AUTONOMOUS BODIES

1: COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH (CSIR)

2: CONSULTANCY DEVELOPMENT CENTRE (CDC)

1. COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH (CSIR)

1.1 BIOLOGICAL SCIENCES

A list of establishments under Biological sciences is given in **Annexure – 12**.

New Clues to Parkinson's Disease Found

A protein called alpha-synuclein plays a very crucial role in the development of Parkinson's disease. CSIR-IICB has shown that the protein (native form), oligomers (early), as well as amyloid fibrils, affect each other in the aggregation pathway.

Out of 20 amino acids they used only two amino acids to direct their study in live neuroblastoma cells (a type of cancerous cells). The first amino acid was glutamate which was responsible for the formation of amyloid fibrils by facilitating early oligomer generation; the other was arginine responsible for amyloid fibril inhibition by inducing a change in the actual (native) structure of the protein. The study also revealed that glutamate acts as a facilitator and arginine as an inhibitor of the late stage of alpha-synuclein aggregation pathway. However, it is not clear whether the observed effects are due to cellular changes or due to direct interaction of these molecules with alpha-synuclein. The nature of the interaction of these molecules with alpha-synuclein as well as the mechanism of internalisation is yet to be better understood.

Anti-TB Cocrystal 4-FDC Drug with Improved Stability

CSIR-NCL has developed an Anti-TB cocrystal drug with improved stability. The cause for the instability of the 4-FDC drug chemical structures was studied and discovered pharmaceutically stable cocrystal by applying Crystal Engineering principles to improve the stability, so that the drug inhibits the cross-reaction between Isoniazid and Rifampicin, and thereby overcomes the formation of inactive by-products.

The pharmaceutical cocrystals of INH (INH-Caffeic acid and INH-Vanillic acid) were used to improve the stability of 4-drug FDC. The pharmaceutically stable cocrystal of INH is able to improve the stability greater than 5-fold compared to the current 4-FDC drugs. The coformer additives which stabilise the formulation are pharmaceutically accepted excipients. Stability studies were carried out under accelerated conditions of 40°C temperature and 75% relative humidity. The first time improvement of stability of anti-TB 4-FDC drugs using cocrystals of INH in a fixed dose formulation was reported.

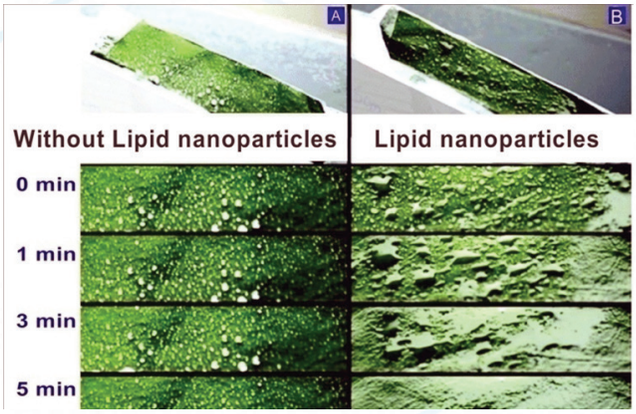
Efficient Delivery of Pesticide to Plants and Crops

CSIR-NCL has developed a potential solution to address the crucial problem of efficient delivery of pesticides to plants by completely eliminating the retraction. A mixture of nanoparticles prepared from plant oils in small quantities and water form a 2 to 3 nanometres thin coat on the leaf and allows this mixture to stick to the surface of plants.

This material remarkably coats the leaf surface within a few milliseconds; subsequently the droplets spread. A natural lipid compound was extracted from the sunflower oil which is edible, biocompatible and is also used as a food emulsifier. The peculiarity of this compound is that while one end is hydrophilic (water attracting), the other is hydrophobic (water repelling), which makes it more suitable for this process. This can improve the efficiency of delivering pesticides to the targeted area on plants. In an experimental study, 10 gm of material per

litre was found enough for effective pesticide spray; that may vary after the field trials.

This invention is protected by a patent filing and the research work has also been published in the Royal Society of Chemistry journal, *Soft Matter*.



Dispersion of pesticide solution (A) without lipid nanoparticles (B) with 1% lipid nanoparticles

Novel Way to Inhibit Bacterial Growth

CSIR-CCMB have discovered a new mechanism to inhibit bacterial growth, paving the way for novel antibiotics to fight against infections resistant to drugs.

The scientists isolated an Antimicrobial Protein (AMP) from the milk of a unique egg-laying mammal, namely, Echidna, also known as spiny anteaters found in Australia and New Guinea. The extracted protein may serve as an alternative to antibiotics used on livestock. The Antimicrobial Protein (AMP) in the milk of the mammal can puncture the cell membranes of multiple bacterial species thereby destroying the infection. The study has been published in the journal *Biochimica et Biophysica Acta–Biomembranes*.

Early Diagnosis of Prediabetes Using Novel Markers

CSIR-NCL, in collaboration with the Chellaram Diabetes Institute, Pune, has identified some novel markers for efficient prediction of prediabetes. The glycated peptides of a protein, namely Albumin were studied and differentiated to evaluate their ability to predict the prediabetic condition.

Prediabetes is a condition wherein the blood glucose or blood sugar levels in the body are higher than the normal. At a certain level of sugar in the body, it becomes type 2 diabetes which is the advanced stage. Prediabetes can be controlled with simple changes in lifestyle and eating habits. In this research work, blood samples were collected from prediabetic but healthy patients for a series of diagnostic tests such as levels of glucose bound haemoglobin (HbA1c), fasting blood glucose, and lipid profiles were also performed. After the inspection, only four peptides were taken out of fourteen as per the selection criteria.

A study was carried out to quantify these four glycation sensitive peptides in the selected patients. All these peptides were observed with a higher fold difference in prediabetes than the corresponding unmodified peptides like FBG, PPG and HbA1c. The study suggested that these peptides may determine prediabetes more efficiently, and therefore they could form a potential panel of biomarkers for diagnosis of prediabetes. Therefore, quantifying these 4 glycated peptides of glucose-sensitive lysine (a building block of protein) residues of albumin will help in diagnosis of prediabetes.

Inflammasome activation in Kupffer cells confers a protective response in nonalcoholic steatohepatitis

Inflamasome activation in liver macrophage related to nonalcoholic steatohepatitis has been explored by CSIR-IICB. Hepatocellular death or ballooning distinguishes the transition of simple steatosis to irreversible nonalcoholic steatohepatitis (NASH).

However, the molecular mechanism of hepatocellular apoptosis in NASH is largely unclear, and discovery of endogenous mediators that could prevent or inhibit cell death is thereby critical in intercepting NASH progression. CSIR-IICB has identified pigment epithelium-derived factor (PEDF), a secreted, moonlighting hepatokine as 1 hepatoprotective agent in mice with diet-induced NASH. Hepatic PEDF expression is induced by IL-1β, which is derived from inflammasome activation in liver-resident Kupffer cells. This study highlights PEDF as a functionally important hepatokine in NASH progression by linking inflammasome activation and hepatocellular death.

Discovery of a major-groove-specific nuclear-localizing, cell-penetrating tetrapeptide.

Identification of key amino acids is required for development of efficient cell-penetrating peptides (CPPs) that have tremendous implications in medicine. CSIR-IICB has studied the importance of two amino acids, arginine and tryptophan, in cell penetration and developed short, non-toxic tetrapeptides with excellent potential for cell penetration and nuclear localization. Among them, Glu-Thr-Trp-Trp (ETWW) emerges as the most promising. Results suggest that it enters into cancer cells following an endocytic pathway and binds at the major groove of nuclear DNA, where successive tryptophan plays major role. CSIR-IICB subsequently showed that it is not a P-glycoprotein substrate and is non-toxic to PC12-derived neurons, suggesting its excellent potential as a CPP. This study provides major fundamental insights about the positional importance of tryptophan and opens new avenues toward the development of next-generation CPPs and major-groove-specific anticancer drugs.

MOF-Bacteriophage Biosensor for Highly Sensitive and Specific Detection of *Staphylococcus aureus*

To produce a sensitive and specific biosensor for *Staphylococcus aureus*, bacteriophages have been interfaced with a water-dispersible and environmentally stable metal–organic framework (MOF). The conjugation of the MOF with bacteriophages has been achieved by CSIR-CSIO through the use of glutaraldehyde as cross-linker. Highly sensitive detection of *S. aureus* in both synthetic and real samples was realized by the MOF–bacteriophage biosensor based on the photoluminescence quenching phenomena: limit of detection (31 CFU/mL) and range of detection (40 to 4 × 108 CFU/mL). This is the first report exploiting the use of an MOF–bacteriophage complex for the biosensing of *S. aureus*. The results of study highlight that the proposed biosensor is more sensitive than most of the previous methods while exhibiting some advanced features like specificity, regenerability, extended range of linear detection, and stability for long-term storage (even at room temperature).

