



III. AUTONOMOUS BODIES

III-A. Council of Scientific & Industrial Research

1. INTRODUCTION

The Council of Scientific and Industrial Research (CSIR) is making wide ranging efforts to achieve a position of leadership at the cutting edge of R&D in the areas of aerospace; biological and chemical sciences and technology; electronics; sustainable energy; materials for futuristic applications as well as affordable healthcare. CSIR is also focusing on efforts for improvement in the quality of life of the underprivileged population through S&T interventions.

The following sections record some of the significant achievements of CSIR during the year 2008-09.

2. S & T CONTRIBUTIONS

2.1 Aerospace Science and Technology

CSIR is a major player in aerospace-related scientific endeavours which is being accomplished, primarily through, its constituent laboratories NAL, CEERI, CMERI, CSIO, CGCRI and a few other laboratories. Some of the recent important contributions are described below:

Chandrayaan

India's pride Chandrayaan satellite was tested at NAL along with the Eutelsat W2M. NAL provided extensive Wind Tunnel test support (fig 17) to the nation's space and defence programmes, National Trisonic Aerodynamic Facility (NTAF) has achieved its highest productivity so far of nearly 1,800 test runs.

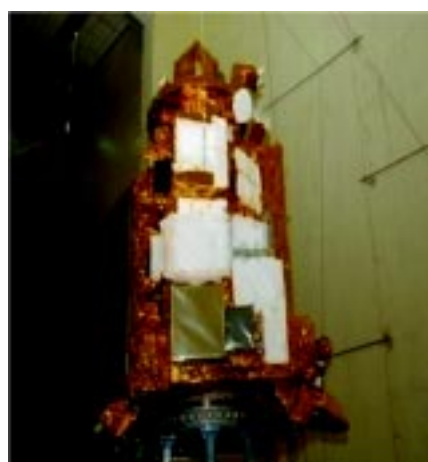


Fig 17: Testing of Chandrayaan-1

HANSA

NAL has delivered two Hansa-3 aircrafts to the DGCA. Efforts to obtain Civil Aviation Safety Authority of Australia (CASA) certification for Hansa-3 gathered momentum with completion of additional analysis, structural and flight tests as compliance requirements.

Flight Trials on LCA – Tejas HUD

The Head up Display is one of critical module for Combat Aircraft which provides a comprehensive display of aircraft data superimposed on the world view under all weather conditions. The technology involves an integrated design approach of electronics, optical and mechanical engineering of military grade standards.

Few airworthy HUD units developed by CSIO are in use for field trials with LCA (fig 18). Addition of



Fig 18: LCA HUD Image during LCA Flight

advanced features like sun glare removal by use of multilayer coating on folding mirror, internally generated display to take care of display processor failure, FPGA based raster mode signal generation for a jitter free display, lower power consumption of less than 50 watts as compared to 145 watts in raster mode of operation etc has further fine tuned the technology. The user of HUD is Air Force for fighter (LCA) and trainer (HJT-36) applications.

Milestones like 1,000 flights with various versions of LCA – Tejas (TD2, PV1, PV2, PV3, LSP1, LSP2, and LSP3) with no failure; field trials of LCA in harsh cold weather of Leh (with LCA PV3 fitted with CSIO HUD S/N 019 with aircraft soaked at -22°C), weapon aiming (the air to air missiles R73 have been test fired successfully from LCA with weapon aiming using HUD), night flying etc were achieved.

HUD variant for HJT-36 has met all essential Safety of Flight standards (SOF) such as MIL STD 704D, EMI/EMC MIL STD 461C, Environmental MIL STD 810D which covers various stringent tests like random vibration, sinusoidal vibration, mechanical shock, drop test, acceleration, low and high temperature operational and storage test, thermal shock, humidity, salt fog, high altitude and rapid decompression etc.

With HUD technology being used for LCA, transfer of technology to BEL, and completion of SOF tests for HJT-36 HUD, India has become one of the top five nations having this technology. Technology denial has thus been eliminated and has secured BEL the production order of HUD both from the HAL (for HJT-36) and ADA (for LCA), Bengaluru.

MEMS Acoustic Sensor for ISRO PSLV Flights

CEERI designed the process steps and fabrication procedure for micro-electromechanical sensors (MEMS) and supplied the chips, mounted on headers and wire bonded. These devices underwent 2-3 iterations before meeting the specifications.

