remote winds. By inhibiting the formation of deep MLs in the southern NEAS, the WICC limits the region of formation of the high-salinity water masses of this region. Since the deep MLs in the NEAS have been linked to the high chlorophyll concentration there, our results imply that the conventional approach of averaging over boxes for studying the impact of physics on biogeochemistry can mask important details that are due to advection because it is the advective component of any budget that is most affected by the averaging process.

In situ oxygen isotope compositions in olivines of different types of cosmic spherules: An assessment of relationships to chondritic particles

Cosmic spherules collected from deep sea sediments of the Indian Ocean having different textures such as scoriaceous (4), relict-bearing (16), porphyritic (35) and barred olivine (2) were investigated for petrography, as well as high precision oxygen isotopic studies on olivine grains using secondary ion mass spectrometry (SIMS). The oxide FeO/MgO ratios of large olivines (>20 μm) in cosmic spherules have low values similar to those seen in the olivines of carbonaceous chondrite chondrules, rather than matching the compositions of matrix. The oxygen isotope compositions of olivines in cosmic spherules have a wide range of $\delta^{18}O$, $\delta^{17}O$ and $\Delta^{17}O$ values as follows: -9 to 40%, -13 to 22% and -11 to 6%. CSIR-NIO results suggest that the oxygen isotope compositions of the scoriaceous, relict-bearing, porphyritic and barred spherules show provenance related to the carbonaceous (CM, CV, CO and CR) chondrites. The different types of spherules that has experienced varied atmospheric heating during entry has not significantly altered the $\Delta^{17}O$ values. However, one of the relict-bearing spherules with a large relict grain has $\Delta^{17}O$ = 5.7%, suggesting that it is derived from 16O-poor material that is not recognized in the meteorite record. A majority of the spherules have $\Delta^{17}O$ ranging from -4 to -2%, similar to values in chondrules from carbonaceous chondrites, signifying that chondrules of carbonaceous chondrites are the major contributors to the flux of micrometeorites, with an insignificant fraction derived from ordinary chondrites. Furthermore, barred spherule data shows that during atmospheric entry an increase in ~10% of $\delta^{18}O$ value surges $\Delta^{17}O$ value by ~1%.

A Novel Hydro-electric Cell as a Source of Green Energy

The CSIR-National Physical Laboratory (NPL), New Delhi has recently come up with the "Hydroelectric Cell" that operates at room temperature, produces no excessive heat and greenhouse gases, and being made of inexpensive precursors is cheaper than fuel cells. The hydroelectric cell also scores over the fuel cell in being risk-free.

A novel renewable energy source and a unique manifestation of the galvanic cell, the hydroelectric cell employs a combination of the material properties and electrode chemistry using only water to generate electrical power. The novelty of this work lies in the generation of electrical energy by the dissociation of water molecules at room temperature by nano-porous lithium substituted magnesium ferrite material.

The hydroelectric cell consists of magnesium ferrite pellet, zinc anode and silver cathode and conducts hydrogen and hydroxide ions due to water molecule dissociation. Owing to the electrochemical reaction, zinc hydroxide gets deposited at the anode and hydrogen gas is produced at the silver electrode and the collection of hydrogen and hydroxide ions is achieved using the electrode reduction potential of zinc & silver.

At present, this cell has a current density of 4.8 mA/cm^2 with a voltage of 950 mV and a maximum power output of 74 mW. Three such cells of diameter 4.8 cm can run a small fan as well as 10 LEDs.

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The cell is an economical green source for producing renewable energy. Based on the work, an Indian Patent # 792/DEL/2015 has been granted and a US patent has been filed (Application No. 15/067,496).

2. CONSULTANCY DEVELOPMENT CENTRE

1. Introduction

Consultancy Development Centre (CDC) is an Autonomous Institution of the Department of Scientific and Industrial Research (DSIR), Ministry of Science and Technology, Government of India set up for promotion, development and strengthening of consultancy skills and capabilities in the country including enhancement of export of consultancy and professional services.

In the changed policy and economic environment at national and international levels, "Knowledge" is being considered as "Power" and consultancy is a knowledge based profession. CDC aims at fostering and promoting intellectual cross - fertilization of knowledge and ideas at regional and sub- regional levels within the country and interaction at the international level as well.

During the financial year 2016-17, plan support of Rs. 40.00 lacs was received from DSIR for carrying out specific projects & activities. Besides plan support activities, CDC undertook various funded projects from various Ministries/ Departments of the Government of India.

CDC regularly brings out biannual Journal – Consulting Ahead. Consulting Ahead is devoted to the publication of articles advancing knowledge through research and cases in all sectors and disciplines of consulting. The objective of Consulting Ahead is to become a source of innovative thoughts, knowledge and information of concern for consultants, clients, policy makers, academicians and professionals from various disciplines. It also aims at sharing of professional achievements, professional concerns and providing a global perspective to consulting profession.

2. Activities

Activities undertaken during the year including on going activities are as follows:

1. Development of CDC website in Hindi and software for feature enhancement of existing website to be developed on responsive mode.
2. CDC Journal "Consulting Ahead.
3. Building Capacities for Consultancy Development & Knowledge Management with Partner Institution (KMPI).
4. Assignment on "Content Development for Certificate Programme in Technology Management"

3. FUNDED PROJECTS

1. Study on "Need based interventions for better marketability of Handicraft Clutures in Uttar Pradesh (Wooden crafts in Nagina and Zari/ Zardozi crafts in Varanasi)"
2. Study on "Preparation of Strategic Roadmap for Metal Handicrafts Service Centre (MHSC), Moradabad"
3. Selection of Agency for Supply, Installation, Commissioning, Implementation of IT Security Solutions for Air India Office.
4. Selection of System Integrator for Implementation of IP Based CCTV Solution at Medical College of Medical Council of India (MCI)
5. Training and Consultancy Services for Implementation of ISO 9001:2008 Quality Management System (QMS) at National Research Development Corporation (NRDC)
6. Assessment/Physical Inspection of MSE Units for National Small Industries Corporation (NSIC) as part of their Single Point Registration Scheme

4. FINANCIAL PERFORMANCE

During the financial year 2016-17, Centre was provided Plan funds of Rs. 40.00 lakhs for carrying out various activities relating to consultancy development and promotion. Expenditure of Rs. 340.33 lakhs was incurred and the total revenue generation from various programmes & activities during the year was Rs. 319.48 lakhs.