Antiproliferative efficacy of curcumin mimics through microtubule destabilization

Curcumin possesses an attractive chemical structure with highly conjugated diferuloylmethane core. CSIR-CIMAP has designed and prepared curcumin mimics with an additional bridged phenyl ring in conjugation. Fourteen diverse analogues were evaluated against a panel of human cancer cell lines. The best analogue of the series i.e. compound 6a exhibited potent cytotoxicity against A431, epidermoid carcinoma cell line and DLD1, colorectal adenocarcinoma cell line. Further, in acute-oral toxicity experiment in rodent model, compound 6a was given in three different oral doses to Swiss albino mice. There were non-

significant changes in various biochemical parameters and major body organs studied, including their absolute and relative weights. It was tolerable up to 300 mg/kg dose in Swiss-albino mice. The present study shows that the novel Curcumin mimic 6a is a safe and efficacious anticancer compound. Which needs to be optimized for better efficacy.

Rutin protects t-butyl hydroperoxide-induced oxidative impairment *via* modulating the Nrf2 and iNOS activity

Rutin (quercetin-3-O-rutinoside), a flavonoid, is predominantly found in the buckwheat, cranberries, mulberry and citrus fruits. It is used as a restorative in the preparation of herbal medicine, multivitamin. CSIR-CIMAP aimed to elucidate whether rutin attenuates oxidative stress and its possible mechanism of action in ameliorating the deleterious effect of t-BHP and provide evidence that rutin protects the antioxidant status of erythrocytes and liver *via* Nrf2 and iNOS pathway from oxidative stress. The study concluded that the dietary factors wherein rutin is an ingredient could be helpful in the maintenance of the intracellular redox-homeostasis and thus may be effective against oxidative stress-related secondary complications.

Picomolar detection of retinol binding protein - 4 for early management of type II diabetes

Type (II) diabetes is one of the major threats to mankind as it causes insulin resistance in human body. Retinol Binding Protein 4 (RBP4) is considered as a potential biomarker for early management of this disease and its low-level detection is an important task. A novel RBP4 biosensor has been developed by CSIR-CSMCRI using homemade plastic chip electrodes (PCEs) as a platform for self-assembled monolayer (SAM) of 4-ATP and further functionalization with glutaraldehyde. Anti RBP4 is used as biorecognition species and electrochemical impedance spectroscopy was used for analysis. A wide concentration range from 100 fg/mL to 1 ng/mL has been tested and a low limit of detection (LOD) of 100 fg/mL has been achieved. This is the first report for fabrication of electrochemical biosensor of RBP4 using Ag-Ab interaction having such low LOD. Excellent reproducibility and quick measurement makes this biosensor extremely useful for the biomedical industry.

Mitigation of climate change using seaweed based biostimulant: A case study with sugarcane cultivation in India

Strategies for sustainably increasing sugarcane productivity without any negative implications to the environment are challenging. CSIR-CSMCRI demonstrated successfully the potential of an agro-technique involving foliar applications of *Kappaphycus alvarezii* seaweed based biostimulant in combination with recommended rate of synthetic fertilizers (RRF) for sustainably enhancing sugarcane production and mitigating environmental impacts. Kappaphycus seaweed extract (KSWE) applied at 5% concentration enhanced cane productivity by 12.5 and 8%, respectively, in plant and ratoon crops. The present study advocates a paradigm shift in policy to encourage use of biostimulants in the context of mitigating adverse effects of global climate change and expecting better returns from sugarcane cultivation.

Specific Cholesterol Binding Drives Drastic Structural Alterations in Apolipoprotein-A1

The Apolipoprotein -A1 (ApoA1) is the major constituent (70%) of high-density lipoproteins (HDL) and yet, the functional monomeric lipid-free form of the protein remained to be

solved. CSIR-IGIB has constructed the first complete ApoA1 monomer structure using large-scale multiple independent atomistic molecular dynamics trajectories. It proposes a mechanism whereby ApoA1 opens in a stage wise manner and mutation at the novel N-terminal site abrogates ApoA1 opening. Thus, availability of the first complete lipid-free structure of ApoA1 shall enable to deciphering the molecular mechanisms of further downstream reactions in reverse cholesterol pathway and shall significantly advance in understanding and maintaining cardiovascular health.

Zinc Oxide Nanoparticles Dispersed in Ionic Liquids Show High Antimicrobial Efficacy to Skin-Specific Bacteria

Zinc oxide (ZnO) nanoparticles have antibacterial properties and are used in many commercial products that exploit this property. However, since these nanoparticles show tendency to aggregate, their efficacy can be reduced. CSIR-IGIB has demonstrated that maximum efficiency is obtained for ZnO nanoparticles dispersed in imidazolium-based ionic liquid against skin-specific *S. epidermidis*. The dispersion is also biocompatible and non-toxic to normal skin keratinocytes. *S. epidermidis* is a prevalent causal agent for different hospital-acquired infections. In most cases, antibiotic-based therapies are not very effective for combating these infections. The ZnO-IL combination can be developed as a potent antibacterial formulation for treating such infections.

Differential transcriptome modulation leads to variation in arsenic stress response in *Arabidopsis thaliana* accessions

Arsenic (As) is a ubiquitous metalloid and a health hazard to millions of people worldwide. The presence of As in groundwater poses a threat as it not only affects crop productivity but also contaminates food chain. In recent past, natural variation in *Arabidopsis thaliana* has been utilized to understand molecular and genetic adaptation under different stresses. Responses of Arabidopsis accessions were analyzed at biochemical and molecular levels towards arsenate [As (V)] stress at CSIR-NBRI. On the basis of reduction in root length, accessions were categorized into tolerant and sensitive ones towards As (V). A number of genes associated with defense and stress-response, transport system, regulatory mechanisms and biochemical processes showed differential expression in contrasting accessions.

Application of four novel fungal strains to remove arsenic from contaminated water in batch and column modes

CSIR-NBRI identified four novel fungal strains (FNBR_3, FNBR_6, FNBR_13, and FNBR_19) that can remove arsenic from contaminated water in batch and column modes. Alginate beads containing 0.1 g biomass were used in a batch experiment (200 mg l^{-1}As; pH 6). Changes in the surface of fungal cells and intracellular As-uptake by fungal biomass were also confirmed by scanning electron microscopy combined with X-ray energy dispersive spectrometer. The presence of different functional groups on fungal cells capable of As-binding was investigated by FTIR. The As-removal by immobilized fungal beads tested in the packed columns also. The As-adsorption by biomass (qe as mg g^{-1}) were recorded as 59.5 (FNBR_3 and FNBR_6), 74.8 (FNBR_13), and 66.3 (FNBR_19) in the column and validated by Thomas model.

Zinc oxide-NP catalyzed direct indolation of *in situ* generated bioactive tryptanthrin (Green Chemistry

A ZnO-NP catalyzed direct indolation

of *in situ* generated tryptanthrin *via* C–H functionalization and C–C bond formation has been developed by CSIR-CDRI. This novel and greener approach has been effectively utilized to accomplish the synthesis of 6-hydroxy-6-(1*H*-indol-3-yl)indolo[2,1-*b*]quinazolin-12(6*H*)-one derivatives in good to excellent yields with high product selectivity. Besides the *in situ* approach, a direct indolation of tryptanthrin has also been developed.

siRNA delivery using a cationic-lipid-based highly selective human DNA ligase I inhibitor

CSIR-CDRI & CSIR-IICT together have illustrated the serendipitous discovery of a cationic-lipid-based human DNA ligase (hLig) I inhibitor and the development of siRNA delivering, a hLigI-targeted cationic-lipid-based non-viral vector. They have tested a small in-house library of structurally similar cationic lipo-anisamides for antiligase activity, and amongst tested, N-dodecyl-N-(2-(4-methoxybenzamido)ethyl)-N-methyldodecan-1-ammonium iodide (C12M) selectively and efficiently inhibited the enzyme activity of hLigI, compared to other human ligases (hLigIIIβ and hLigIV/XRCC4) and bacterial T4 DNA ligase. Furthermore, upon hydration with equimolar cholesterol, C12M produced antiligase cationic liposomes, which transfected survivin siRNA and showed significant inhibition of tumor growth.

Identification of lead compound with promising therapeutic potential against experimental visceral leishmaniasis.

In an endeavor to search for affordable and safer therapeutics against debilitating visceral leishmaniasis, CSIR-CDRI examined antileishmanial potential of ammonium trichloro [1,2-ethanediolato-O,O']-tellurate (AS101); a tellurium based non toxic immunomodulator. AS101 showed significant *in vitro* efficacy against both *Leishmania donovani* promastigotes and amastigotes at sub-micromolar concentrations. AS101 could also completely eliminate organ parasite load from *L. donovani* infected Balb/c mice along with significant efficacy against infected hamsters (□93% inhibition). Analyzing mechanistic details revealed that the double edged AS101 could directly induce apoptosis in promastigotes along with indirectly activating host increased ROS generation and anti-leishmanial IgG production. AS101 could inhibit IL-10/STAT3 pathway in *L. donovani* infected macrophages. These findings provide the first evidence for the mechanism of action of AS101 with excellent safety profile and suggest its promising therapeutic potential against experimental visceral leishmaniasis.