Zinc oxide layer, deposited by reactive sputtering was sandwiched between a pair of aluminium electrodes and separated by a thin dielectric layer of 0.1 micron Plasma Enhanced Chemical Vapour Deposition (PECVD) Silicon Dioxide. A 25-micron thick silicon diaphragm with cavity was anodically bonded to Pyrex glass. In the first version, the pressure developed inside the silicon cavity was released through the hole in glass. In the second version, a built-in acoustic tunnel was incorporated in the cavity. A patent has been filed on the method for fabricating acoustic tunnel to compensate acoustic pressure using bulk micromachining in MEMS acoustic sensor (fig 19).

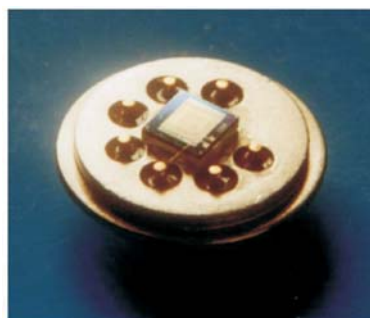


Fig 19: Packaged MEMS acoustic sensor used in PSLV Satellite

The sensor chips were integrated with electronics and housed in a package for sound pressure measurement in launch vehicles of Vikram Sarabhai Space Centre (VSSC).

General Contributions of NAL

NAL has supplied Carbon Composite Airframe Components/Assemblies for eight Tejas (LCA) LSP Aircrafts for HAL. The laboratory successfully carried out in-situ hybrid metal/composite repair of a large crack in the port side Main Landing Gear (MLG) Beam of a MiG – 23 trainer aircraft. After



repair the aircraft was put back for operational use. Further NAL successfully completed in-flight measurement of vibration and temperature on a Mig -29 aircraft for the IAF which will help in generating standards for indigenous design of on-board equipment.

Fog Forecasting

The fog forecast model developed by C-MMACS has now been inducted into national weather service by Indian Meteorological Department beginning November, 2008. IMD has also expressed interest in operational use of the air pollution forecast model developed by C-MMACS.

2.2 Biology and Biotechnology

The importance of this sector is evident from the fact that more than a dozen laboratories are involved and their contributions include important technologies that are being commercialized and publications in world's top journals. During the year, some achievements of high value were reported as described below.

Differential Dynamics and Stability of Lamin A rod Domain Mutants

Mutations in the human lamin A gene give rise to highly debilitating diseases termed laminopathies. Laminopathic cells harboring certain mutations in lamin A display aberrant nuclear morphology due to abnormal lamina assembly. To understand the molecular mechanisms involved in these processes, CCMB has studied the dynamics and stability of GFP-tagged lamin A constructs harboring disease-causing missense mutations in the rod and tail domains of the protein. Analysis of the mobilities of these proteins by fluorescence recovery after photobleaching (FRAP) and fluorescence loss in intensity after photobleaching (FLIP) techniques in live HeLa cells indicated that mutants that formed large aggregates, like E203G, G232E, Q294P and R386K were substantially more mobile than wild-type and mutant lamins H222P and R482L that assembled at the nuclear periphery. Nuclear extractions with detergent, nucleases and salt resulted in the dispersal of large

aggregates into smaller foci throughout the nucleoplasm, whereas more stable lamins were retained at the nuclear periphery. The significant alterations in the dynamics and stability of certain rod domain mutants of lamin A are likely to have profound consequences for the organization of nuclear functions.

Functional Characterization of Mouse WDR-13 Protein

Large number of Willon-Disease-Repeat (WDE) proteins involved in variety of functions, although only few of them are characterized for their true physiological roles. As these proteins function in multi-protein complexes, it is rather difficult to individually express, purify fold and functionally characterize these proteins. Evolutionary conservation of the protein sequence-structure and function is well known. Realizing that WDR13 is an unstable protein and expecting that protein instability could be an evolutionarily conserved property, CCMB analysed a set of WD-repeat proteins for their Protein Instability Index and sequence motifs present in them, employing bio-informatics, and using this information predicted the physiological functions of WDR13.

Role of Tyrosine Kinase Ephb4 in the wnt Pathway

Colorectal cancer almost invariably initiates with an activation mutation in the wnt signaling pathway, the single most dominant force in controlling cell fate along the crypt-villus axis in the small intestine. This process results in the up regulation of various intermediates in the pathway, especially Receptor Tyrosine Kinases (RTK's). Eph receptor (largest of the RTK's) activation leads to a number of downstream effects, which influence cell attachment, migration and interaction with ligand-expressing cells. Upregulation of EphB4 has been observed in colorectal tumours by CCMB and by other researchers around the world. In CCMB's murine colon cancer models (wnt-upregulated), upon wnt induction, β -catenin goes nuclear and causes the upregulation of downstream genes like c-myc etc (fig 20). High level of expression of Ephb4 is also observed in HEK 293 cells upon wnt