Biofilm: a resource of anti-biofilm agents and their potential implications in targeting antibiotic drug resistance

Biofilms play an important role in the antibiotic drug resistance, which is threatening public health globally. Almost, all microbes mimic multicellular lifestyle to form biofilm by undergoing phenotypic changes to adapt adverse environmental conditions. Many anti-biofilm agents have been experimentally validated to disrupt the biofilms during last three decades. To organize this data, CSIR-IMTECH developed the 'aBiofilm' resource (http://bioinfo.imtech.res.in/manojk/ abiofilm/) that harbors a database, a predictor, and the data visualization modules. The database contains biological, chemical, and structural details of 5027 anti-biofilm agents (1720 unique) reported from 1988-2017. These agents target over 140 organisms including Gram-negative, Gram-positive bacteria, and fungus. They are mainly chemicals, peptides,

phages, secondary metabolites, antibodies, nanoparticles and extracts. They show the diverse mode of actions by attacking mainly signaling molecules, biofilm matrix, genes, extracellular polymeric substances, and many more. The QSAR based predictor identifies the anti-biofilm potential of an unknown chemical with an accuracy of 80.00%. This comprehensive platform would help the researchers to understand the multilevel communication in the microbial consortium. It may aid in developing anti-biofilm therapeutics to deal with antibiotic drug resistance menace.

Drug and nanoparticle-mediated rapid naked eye water test for pathogens detection

Inspired by the interaction of colistin with lipopolysaccharides (LPS) of the bacterial outer membrane, CSIR-IMTECH described a simple, cost effective and rapid assay for the detection of bacterial contamination in water samples. Colistin, a bactericidal drug, has been used in a receptor configuration for detection of pathogenic microorganisms without involving any tedious sample preparation step. The approach employs the cationic antibiotic drug for dual purpose, firstly, as a primary binder for pathogens and secondly, as an aggregator for negatively charged Gold nanoparticles (GNPs). The former consists of colistin binding to bacteria in water that renders GNPs free in solution thus depicting red color and the latter shows colistin driven aggregation of GNPs producing blue colored solution. The assay works in a two-step procedure that involves addition of colistin and GNPs to the water sample before results can be visualized based on color change. The assay is sensitive at a concentration up to 10 bacterial cells mL−1 in a time frame of 5 min without requiring any expensive reagents and instruments.

Alternative route for improving photosynthesis is crop plants

CSIR-IHBT identified a unique pathway for re-assimilation of photorespired CO_2 and NH_3 in C3 plants at high altitude. Pathway was transplanted with success in Arabidopsis, a C3 plant species; the transgenics showed improved photosynthesis and yield, and reduced photorespiratory losses. The work which shows an alternative route for improving photosynthesis in crop plants through introduction of C4-like traits into C3 plants, was well appreciated by the F1000 prime group (a faculty of more than 8,000 international leading experts in biology and medicine).

Purification, identification and characterization of two novel antioxidant peptides from finger millet (Eleusine coracana) protein hydrolysate

CSIR-IHBT successfully identified antioxidant peptides from a finger millet protein hydrolysate. Two potential antioxidant peptides were identified as TSSSLNMAVRGGLTR and STTVGLGISMRSASVR. Synthetic peptides with the same sequence were synthesized and characterized for their antioxidant activity. Molecular docking studies revealed that potential antioxidant activity from both peptides resulted from the interaction of serine and threonine residues with free radicals. The current study suggested that natural peptides identified from finger millet have potent antioxidant activity and regarded as a promising source for a functional food ingredient.

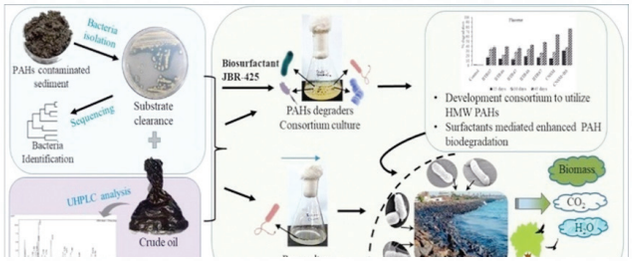
Plant virology studies

In the area of virology, wildly growing *Ficus palmata* was identified by CSIR-IHBT as a

natural host of apple stem grooving virus, a very important virus of apple. In another study, *Rumex nepalensis* was identified as an off-season host of *Tomato leaf curl virus*. Interestingly, *P. kurroa*, an ethno-pharmacologically important endangered medicinal herb, traditionally used in several preparations of Indian Ayurvedic medicine, was found to be naturally infected by a complex of alternanthera yellow vein virus and cotton leaf curl Multan betasatellite when grown at mid hill altitude in Palampur. Alternate hosts are important for survival of the viral pathogens during unfavourable conditions.

Improved polycyclic aromatic hydrocarbon degradation in a crude oil by individual and a consortium of bacteria.

In this study, CSIR-IITR reported the ability of *Stenotrophomonas maltophilia, Ochrobactrum anthropi, Pseudomonas mendocina, Microbacterium esteraromaticum and Pseudomonas aeruginosa* to degrade multiple polycyclic aromatic hydrocarbons (PAHs) present in crude oil. The PAHs in the crude oil sample obtained from Digboi oil refinery, India were estimated to be naphthalene (10.0 mg L^{-1}), fluorene (1.9 mg L^{-1}), phenanthrene (3.5 mg L^{-1}) and benzo(b) fluoranthene (6.5 mg L^{-1}). Consortium of these bacteria showed enhanced biodegradation of 89.1%-naphthalene, 63.8%-fluorene, 81% of phenanthrene and 72.8% benzo(b)fluoranthene in the crude oil. The degradation was further improved up to 10% by consortium on addition of 40 µg mL^{-1} rhamnolipid JBR-425 biosurfactant. These results suggest that the developed bacterial consortium has significant potential in PAH remediation.



PAH remediation by bacteria

Preclinical development of *Crocus sativus* based botanical lead IIIM-141 for Alzheimer's disease

CSIR-IIIM has shown that *Crocus sativus* extract (IIIM-141) display promising efficacy in a genetic mice (5XFAD) model of Alzheimer's disease (AD). The acute oral toxicity study has shown that IIIM-141 is safe up to the dose of 2000 mg/kg, with no effect on the body weight, and biochemical/ hematological parameters of the rats. The repeated oral administration of IIIM-141 for 28-days at 100 mg/kg dose, does not caused any pre-terminal deaths and abnormalities in Wistar rats. The pharmacokinetic analysis indicated that after oral administration of IIIM-141, the majority of crocin gets hydrolyzed to its aglycone crocetin. The sustained release capsule formulation was developed, which showed improved *in vitro* dissolution profile and significantly enhanced plasma exposure in the pharmacokinetic study. The data serves as the benchmark for the further research on this botanical candidate.

AKT Inhibition Modulates H3K4 Demethylase Levels in PTEN-Null Prostate Cancer

Hyperactivated AKT kinase due to loss of its negative regulator PTEN influences many aspects of cancer biology, including chromatin. AKT primarily regulates acetyl-CoA production and phosphorylates many histone-modulating enzymes, resulting in

their activation or inhibition. Therefore, understanding the therapeutic impact of AKT inhibition on chromatin-related events is essential. Here, CSIR-IIIM reported that AKT inhibition in prostate-specific PTEN knockout mice significantly induces di- and trimethylation of H3K4 with concomitant reduction in H3K9 acetylation. It was observed that miR-137. The mechanism by which AKT kinase modulates the prostate cancer epigenome through regulating H3K4 methylation has been identified. Additional studies on AKT inhibition-mediated induction of H3K4 methylation will help in designing strategies to enhance the therapeutic efficacy of PI3K/AKT inhibitors.

A lipid-based cell penetrating nano-assembly for RNAi-mediated anti-angiogenic cancer therapy

Limited tumor tissue penetration is one of the key impeding factors retarding successful in vivo exploitations of anti-angiogenic cancer therapy. CSIR-IICT reported the design of a cell penetrating peptidedecorated lipid nano-assembly which, upon systemic administration, induces significant mouse tumor growth inhibition via enhanced tumor infiltration of encapsulated anti-angiogenic siRNA.

Leishmania species and stage-specific adaptive mechanisms explored

The hurdles in drug and vaccine development pipelines for leishmaniasis, a complex, multifaceted disease, are largely due to the digenetic lifecycle, differential clinical manifestations of the parasite, and the incomplete understanding of its adaptations within its hosts. For the first time, CSIR-NCL reviewed the distinct computational and experimental techniques employed to identify the species and stage-specific adaptive mechanisms at different levels of biological organization, the progress made so far, and limitations in comprehending leishmaniasis as a systems biology disease. Based on the available perspectives, suggestions were made to tackle the growing challenges for bridging the genotype with the phenotype. A systems perspective can be instrumental in understanding the complexities of the disease and can provide insights for targeted control.

Nanobeadsfor detection of bilirubin in human blood serum

Amphiphilic polystyrene having pendant glucuronic acid was synthesized by CSIR-NCL covalently incorporating oligo(p-phenylenevinylene)(OPV)basedfluorophore. The OPV fluorophore functioned as signal transducer and glucuronic acid on surface of PS nanobeads acted as interaction site for free bilirubin to facilitate non-covalent interaction via hydrogen bonding. Visual color change from blue to bluish green was observed under UV lamp after addition of bilirubin into polymer. The limit of detection was found to be as low as 20 nM which is far less than the clinical range for causing jaundice (< 25 to > 50 µmol/L). The developed sensor showed its effectiveness towards real time monitoring of free bilirubin in human serum.

Aggregation of Respiratory Complex Subunits Marks the Onset of Proteotoxicity in Proteasome Inhibited Cells

Living cells have a robust protein quality control mechanisms to ensure their correct folding, functioning and degrading the proteins that are not required or damaged. With age, these control mechanisms are known to weaken, and cause proteins to misfold, aggregate and possibly cause toxicity in cells. This study by CSIR-CCMB investigates the players and mechanisms of early stages of protein aggregation. It shows

that by inhibiting proteasomal machinery in cells, which helps in degrading proteins, Respiratory Chain Complex (RCC) proteins are one of the first ones to aggregate. It also shows that specific signatures in the protein sequence, called the Low Complexity Regions partially contribute to this aggregation. Aggregation of the RCC proteins could deregulate formation of functional protein complexes in mitochondria and lead to mitochondrial dysfunction.

Reconstructing the demographic history of the Himalayan and adjoining populations

The prehistoric human settlement in the Himalayas is poorly understood. The difficult terrain of the Himalayas has not favoured large-scale human migrations, population admixture and assimilation in the region. Such conditions might have facilitated the existence of several small isolated communities in this region. In this study by CSIR-CCMB the authors have tried to reconstruct the demographic origins of the Himalayan and adjoining populations (HAAPs). Through genome analyses, this study shows higher similarities of HAAPs with those in East Asia than with the closer neighbours of South Asia. However, now the HAAPs form a distinct genetic cline due to different degrees of admixture with East and South Asians. The study also estimates a recent westward migration into Northeast India and Northern Nepal from the East Asia.

1.2 CHEMICAL SCIENCES

A list of establishments under Biological sciences is given in **Annexure – 12**.

Biodiesel from Tung Oil

CSIR-CMERI, Ludhiana station, has come up with a promising alternative to reduce the dependency on fossil fuels by designing and developing a biodiesel plant to convert vegetable into biodiesel. Tung oil has been used in different industrial applications such as ceramic, paint, paper and cloth production. More recently, Tung oil (*Aleuritesfordii*) has been regarded as a promising non-edible source of biodiesel production.

A semi-continuous type biodiesel plant has been designed, developed and tested at CSIR-CMERI. The plant with the capacity of 600 litres/day is able to produce biodiesel from any edible and non-edible vegetable oil irrespective of its FFA (Free Fatty Acids) content. This plant was utilised for making biodiesel based on optimised parameters to produce biodiesel from Tung seed oil.

In the northeastern part of India, a sufficient quantity of non-edible oil seeds like Tung is available having oil content ranging from 30 to 40 %. The seeds can be extracted in an oil expeller. The extracted oil can be used to make biodiesel through transesterification. The biodiesel produced (calorific value of 9500–10500 kCal/kg) can be used to run engines and diesel gensets locally.

The leftover cake can be fed into the biogas plant. The biogas produced (calorific value of 5700 kCal/kg) can be used for cooking purpose or lighting purpose (directly or through generating electricity).

Biodiesel from Tung Oil

Dyes Sensitised Solar Cells

CSIR-NCL and IIT Roorkee have developed

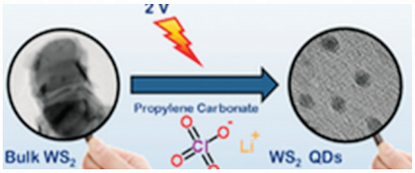
organic dyes that can increase the efficiency of Dye Sensitised Solar Cells (DSSC). A process has been established to produce functional porphyrins without the use of platinum and palladium catalysts and have developed simple, efficient, cost-effective sensitisers which involve fewer synthetic steps resulting in five porphyrin Zn(II) complexes with power conversion efficiency 5.3% to 7.1%.

Synthesis of Quantum dots from 2D Materials

Transition metal dichalcogenides quantum dots (TMDQDs) with few layers based on 2D layered materials are in the forefront of recent research owing to their unique band structure. Such quantum dots (QDs) can be employed for components in optoelectronic devices.

CSIR-CECRI have developed a novel single step electrochemical route for the synthesis of tungsten-di-sulfide quantum dots (WS_2) from their bulk counterpart. The average size of the WS2 QDs is 3 nm ± 1 nm (N=102) with few layers.

Time dependent TEM investigations revealed that time has played a vital role in this electrochemical transformation. This electrochemical transformation provides a facile method to obtain WS_2 QDs from their bulk counterpart which is expected to have greater impact on the design and development of nanostructures derived from 2D materials. Further, the QDs thus obtained exhibited higher photoluminescence (PL) quantum efficiency (5%) and exhibit an excitation-wavelength dependent photoluminescence.

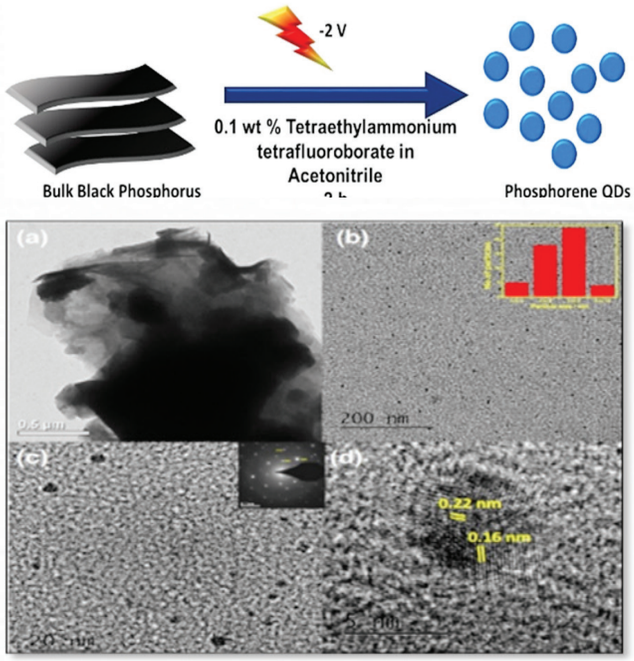


Schematic representing the single step electrochemical transformation of bulk WS_2 to WS_2 quantum dots

Electrosynthesis of Nitrogen-Doped Blue Luminescent Phosphorene Quantum Dots (NPQDs)

CSIR-CEERI has reported a facile one-step route for the electrosynthesis of Nitrogen-Doped Blue Luminescent Phosphorene Quantum Dots (NPQDs) from Black Phosphorous (BP) at room temperature. This is the first report on the electrosynthesis of NPQDs.

The nitrogen percentage in NPQDs can be varied by the appropriate choice of solvent and supporting electrolyte. NPQDs synthesised in this work have an average size of 6 ± 1.5nm (N=50) and exhibit ca. 88.7% quantum efficiency1.



Scheme representation of Electrosynthesis of NPQDs from bulk black phosphorous

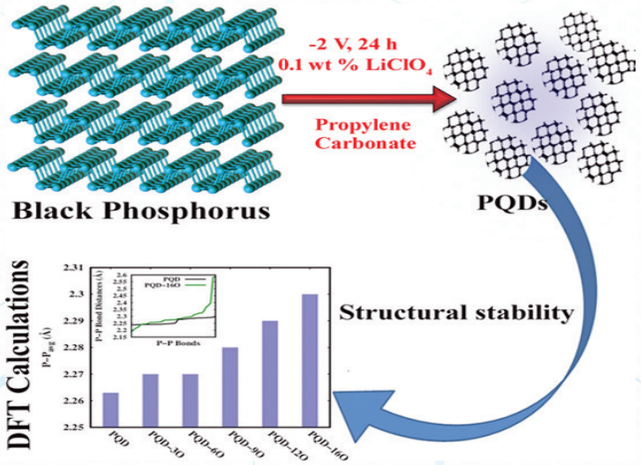
Structural Stability Determination of Phosphorene Quantum Dots (PQDs)

CECRI-CSIR have investigated the role of structural distortion in determining the stability of electrochemically synthesised blue luminescent Phosphorene Quantum

Dots (PQDs) from bulk black phosphorus.

The team has found that there occurs a structural distortion during the electrosynthesis of PQDs [Average size=8 ± 1.5 nm (N = 60)] from black phosphorus leaving unsaturated edge sites which will be easily passivated by oxygen functionalities to maintain the structure. These functional groups exert a +I effect (electron donating effect) and increase the electron density on the PQD skeleton causing in-plane P−P bonds to elongate.

The researchers further investigated the role of oxygen content in maintaining the structural integrity of oxygenated and non-oxygenated PQDs by Density Functional Theory calculations which emphasised the experimental evidence that an increasing oxygen content results in structural distortion of PQDs while an optimum oxygen content balances the stability of PQDs.