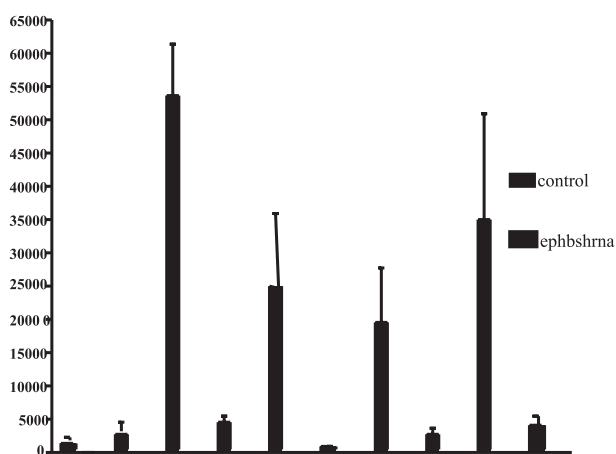


Fig 20: EphShRNA

induction with LiCl. Also Ephb4 cDNA can alone induce wnt pathway and knockdown using RNA interference (siRNA/shRNA) technology has helped in downregulating the pathway. Thus Ephb4 is proved to be a wnt inducer and regulator of the wnt pathway. The levels of EphB4 in various human colon cancer samples are being tried to develop this into an assay system for the early diagnosis of colon cancers.

Chemical Conversion of the Cytotoxic Taxoid Brevifoliol into its Different Derivatives and their Cytotoxic Activity

CIMAP synthesized several taxol like analogues of brevifoliol by coupling brevifoliol or its oxidized derivatives with 2-monosubstituted-4-phenyl-1, 3-oxazolidine carboxylic acid after removal of the protecting group with an acid treatment. Brevifoliol and its synthesized analogues were tested for their cytotoxic activity against different cancer cell lines, oral (KB), breast (MCF-7), colon (CaCO₂) and liver (HepG-2) as determined by MTT assay.

Brevifoliol was turned out to be almost three times more active than taxol against colon cancer cell lines. The C-13 oxidized brevifoliol retained significant activity as compared to brevifoliol. Out of the seven synthesized analogs, C-13 oxidized brevifoliol-5-[N-tert-butoxycarbonyl amino-(2'R, 3'S)-3'-phenyl isoserine] analog was interesting as it exhibited selective and potent cytotoxicity against liver cancer cell lines predominantly.

Anti Helicobacter Pylori Activity of Artemisinin Derivatives

Artemisinin, a sesquiterpene lactone endoperoxide derived from *Artemisia annua*, is an established antimalarial drug. It has also strong anti *Helicobacter pylori* activity also. In an attempt to develop novel anti *H. pylori* agents, a series of artemisinin analogues, natural and also synthetically derived, were investigated for anti *H. pylori* activity in vitro. CIMAP has examined sixteen derivatives by disc diffusion sensitivity assay and MIC and MBC values. Further, the antibacterial spectrum was assessed against a panel of 10 *H. pylori* strains, 13 other bacterial strains and 8 fungal strains. The most active compound exhibited MIC ~ 0.5 mg/ml and MBC ~ 1 mg/ml against *H. pylori* while the MIC against other bacteria appeared more than 100 mg/ml. Among all the derivatives, GRB-1 appeared to be the best, and exhibited better potential than its a-analogue. Time-kill kinetics of *H. pylori* strain ATCC 43504 revealed complete killing within 30 h at MIC dose of GRB-1. The changes in bacterial morphology over time with treatment of GRB-1 indicated drastic damage to cell membranes, as investigated by transmission electron microscopy. Since *H. pylori* is strongly implicated in the manifestation of gastroduodenal disorders and also gastric cancers, the invention of potent artemisinin analogues is therefore, expected to contribute to current novel therapy for peptic ulcer diseases.

Gallic Acid Based Podophyllotoxin and Etoposide Analogues as Anticancer Agents

Podophyllotoxins are lignan compounds possessing potent tubulin polymerization inhibition activity, but toxic too. On modification, two of the emerged drugs i.e. etoposide and teniposide, showed potent topoisomerase II inhibitors with reduced toxicities. Based on structure and activity relationship along with structure and toxicity relation, CIMAP studied the structural modification of podophyllotoxin by shifting lactone moiety from D-ring to C ring and further to evaluate importance of ring A for cytotoxicity against human cancer cells and toxicity. Two of the analogues exhibited potent in vitro cytotoxicity against colon cancer (CaCO₂) cell lines, while five other analogues possessed

higher level of cytotoxicity against other human cancer cells. The study revealed that rings A and D are not essentially required for inducing cytotoxicity. p-Demethylated E-ring analogues exhibited better potency than the corresponding methylated analogues. These analogues showed toxicity comparable to podophyllotoxin against human erythrocytes though at much higher concentrations (100 mg/mL). The study insights into their SAR which may help in the development of newer anticancer agents.