Schematic representation of the synthesis of PQDs from black phosphorous

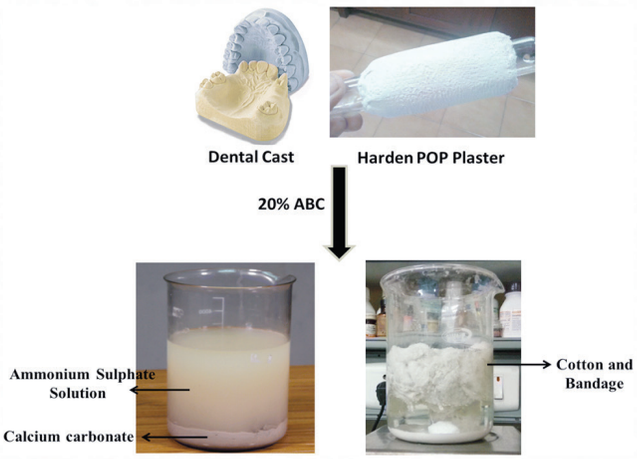
Eco-Friendly Disintegration and Disinfection of Plaster of Paris (POP) from Biomedical Waste

Plaster of Paris (POP) is being used in Healthcare (Orthopaedics and Dentistry) sector for various uses. The plaster casts are made out of POP for the immobilization of broken bones while it heals and for surgical bandages. In dentistry, POP is used for mounting casts or models of oral tissues. Generally, around 7–8kg/day POP plaster waste is generated by Dental and Orthopaedic hospitals. Such hazardous waste containing various microbial loads is collected by local Municipal bodies which is burnt in open space or incinerated at high temperature or left as it is for decomposition.

The burning of this waste emits the toxic gases and heavy metals into the environment. It bears some cost in addition. The POP waste from such biomedical origin if not disposed appropriately might enter into natural bodies such as rivers, lakes, wells, and ponds causing water pollution, introducing various health issues (like antimicrobial resistance, disturbance of natural flora) and ultimately a threat to aquatic flora and fauna. Therefore, the disposal of biomedical wastes has become a major problem and warrants greener alternatives for management.

CSIR-NCL, has come up with a greener process to address this issue. The eco-friendly and rapid disintegration of biomedical-related POP waste is achieved by treating it with ammonium bicarbonate solution (20%w/v ABC) that forms non-hazardous products but value added chemicals like ammonium sulphate and calcium carbonate in the form of sludge. The ammonium sulphate [$(NH_4)_2SO_4$] is generally used in agriculture as a chemical fertilizer and calcium carbonate ($CaCO_3$) can be used as a raw material for making chalks or as an additive in the cement industry for making bricks and sheets proving this as a greener, cost-effective and a value addition process. The antimicrobial and antibiofilm activity of ammonium bicarbonate has been documented in disinfection microbiology, which also revealed that it can also disinfect the POP waste generated from patient samples like burns, accident, fractures and

dental problems of medical waste. Moreover, it is a good alternative for POP incineration, which can also minimise the air pollution and keeps environment safe.



Disintegration of POP waste by ammonium bicarbonate

Highly sensitive detection of dipicolinic acid with a water-dispersible terbium-metal organic framework

The sensitive detection of dipicolinic acid (DPA) is strongly associated with the sensing of bacterial organisms in food and many types of environmental samples. The demand for a sensitive detection method for bacterial toxicity has increased remarkably. Herein, CSIR-CSIO investigated the DPA detection potential of a water-dispersible terbium-metal organic framework (Tb-MOF) based on the fluorescence quenching mechanism. The Tb-MOF showed a highly sensitive ability to detect DPA at a limit of detection of 0.04 nM (linear range of detection: 1 nM to 5 μM) and also offered enhanced selectivity from other commonly associated organic molecules. The present study provides a basis for the application of Tb-MOF for direct, convenient, highly sensitive, and specific detection of DPA in the actual samples.

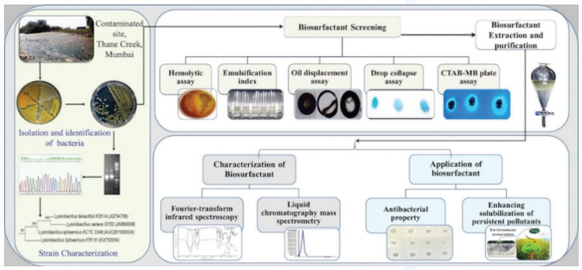
Multifunctional amines enable the formation of polyamide nanofilm composite ultrafiltration and nanofiltration membranes with modulated charge and performance

Conventional thin film composite (TFC) nanofiltration (NF) membranes are positively or negatively charged with an active layer thickness of several nanometers depending on the preparation conditions. Low molecular weight cut-off (MWCO) ultrafiltration (UF) membranes obtained by the phase inversion process show low permeate flux due to the formation of a several micrometre thick skin layer. CSIR-CSMCRI has developed an extremely simple route to produce novel TFC NF (MCO~180 Da) and UF (MWCO~1 and 10 kDa) types of membranes with an active layer thickness in the range of 12–36 nm via supported interfacial polymerization using polyethyleneimine (PEI) as a monomer. TFC NF membranes exhibited a permeate water flux of 19–24 L $m^2h^{-1}bar^{-1}$ which is about 4–5 times higher than those of PEI-based membranes and 1.3–4 times higher than few commercial NF membranes of similar MWCOs. The process is scalable, and the membranes are useful for the separation of charge and neutral solutes with high efficiency.

Rhamnolipid from a Lysinibacillus sphaericus strain IITR51 and its potential application for dissolution of hydrophobic pesticides.

Rhamnolipid produced from a *Lysinibacillus sphaericus* IITR51 was characterized and its ability for dissolution of hydrophobic pesticides were evaluated by CSIR-IITR. *L. sphaericus* produced 1.6 g/L of an anionic biosurfactant that reduced surface tension from 72 N/m to 52 N/m with 48% emulsification index. The biosurfactant was found stable over a wide range of pH (4.0-10.0), temperature (4-100 °C), salt concentration (%14-2) and was identified

as rhamnolipid. The bacterium utilized benzoic acid, chlorobenzene, 3- and 4-chlorobenzoic acid as sole source of carbon and was found resistant to arsenic, lead and cadmium. Furthermore, the isolated biosurfactant showed antimicrobial activities against different pathogenic bacteria. The results obtained indicate the usefulness of rhamnolipid for enhanced dissolution and thereby increasing the bioavailability.



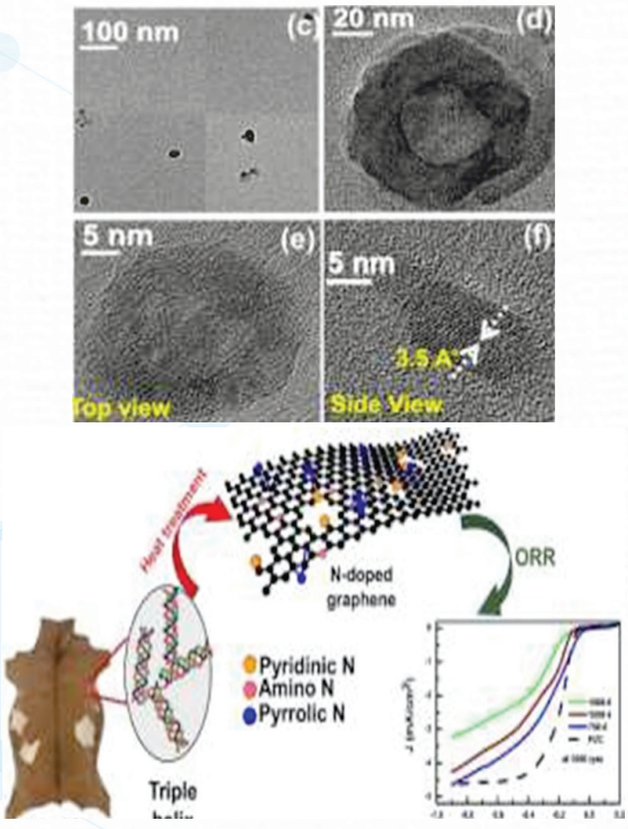
Anoinic biosurfactant by bacteria

Nitromethane as a Carbanion Source for Domino Benzoannulation with Ynones: One-Pot Synthesis of Polyfunctional Naphthalenes and a Total Synthesis of Macarpine

A one-pot, transition-metal-free, domino Michael/ SNAr protocol of general applicability has been devised by CSIR-IICT for the regioselective synthesis of polyfunctional naphthalenes by employing nitromethane and ortho-haloaryl ynones. Nitromethane has been utilized as a one carbon carbanion source that is incorporated into a variety of ynones to end up as an aromatic nitro substituent. The methodology has been further extended to alicyclic o-haloynones to increase functional diversity pattern and to deliver various benzocarbocyclic scaffolds. The efficacy of this methodology of domino process has been well demonstrated by total synthesis of quarternary benzophenanthridine plant alkaloid macarpine which displays cytotoxic activity against HeLa S3 tumor cell lines with an IC50 of 0.192 mg/mL.

N-rich carbon nano-onions from collagen biowastes for oxygen reduction reaction

A facile strategy was developed by CSIR-CLRI to synthesize nitrogen-rich carbon nano- onion architectures from the renewable biological resource, collagen, for use as a metal-free ORR catalyst. The product contains an appreciably high percentage of nitrogen (7.5%) integrated into the carbon molecular skeleton. The materials exhibit outstanding ORR electrocatalytic activity with low on set potential, high current density, superior methanol cross over immunity and better durability than the benchmark Pt/C catalyst in alkaline medium. The findings ascertain that renewable biomasses can be easily transformed into novel carbon nanostructures with excellent catalytic activity.