Antiproliferative and Antioxidant Activity of Juglans Regia Fruit Extracts

CIMAP evaluated methanolic, aqueous methanolic and subsequent partitioned fractions of raw walnut (*Juglans regia* L.) ed for antiproliferative activity against various human cancer cell lines i.e. MCF-7 (hormone dependent breast cancer), KB (oral), HepG2 (liver), CaCO2 (Colon) and WRL68 (liver). These fractions have also been evaluated for their phenolic content, antioxidant and reducing power capacity. Chloroform and ethyl acetate fractions possessed very good antiproliferative activity. In both these fractions, the best activity was found against HepG-2, liver cancer cell line (IC50= 9mg/mL and 15mg/mL respectively). The results revealed that the raw walnut contained potent antiproliferative activity. Having a rich phenolic content and high antioxidant activity, it may act as cancer-protective too.

Fishmap: A Community Resource for Zebrafish Genomics

FishMap (fig 21), a unified and centralized resource for storage, retrieval, and display of genomic information of zebrafish has been developed at IGIB. The data was organized into nine major sections, which include comparative genomics, mapping and sequencing, gene and gene predictions, expression and regulation, and variation and repeats. The datasets were linked to related data sources. FishMap was built on the Gbrowse, which was a part of the Generic Model Organism Database Consortium Project. The database is amenable to programmatic access through the Distributed Annotation System as well as BioMoby protocols, thus making it a central community resource that can be

integrated with existing data mining and analysis workflows.



Fig 21: FishMap

Mitochondrial Structural Changes and Dysfunction are Associated with Experimental Allergic Asthma

An imbalance between Th1 and Th2 immune response is crucial for the development of pathophysiological features of asthma. A Th2-dominant response produces oxidative stress in the airways, and it is thought to be one of the crucial components of asthma pathogenesis. IGIB demonstrated that OVA-induced experimental allergic asthma in BALB/c mice (fig 22) was associated with mitochondrial dysfunction. Studies suggested that mitochondrial structural changes and dysfunction are associated with allergic asthma. These findings may help in the development of novel drug molecules targeting mitochondria for the treatment of asthma.

G-Quadruplex DNA Motifs as Regulatory Elements

IGIB has reported a unique strategic approach to modulate quadruplex (G4) regulated gene expression (for example c-MYC expression) by LNA modified complementary strand as a pharmacological agent utilizing the selectivity and specificity offered by Watson and Crick base pairing. LNA modifications have been found to confer increased thermodynamic stability to the duplex and thus favor predominance of the duplex population over that of the quadruplex. This finding has application for trapping quadruplex structure located in promoter regions of several oncogenes and controls their expression. Using a combination

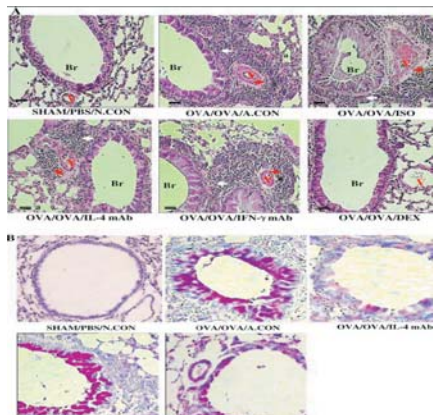


Fig 22: Effect of IL-4 mAb or IFN- γ mAb on airway inflammation, goblet cell metaplasia, and OVA-specific IgE, IgG1, and IgG2a levels. A, Representative photographs of H&E staining are shown. Br, bronchus; V, vessel; a, alveolus; red arrows indicate the perivascular inflammation; and white arrows indicate the peribronchial inflammation. OVA/OVA/ISO indicates OVA-sensitized and challenged mice administered with isotypic control Ab. Bars, 50 μ m. B, Representative photographs of eriodic acid Schiff staining were shown. Black arrows indicate the goblet cell metaplasia. Bars, 50 μ m. C, OVA-specific IgE (i), IgG1 (ii), and IgG2a

of in silico and experimental approaches, evidence that the G-quadruplex, G4 motif has regulatory potential in transcription control, has been presented.