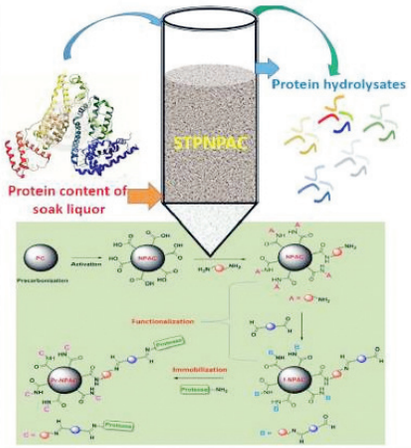


2.10: Nono-onions with ORR electrocatalytic activity

Removal of Proteins in HighTDS Leather Wastewater by Protease immobilized

Nanoporous- Activated Carbon

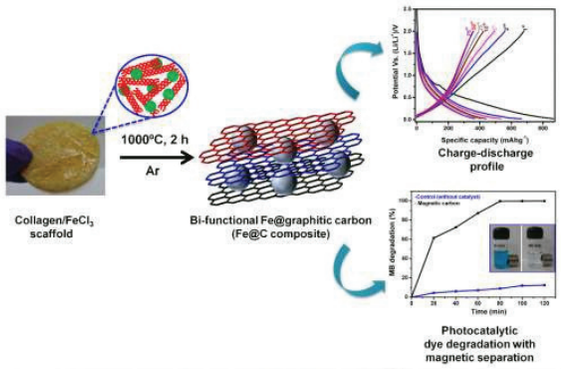
The technology development has been carried out by CSIR-CLRI for the degradation of proteins in high soak liquor (TDS containing wastewater) discharged from leathe rindustry, and the degradation was achieved by halotolerant protease-immobilized functionalized nanoporous-activated carbon (STPNPAC). The protein present in soak liquor was completely fragmented by 90min at pH6 and 30^{0}C using STPNPAC-packedbed reactor. The biodegradability index of soak liquor was increased to 0.426, highly favorable for the complete removal of organic components in subsequent operations.



Protein degradation by protease using STPNPAC reactor

Bi-functional Fe@C nanoparticles from collagen biowastes for energy and environmental applications

Bi-functional iron encapsulated carbon (Fe@C) nanoparticles were synthesized from collagen bio-waste for energy and environmental remediation applications. A simple high-temperature treatment transformed highly insulating and paramagnetic collagen- FeCl3 scaffolds into perfectly conducting and ferromagnetic bi-functional Fe@C nanoparticles. The structural and morphological analysis reveals that different phases of Fe nanoparticles are embedded in the graphitized carbon matrix forming a core-shell type of nanostructures. The mesoporous nanoparticles showed an exceptional photocatalytic activity towards100% degradation of methyleneblue within 80min of sunlight irradiation. CSIR-CLRI demonstrated that the presence of Fe nanoparticles in graphitic carbon lattice enabled an outstanding Li+storage property with large reversible specific capacity (~384mAh/g) after 75 cycles. CSIR-CLRI results provide a cost-effective, scalable and sustainable approach for the synthesis of functional nanomaterials from industrial bio-waste for applications in energy and environmental remediation.

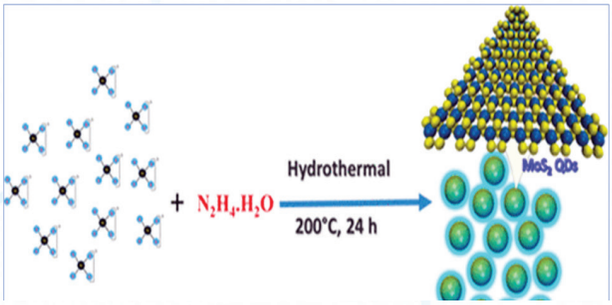


Bi-functional iron embedded carbon nanostructures from collagen waste showing photocatalytic activity

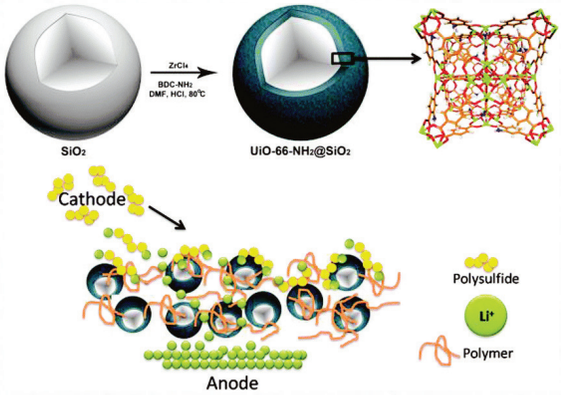
MoS_2 Quantum Dots as Efficient Catalyst Materials for the Oxygen Evolution Reaction

The development of an active, earth-abundant, and inexpensive catalyst for the oxygen evolution reaction (OER) is highly desirable but remains a great challenge. By combining experiments and first-principles calculations CSIR-CECRI demonstrate that MoS_2 quantum dots (MSQDs) are efficient materials for the OER. Our theoretical and experimental findings provide important insights into the synthesis process of MSQDs and their catalytic properties and suggest

promising routes to tailoring the performance of the catalysts for OER applications.



Schematic representation of the MSQD synthesis. Ammonium tetrathiomolybdate was used as a single precursor for MoS_2 growth



Synthesis of the UiO-66-NH2@SiO2 (top) and the permselective membrane showing the proposed membrane action mechanism

Metal–organic framework@SiO_2 as permselective separator for lithium–sulfur batteries

The shuttling of polysulfides between the electrodes in a lithium–sulfur battery (Li–S) system remains a challenge to be addressed in order to realize the full potential of this promising technology. In order to overcome this issue several strategies have been adopted by CSIR-CECRI. In this work, UiO-66-NH_2@SiO_2 was successfully synthesized and coated on a commercial Celgard 2320 membrane. The coating of UiO-66-NH_2@SiO_2 on a Celgard 2320 membrane has not only enhanced the thermal stability and wettability but also other electrochemical properties such as ionic conductivity, compatibility and charge–discharge behaviour. The enhanced discharge capacity was attributed to the electrostatic and/or H-bonding interactions between the polysulfide and UiO-66-NH_2@SiO_2 as evidenced by its positive zeta potential (+56.42 mV). More importantly, the permselective properties of the membrane significantly play against the self-discharge of Li–S cells in which 98.5% of its capacity was retained even after 40 h which is superior to earlier reports.

CO_2 fixation and production of biodiesel by *Chlorella vulgaris* NIOCCV under mixotrophic cultivation

In this study by CSIR-NIO, *Chlorella vulgaris* NIOCCV was cultivated in seafood processing industry wastewater with continuous supply of 5%, 10%, and 20% CO_2. The optimum CO_2 fixation efficiency (RCO_2), biomass productivity, specific growth rate (SGR), and lipid content were recorded on dry weight basis at CO_2 supply of 10%. The fatty acid methyl ester-derived biodiesel properties determined at same condition were in compliance with national and international fuel standards. The synergistic environmental benefit of nutrients removal from wastewater is shown as an additional advantage of microalgal cultivation. Thus, integration of algae-based CO_2 fixation with wastewater treatment and biodiesel production may realize microalgal CO_2 capture technology as environmentally sustainable and economically more attractive.

Artificial photosynthesis using sunlight to generate fuel

A quasi-artificial leaf (QuAL) device was developed by CSIR-NCL in a wireless configuration with TiO_2/Mn-CdS composite

and NiCu as co-catalyst for solar hydrogen production in direct sunlight. The device works at no applied potential and generates 10.5mL/h of hydrogen, with power conversion efficiency of 4.8%. A good resemblance of NiCu alloy to Pt in terms of electrochemical activity makes the device economical. High lifetime of electrons in Mn-CdS helps to greatly improve charge utilization for H_2 production in QuAL device. In addition, re-absorption of emitted light is successfully utilized to enhance hydrogen yield in the present work.

Flexible supercapacitor electrode materials

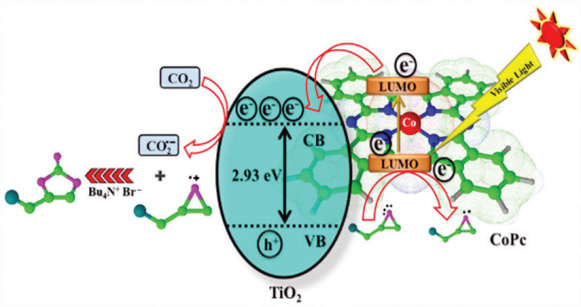
Perylenediimide (PDI) and benzodithiophene (BDT) based donor-acceptor random and alternate π conjugated polymers were developed and explored as composite electrode materials in Type III supercapacitor device by CSIR-NCL. Results show that the donor-acceptor alternate design involving P(PDI-alt-BDT) is an excellent supercapacitor electrode material with specific capacitance of 113 F g-1with excellent stability up to 4000 cycles and almost 100% retention of the initial capacitance in single electrode setup in PC-LiClO4 organic electrolyte. Flexible supercapacitor device were also fabricated which shows areal capacitance of 35 mF cm-2 at a current density of 0.5 mA cm-2, which is promising for commercial application.