A Novel Pressure-Induced Immunoassay Procedure

IGIB has invented a novel pressure-induced immunoassay procedure. Detection and quantification of an antigen or antibody molecule in a test sample is conventionally carried out by Immunoassay technique. The process of the present invention involves the immobilization of biomolecules onto a solid support by pressure energy followed by performing subsequent ELISA steps by controlled pressure energy. The developed PIA procedure is useful in agriculture, diagnostics, food technology, forensic applications, laboratory research and environmental monitoring. This method involves use of pressure energy to shorten the time of ELISA procedure without changing its ingredients but does not produce heat energy and has the potential for automation.

“Metal-Free Decarboxylation of N-Heteroaryl and Aryl Carboxylic Acids

Ionic liquids have been introduced as clean catalysts and reaction medium for the metal-free decarboxylation of structurally diverse N-heteroaryl and aryl carboxylic acids into pharmaceutically and industrially important indoles, styrenes, stilbenes and arene derivatives under microwave irradiation in aqueous conditions. The decarboxylation of indole and α -phenylcinnamic acids was successfully carried out by IHBT without addition of any metal catalyst in neat 1-hexyl-3-methylimidazolium bromide ([hmim]Br) and 1-methylimidazolium p-toluenesulfonic acid ([Hmim]PTSA), respectively, while addition of a mild base like aqueous sodium hydrogen carbonate (NaHCO_3) to [hmim]Br further improved the decarboxylation of hydroxylated cinnamic and aromatic acid substrates. Metal free decarboxylation of N-heteroaryl and aryl carboxylic acids is shown in fig 23.

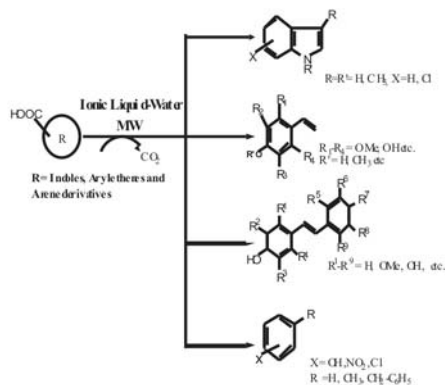


Fig 23: Metal-free decarboxylation of N-heteroaryl and aryl carboxylic acids

Nucleopolyhedrovirus based Biopesticides for Management of Helicoverpa Armigera

There has been great demand for development of eco-friendly biopesticides in view of the increasing concern for adverse health and environmental effects of pesticides used in agriculture. Entomopathogenic viruses constitute an important group of biopesticides. The polyphagous lepidopteron pest *Helicoverpa armigera* has shown resistance against almost all chemical pesticides. A highly efficacious local strain of nucleopolyhedrovirus (HaNPV) has been isolated and tested against *H. armigera* by IHBT. The



molecular characterization confirmed it to a new indigenous strain. The strain has shown higher efficacy than the market product. The biopesticide start inducing larval mortality within a week after treatment with typical symptoms of larvae hanging by their abdominal legs. Various aspects of formulation development are being assessed for its commercialization and prospects of transferring the technology to farmers through rural entrepreneurship are explored.

Characterization of Minor Aroma Components for Kangra Tea

Characterization of minor aroma components in orthodox black tea associated to uniqueness of quality in relation to geographical location is essential for bestowing geographical indication to Kangra tea. IHBT has identified 138 aroma compounds from Kangra tea. The volatile components detected included geraniol, linalool, linalool oxides (both furanoid and pyranoid), *trans*-2-hexenal, phytol, α -ionone, 1-ethyl-2-formyl pyrrole, methyl salicylate and 3,7-dimethyl-1,5,7-octatrien-3-ol. Apart from these components 6,10,14-trimethyl-2-pentadecanone, nerolidol, methyl palmitate, *cis*-3-hexenyl hexanoate, geranic acid, palmitic acid, octanoic acid, isovaleric acid 2-ethyl-6-methyl pyrazine, 2-ethyl-3-methyl pyrazine, *Z*-2-hexenyl caproate and methyl pyrazine were identified as the important minor compounds. The minor components which appeared responsible for unique flavour included 2-amylfuran, 1-pentanol, epoxylinool, *cis*-jasmone, 2-acetyl pyrrole, farnesyl acetone, cadinol. The volatile compounds α -irone, 2,7-epoxymegastigma-4,8-diene and 1,3-dioxalane have been identified for the first time in tea. The geographical indication in terms of distinctiveness of aroma components is value addition for commerce to Kangra tea.

The Caspase-Independent Algorithm of Programmed Cell Death in Leishmania Induced by Baicalein: The Role of Ldendog, Ldfen-1 and Ldtatd as a DNA 'Degradosome'

In the post-genomic perspective, the quest of programmed cell death (PCD) mechanisms in kinetoplastid parasites lies in the identification and

characterization of cell death executor proteins. IICB has shown that baicalein (BLN), a potent topoisomerase IB inhibitor, generates an oxidative stress in the parasites leading to altered physiological and morphological parameters, which are characteristic of PCD. For the first time it has been elucidated that, caspase-independent activation of a novel effector molecule, endonuclease G (LdEndoG), mediates BLN-induced cell death. Functional characterization of LdEndoG identifies Flap endonuclease-1 (LdFEN-1) and LdTatD-like nuclease as other effector molecules. BLN treatment translocates LdEndoG from mitochondria to nucleus, where it forms separate complexes with LdFEN-1 and LdTatD to constitute a DNA 'degradosome' unique to these parasites. Conditional antisense knockdown of LdEndoG provides protection against PCD. This knowledge paves the path toward a better understanding of the PCD pathway in simpler systems, which could be exploited in anti-leishmanial chemotherapy.

Suppression of Tumour Necrosis Factor Alpha, Interleukin-1 Beta in Rheumatoid Arthritis Patients

Leishmanial lipid is a strong immunosuppressor of host cells. Inhibition of the inflammatory responses of synovial cells through induction of apoptosis is one of the main targets of therapeutic intervention in rheumatoid arthritis (RA). IICB examined the antiinflammatory and apoptosis-inducing effects of leishmanial lipid on adherent synovial fluid mononuclear cells (SFMCs) in patients with RA. Leishmanial lipid inhibited the release of tumor necrosis factor alpha, interleukin-1 beta, and NO in the culture, decreased their cytosolic protein levels, and decreased NF-kappa B p65 levels in SFMCs, in a dose-dependent manner. It had the reverse effect on interleukin-10 levels. Leishmanial lipid-induced apoptosis involved the activation of caspase 3, caspase 9, and Bax, the release of cytochrome c, the alteration of mitochondrial membrane potential, and the downregulation of Bcl-2. These results suggested that leishmanial lipid has strong antiinflammatory and apoptosis-inducing effects on SFMCs from patients with RA, and that apoptosis occurs via the mitochondrial pathway.

A Mosaic of RNA Binding and Protein Interaction Motifs in a Bifunctional Mitochondrial Trna Import Factor from Leishmania Tropica

Proteins that participate in the import of cytosolic tRNAs into mitochondria have been identified in several eukaryotic species, but the details of their interactions with tRNA and other proteins are unknown. In the kinetoplastid protozoon *Leishmania tropica*, multiple proteins are organized into a functional import complex. RIC8A, a tRNA-binding subunit of this complex, has a C-terminal domain that functions as subunit 6b of ubiquinol cytochrome c reductase (complex III). IICB has shown that the N-terminal domain, unique to kinetoplastid protozoa, is structurally similar to the appended S15/NS1 RNA-binding domain of aminoacyl tRNA synthetases, with a helix-turn-helix motif. Structure-guided mutagenesis coupled with in vitro assays showed that helix alpha 1 contacts tRNA whereas helix alpha 2 targets the protein for assembly into the import complex. Inducible expression of a helix 1-deleted variant in *L. tropica* resulted in formation of an inactive import complex, while the helix 2-deleted variant was unable to assemble in vivo. Moreover, a protein-interaction assay showed that the C-terminal domain makes allosteric contacts with import receptor RIC1 complexed with tRNA. These results helped explain the origin of the bifunctionality of RIC8A, and the allosteric changes accompanying docking and release of tRNA during import.

Molecular Signature of Hypersaline Adaptation: Insights from Genome and Proteome Composition of Halophilic Prokaryotes

Identification and analysis of distinct macromolecular characteristics of halophiles provide insight into the factors responsible for their adaptation to high-salt environments. IICB presents an extensive and systematic comparative analysis of genome and proteome composition of halophilic and non-halophilic microorganisms, with a view to identify such macromolecular signatures of haloadaptation. Comparative analysis of the genomes and proteomes of halophiles and non-halophiles reveals some common trends in halophiles that transcend the boundary of

phylogenetic relationship and the genomic GC-content of the species. At the protein level, halophilic species are characterized by low hydrophobicity, over-representation of acidic residues, especially Asp, under-representation of Cys, lower propensities for helix formation and higher propensities for coil structure. At the DNA level, the dinucleotide abundance profiles of halophilic genomes bear some common characteristics, which are quite distinct from those of non-halophiles, and hence may be regarded as specific genomic signatures for salt-adaptation. The synonymous codon usage in halophiles also exhibits similar patterns regardless of their long-term evolutionary history.