Crop protection: Understanding regulation of protease gene expression in cotton bollworm (*Helicoverpa armigera*) and identification of peptides for growth inhibition

Insects cope up with plant defensive protease inhibitors (PIs) present in the ingested food by differentially regulating digestive proteases. Mechanisms regulating protease gene expression in insects are largely unknown. Multi-domain PI arrests growth and development of cotton bollworm. CSIR-NCL presented evidence supporting a dynamic transition in cotton bollworm protease expression upon PI-ingestion by identifying a distinct novel PI isoform of cotton bollworm in larvae feeding on PI. Based on present and earlier studies a potential mechanism of protease regulation in cotton bollworm and subsequent adaptation strategy to cope with anti-nutritional components of plants is proposed.

Photocatalytic synthesis of cyclic carbonates from CO_2 and epoxides using CoPc/TiO_2 hybrid under mild conditions

First report on the photocatalytic coupling of carbon dioxide with epoxides to give cyclic carbonates under extremely mild such as room temperature and atmospheric pressure conditions using a hybrid photocatalyst consisting of cobalt phthalocyanine grafted on titanium oxide (CoPc/TiO_2) under visible irradiation is described by CSIR-IIP. The developed protocol provided almost quantitative conversion of various epoxides to corresponding cyclic carbonates in excellent yields without any evidence for the formation of any by-product. At the end of the reaction, the photocatalyst was separated by centrifugation and reused for several subsequent recycling runs without any significant loss in activity, and no leaching had observed during the photocatalytic reactions.



Photocatalytic synthesis of cyclic carbonates from epoxides and CO_2

1.3 PHYSICAL SCIENCES

A list of establishments under Biological sciences is given in **Annexure – 12**.

A Solution to *Parali* Burning

Delhi along with the National Capital Region (NCR) has been cited among the 20 most polluted cities in the world. Especially during the winter seasons, the air and smog pollution level reaches almost 30 times more than the World Health Organization's (WHO) safe limits.

A large portion of the harvested agro-residues (~140 MT), known as *parali* in the larger area of north India, is burned in the field primarily to clear the field for farming activities for the cultivation of the next crop.

To provide a solution to reduce Delhi's smog pollution and stop burning of agro-waste *parali* in Delhi and neighbouring States (Haryana, Punjab and Uttar Pradesh) and converting them into useful materials. CSIR-AMPRI is working develop a technology for utilising paddy and wheat straw as raw materials for "manufacturing hybrid greenwood", which may be used as a substitute of wood or particle board.

There is a possibility of converting agro-waste residues, especially the paddy, wheat and maize straw into commercially viable materials equivalent or better than that of commercially available synthetic wood such as particle board, plywood, etc. This envisaged unique programme also aims to contribute to the Government of India initiatives on Make in India, Clean India and Skill Development.

Wood substitute hybrid composite materials based on fly ash/red mud/marble wastes reinforced with natural fibres developed by CSIR-AMPRI

CSIR-NPL Develops Device for Single-layer Graphene

CSIR-NPL has designed a low-pressure chemical vapour deposition (LPCVD) device that allows high quality, single-layer graphene measuring 4 inches in length and 2 inches in width to be grown. The quality of the single-layer graphene is metrology-grade, and can be used in next-generation quantum devices.

The LPCVD device developed indigenously costs about Rs. 5,00,000, which is one-tenth of the imported ones. The quality of the single-layer graphene grown using this device is also superior.

Single-layered graphene

Natural Composite for Stronger Bone Grafts

CSIR-NML has developed a novel nanocomposite that has shown potential

to be used as a regenerative bone graft especially in regions that need high strength. The nanocomposite was synthesised through a simple and cost-effective route. The composite contains carboxymethyl cellulose, gelatin and hydroxyapatite, with the hydroxyapatite in nanoscale (25-10 nm size). Since bone grafts to be used in load-bearing applications must match the strength of the natural bone, the researchers evaluated the strength and elasticity of the nanocomposite and found it to be in the same range as human cancellous and cortical bone. The new polymer nanocomposite is thermally stable up to 200^0C, biodegradable and also accelerates the formation of new bone apatite under simulated body fluid.

Composite membrane synthesis for application in waste water treatment

Composite membranes and their application for water/wastewater treatment have been acknowledged as an important field that can lead to many significant niche areas. These membranes combine the merits of both ceramic and polymeric materials where conventional membranes are either inapplicable or inefficient. Knowledgebase for preparation of composite membrane followed by its application in wastewater treatment using nanofiltration set up has been generated by CSIR-CGCRI. A ceramic-polymer composite membrane and a ceramic-ceramic membrane were developed in parallel and the preparation processes kept similar with an aim of comparison. The ceramic-ceramic membrane was prepared using different phases of alumina following sol-gel method and subsequent sintering.

Awareness Campaign at 100 traffic intersections of Delhi and related studies

When the vehicles are waiting for their turn to clear a signalized intersection, the drivers normally do not keep the engines off and this result in extra fuel consumption due to idling and increased vehicular emissions. This fuel consumption can be saved along with reduction in corresponding emissions by switching off the vehicle engine during idling at signals. A 40 days long awareness campaign was carried out by CSIR-CRRI at 100 signalized intersections in Delhi to create awareness amongst drivers regarding switching off their engines during idling. Impact of awareness campaign was estimated based on the number of vehicles switching-off their engines during idling which is further used to estimate idling fuel losses and corresponding emissions.

The study established that there was 9357 CO_2e (CO_2 equivalent) tonnes of emissions per day at selected 100 signalized intersections before the start of campaign, which reduced to 7976 t/day CO_2e after the study (~14%). Thus, the study helped in saving ~1381 CO_2e tonnes of emissions per day.

Impact of Road Condition on Fuel Consumption of Vehicles

Five roads in NCR were selected by CSIR-CRRI to quantify the fuel consumed per km for typical small car with petrol fuel, big car (SUV) with diesel fuel, and diesel truck in loaded and unloaded conditions. Fuel consumption tests were conducted on good, fair and bad condition of roads to find the fuel consumed by these vehicles for different road conditions at three steady speeds 20, 50 and 70 kmph for the test sample length of 1100 km with fuel sensor installed and road condition measured in term of IRI (International Roughness Index). Section is defined based on IRC guideline (good, fair and poor). Correlations between road condition and fuel consumption for pertro, diesel and truck were established.

This study by CSIR-CRRI showed that good roads with IRI<2.8 have lesser fuel consumption as compared to bad roads with IRI>4.00. Also, saving in fuel is observed at optimum speed of 50 kmph. Maintenance cost to maintain the roads from poor to good is estimated approximately Rs. 25.83 lakh per km /lane/year and for poor to fair is Rs.12.04 lakh per km, whereas fuel cost for poor to good condition, poor to fair were found Rs.14.45 lakh per km per lane/per year and Rs 41.17 lakh/km/lane respectively. The fuel cost was estimated Rs.41.6 lakh where as maintenance cost was Rs.85 lakh km/lane for poor to good for CC roads. To maintain fair to good condition, the fuel cost was estimated Rs.15.33 lakh per lane per year verses maintenance cost of Rs.0.5 lakh per km per lane per year. The result in this study will be guiding factor for road maintenance department for utilising the fuel loss comparison verses maintenance cost and decide priority in maintenance activity. A dissemination of the results was done by organizing a national level workshop in CSIR-CRRI on July 05, 2018.

1.4 ENGINEERING SCIENCES

A list of establishments under Biological sciences is given in **Annexure – 12**.

Performance of Confined Masonry Buildings under Quasi-Static Condition: CSIR-CBRI, Roorkee

Since the dawn of civilization, masonry is the most commonly used material in building industries, especially for low to medium rise buildings due to several advantages such as resistance, acoustic and thermal insulation, simple and economic construction, etc.

However, Unreinforced Masonry (URM) buildings have proven vulnerable in seismic events, with significant building damage and numbers of fatalities, the world-over. To improve the seismic resistance of masonry buildings, different methods have been attempted over the years, leading to the concept of reinforced masonry (RM) and confined masonry (CM) systems.

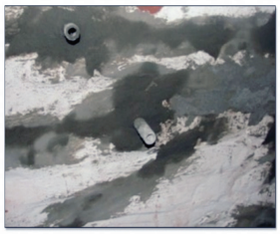
Thus, to study the seismic performance of different masonry building typologies, an experimental study was performed by CSIR-CBRI on full-scale single room masonry buildings measuring 3.01 x 3.01 m in plan and 3.0 m in height with similar geometry, material properties and construction practices for all the building typologies.

Unreinforced (URM), reinforced (RM) and confined masonry (CM) were tested under quasi-static cyclic loading and data was recorded in terms of displacement capacity at corresponding load. CM building performed significantly well when compared to URM and RM buildings demonstrating high displacement capacity, along with high initial stiffness, ductility, energy dissipation with relatively lower structural damage. There is a need to explore the effective and efficient retrofitting measure for damaged CM building so as to improve its behaviour when subjected to lateral loading.