A Non-Recombinant Membrane Antigen and Diagnostic Kit Thereof for Detection of Visceral Leishmaniasis and PKDL

IICB has invented a non-recombinant membrane antigen and diagnostic kit for detection of visceral leishmaniasis.

The present invention provides a non-recombinant membrane antigen (LAg) obtained directly from promastigotes of *Leishmania donovani* strain AG83, wherein the said membrane antigen (LAg) being characterized by a complex of 25-35 polypeptides having molecular mass in the range of 18 - 155KDa and having sensitivity and specificity in the range of 95 - 100 per cent to anti-leishmanial IgG antibodies present in the serum of patient suffering from Visceral Leishmaniasis (VL) or post kala-azar dermal leishmaniasis (PKDL).

The present invention also provided a process for the preparation of the said membrane antigen and the method of using it for the detection of anti-leishmanial IgG antibodies present in the serum of patient suffering from visceral leishmaniasis (VL) or post kala-azar dermal leishmaniasis (PKDL).

The present invention further provided a diagnostic kit comprising the said non-recombinant membrane antigen, useful for detecting anti-leishmanial IgG antibodies present in the serum of patient suffering from visceral leishmaniasis or post kala-azar dermal leishmaniasis.

Marine Molecular Biology: An Emerging Field of Biological Sciences

NIO after extensive studies, highlighted the importance of Marine molecular Biology. They opined that an appreciation of the potential applications of molecular biology is of growing importance in many areas of life sciences, including marine biology. During the past two decades, the development of sophisticated molecular technologies and instruments for biomedical research has resulted in significant advances in the biological sciences. However, the value of molecular techniques for addressing problems in marine biology has only recently begun to be cherished. It has been proven that the exploitation of molecular biological techniques will allow difficult research questions about marine organisms and ocean processes to be addressed. Marine molecular biology is a discipline, which strives to define and solve the problems regarding the sustainable exploration of marine life for human health and welfare, through the cooperation between scientists working in marine biology, molecular biology, microbiology and chemistry disciplines. Several success stories of the applications of molecular techniques in the field of marine biology are guiding further research in this area. There are several molecular techniques which have application in marine microbiology, marine invertebrate biology, marine ecology, marine natural products, material sciences, fisheries, conservation and bio-invasion etc. Schematic representation of metagenomic library preparation from marine environmental samples is shown in fig 24.

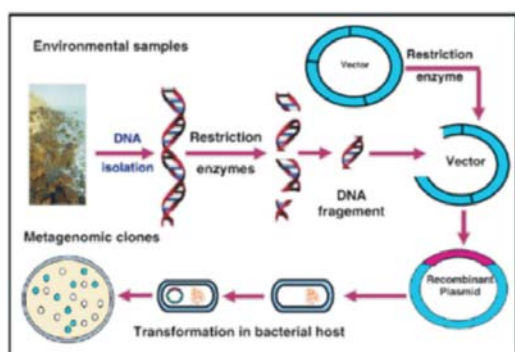


Fig 24: Schematic representation of metagenomic library preparation from marine environmental samples

Biodiversity Assessment, Prospection and Conservation of Plant Resources of India

NBRI has collected two-hundred accessions, representing 15 species of *Berberis*, along with location data from Himachal Pradesh, North East India, Uttarakhand, Madhya Pradesh and Tamil Nadu. High quality genomic DNA was isolated from these accessions. Six primer sets, belonging to three genes i.e. *rpoB*, *rpoC1* and *matK*, were selected. Sequences of 48 samples using *rpoC1*-1, *rpoC1*-2 and 40 sequences of *rpoB*-1 and *rpoB*-2 from different *Berberis* species were analysed. However, there was no variation at sequence level among the samples. This indicates that both the regions may not be suitable for barcoding in *Berberis*. The reported *matK* primer failed to give any PCR amplification. A modified *matK* primer was designed and named as *matK*-nbri.

The ratio of inter-specific and intra-specific distances for *rbcL* was very low, thus may not be suitable for barcoding in *Berberis*. Data analysed, so far, indicate that ITS is superior barcoding marker for *Berberis* followed by *trnH-psbA* and *matK*, though none of these and other commonly used markers (*rpoB*, *rpoC*, *rbcL*) distinguish *Berberis* at species level.

High Throughput Marker Assisted Selection System for Improvement of Drought Tolerance and Fibre Quality Related Traits in Cotton

JKC725 was selected as a superior parent and JKC703 as inferior parent for the detailed microarray studies. The microarray was carried out by NBRI at six different stages of fibre development, viz. 0 dpa, 6 dpa, 9 dpa, 12 dpa, 19 dpa and 25 dpa. The microarray experiment for the fibre quality resulted in selection of 10 genes, each for fibre initiations, elongation and secondary cell wall thickening stage.