To explore the best suitable retrofitting technique, various alternate options viz. Welded Wire Mesh (WWM), Chicken Mesh (CM), Nylon Mesh (NM), Industrial Geo-grid (IG), Polypropylene Band (PB) and Plastic Cement Bag (PCB) were evaluated for retrofitting of masonry prisms and wallets. The results showed Plastic Cement bag mesh was the most effective strategy as retrofit measure. In addition, this material has advantages like low cost, high flexibility, minimum thickness, non-corrodible nature, adequate grip and reuse of waste material.

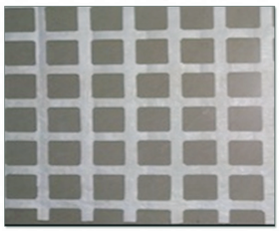
Figure presents the preparation of mesh from empty plastic cement bags and cementitious

grouting for filling the cracks in masonry walls of CM. Subsequently, plastic mesh was fixed on both faces of masonry wall by means of epoxy and nails, which were later embedded in 15 mm thick cement: sand (1:4) mortar.



Preparation of plastic cement bag mesh

Cementitious grouting



Jacketing using plastic cement bag

Plastering and curing

Strengthening of damaged CM building

Full-scale retrofitted confined masonry building subjected to lateral cyclic load

Damage pattern for retrofitted confined masonry building subjected to lateral cyclic load

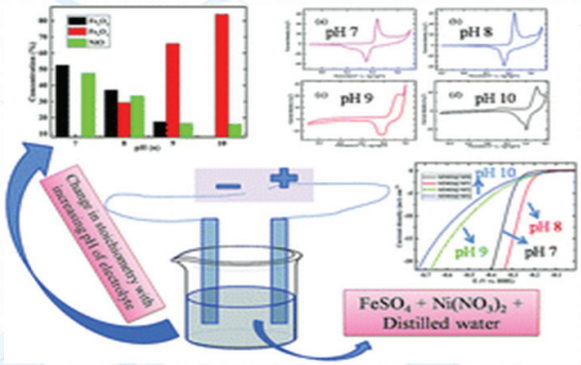
Durability Studies of Nano-Engineered Fly Ash Concrete

Mechanical and durability studies of nano-engineered fly ash concrete have been investigated by CSIR-CBRI using various concrete mixes containing 30–50% fly ash (FA), 3% silica nanoparticles (SNPs) and 6% silica fume (SF) at constant water/cement (w/c) ratio of 0.29. Durability parameters i.e. carbonation (2% CO_2, 20°C, 65% RH) and sulphate attack (5% magnesium sulphate) were used and the specimens were exposed up to 180 days. Long-term carbonation results revealed that SNPs incorporated mixes show a reduction of carbonation depth up to 73% with respect to control specimens containing 30% FA. Similarly, SNPs incorporated specimens show significant resistance towards the sulphate attack of about 39% as compared to control specimens. For the comparison purpose, SF containing specimens were also evaluated, however, higher resistance were observed for SNPs incorporated concrete specimens. Diffusion coefficient and service life of SNPs incorporated specimens were studied using Meta and Demis model, revealed exponential enhancement in the service life of SNPs incorporated concrete mixes.

Controlled electrodeposition of iron oxide/nickel oxide@Ni for the investigation of the effects of stoichiometry and particle size on energy storage and water splitting applications

CSIR-CMERI carried out controlled synthesis of nickel/iron multimetal oxides with different stoichiometry and particle sizes. Electrodeposited samples grown at different pH values showed a wide range of electrochemical properties such as dissimilar current response and potential window due to the formation of different stoichiometry and surface morphologies. Smaller particle size

and higher content of NiO are advantageous due to the creation of a facile diffusion path. Moreover, electrical conductivity as well as series resistance increased for the samples with smaller particle size due to the quantum size effect. The quantum size effect was confirmed from the blue shift of the UV-vis absorbance spectrum. Finally, an asymmetric supercapacitor (ASC) cell was fabricated with electrodeposited samples, which showed a large potential window of □1.6 V along with a high energy and power density of □91 W h kg^{-1} and 7200 W kg^{-1}, respectively. Furthermore, the ASC exhibited very low relaxation time constant (□1.3 ms) and long stability of □83% after 10 000 CD cycles, ensuring the effectiveness of electrodeposited multimetal oxides for energy storage as well as water splitting applications.



Schematic representation of super capacitor cell with electrodeposited samples, showing large potential window for energy storage and water splitting applications

A novel non-enzymatic zinc oxide thin film based electrochemical recyclable strip with device interface for quantitative detection of catechol in water

Catechol, one of the major effluents released by various chemical and metal processing industries, causes severe pollution of groundwater. Monitoring of catechol in water using cost-effective, hand held sensor is demanding for the safety of the environment. In this work by CSIR-CMERI, non-enzymatic zinc oxide thin film based electrochemical strip sensor is developed on conducting glass substrate for detection of catechol. The preparation of strip without employing standard Pt or Ag/AgCl electrodes and simply depositing ZnO through wet chemical process represents a cost-effective innovative technique. The strip is integrated with readout meter and an algorithm is built based on the experimentally observed linear variation of amperometric current with catechol concentration. The quantitative detection performance is demonstrated by testing 0.1–12 ppm catechol solutions.

Facile synthesis of flower-like morphology $Cu_{0.27}Co_{2.73}O_4$ for a high-performance supercapattery with extraordinary cycling stability

CSIR-CMERI has shown that the partial replacement of Co by Cu in cobaltite to give $Cu_{0.27}Co_{2.73}O_4$ with unique flower-like morphology is found to be very beneficial for supercapacitor–battery hybrid applications. The 3D architecture of the material on a conductive substrate resulted in outstanding supercapattery performance. Asymmetric assembly of the material with activated carbon in a two-electrode system delivered high energy and power densities as well as a high specific capacity. The device also showed excellent cycling stability over 20 000 cycles, with a capacity retention value of 86.9%.

Design of notch to distress the goaf edge pillars to enable coal extraction under massive strata

The trial and errors method are generally practiced to determine geometry and pattern of the blast holes parameter to create a suitable sized notch in B&P method of coal mining.

A detailed designs of notch to weaken the overhanging roof strata at the goaf edge has been developed by CSIR-CIMFR to optimize the cost and safety. The developed designs and their results have been crosschecked with the experimental observations.

A Hybrid Structural Health Monitoring Technique for Detection of Subtle Structural Damage

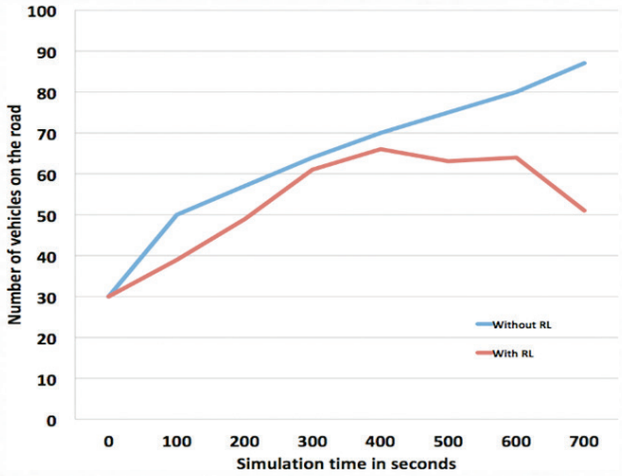
There is greater significance in identifying the incipient damages in structures at the time of their initiation as timely rectification of these minor incipient cracks can save huge maintenance cost. However, the change in the global dynamic characteristics of a structure due to these subtle damages are insignificant enough to detect using the majority of the current damage diagnostic techniques. Also, the sensitivity of global dynamic characteristics like modal frequencies and mode shapes depends on the spatial location of these subtle damage. In view of this, a hybrid damage diagnostic technique for detection on minor incipient damages in the structures is developed by CSIR-SERC. In this hybrid technique, modal-effective-damage is identified rather than damage, by isolating the modes affected by the subtle damage in the structure.

1.5 INFORMATION SCIENCES

A list of establishments under Biological sciences is given in **Annexure – 12**.

High Performance Computing and Cyber Security- Adaptive Traffic Signal Control in Vehicular Networks: Simulation model developed

Existing road intersection management is done through trafficlights. The inefficient traffic light control causes numerous problems, such as long delay of travellers, huge waste of energy and worsening air quality. It may also contribute to vehicular accidents. Artificial Intelligence provides the ability to continuously learn to augment its ability to make good judgment by recognizing its surrounding. Reinforcement learning (RL) is a part of machine learning paradigm where an agent aims to maximize there ward by choosing the right action, by interacting with the environment repeatedly to develop a suitable policy. The comparison in traffic condition with and without using the Re inforcement learning. Here, the number of vehicles on the road at a time is treated as the parameter to define the performance. It can be seen that, in the initial stage, there are not much improvement in the case, where the signal is controlled using RL. However, as the time progresses, the RL learns from the traffic pattern and improves the traffic condition. The results is an outcome of the simulations carried out using SUMO (SimulationofUrbanMobility) model by CSIR-4PI.



Number of vehicles on the road for the two scenarios of traffic control (one with RL and one without RL). Decrease in the number of vehicles on the road is an indication of the increase in efficiency.