Detailed microarray of two contrasting parents at different developmental stages viz. cotyledon, first leaf and flowering stage were generated. The microarray analysis resulted in several potential genes for the drought tolerance in cotton. Many of these genes are validated by real time analysis. Transcriptome sequencing from leaf and root of drought-treated three germplasms of cotton was

performed. The sequencing data resulted in identification of 21,836 genes, out of which 14,000 were unique. Using microarray and transcriptome sequencing, 10 genes for leaf and 10 for root were selected for further validation.

Transgenic Banana Plants

NBRI has developed transgenic banana plants using different constructs. These target plants were developed for fruit specific repression of the *MaMADS*, *MaEXP1* and *MaNAP* genes by antisense expression and sense and antisense expression of the *MaEXPA2* gene (fig 25). All the genes were driven by ACO promoter for fruit specific expression. The constructs were introduced both in Rasthali (AAB genome, NR) and Robusta (AAA genome, R). In addition, transgenic banana plants were also raised for the study of the promoters of *MaEXP1* gene and the *MaIFR* genes. In order to confirm the integration of transgene and promoters in these lines, DNA was isolated from a small portion of the leaves and PCR amplified using primers specific to the *MaACO* promoter (forward primer) and the NOS terminator (reverse primer) for those constructs that contained genes in sense and antisense orientation. For those constructs prepared for the study of promoters, amplification was carried out using the primers 101F and GusR. Fig. shows a representative amplification of *MaMADS* gene in putative transgenics.

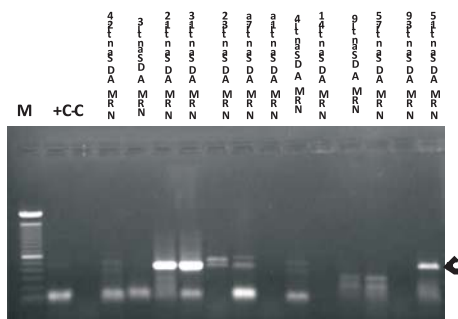


Fig 25: PCR analysis of banana transgenic plants with antisense *MaMADS* genes. M. 100 bp size marker; +C and -C are positive and negative controls respectively Name of different transgenic lines for which analysis was carried out are written above the gel picture

Plant Based Screening Technologies for Biomonitoring and Assessment of Heavy Metal/Metalloid Pollution.

NBRI has investigated metal (Cr, As, Cu, Zn, Mn, Fe, Ni) accumulation potential of green (GA) and blue green (BGA) algae growing naturally in Cr contaminated sites of districts Unnao and Kanpur, Uttar Pradesh, with a view to identify suitable native algal strains for bio-monitoring and phytoremediation purposes. Thirty-three algal species were encountered during the study in all the seasons from five selected Cr-contaminated sites. Out of 33, eleven belonged to BGA and twenty-two to GA. Of these, a few strains i.e. *Oscillatoria tenuis*, *O. nigra* and *Phormedium bohneri* (BGA), *Chlamydomonas angulosa*, *Chlorococcum vitiosum*, *Hydrodictyon reticulatum*, *Rhizoclonium hieroglaphicum*, *Ulothrix tenuissima*, *Oedogonium capillaiforme*, *O. epiphyticum*, *Spirogyra adenata* and *Spirogyra crassa* (GA) produced good biomass. Fifteen fungal isolates were isolated from the soil of arsenic affected area of West Bengal showing different arsenic accumulation potential. *Trichoderma* sp. showed different arsenic accumulation potential whereas *Sordaria* sp. and *Rhizopus* sp. showed high perithecia number and sporulation during 100 ppm arsenic exposure (fig 26 and 27).

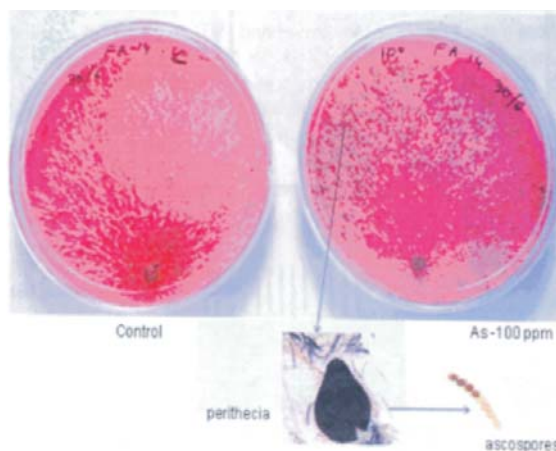


Fig 26: Timulatory effect of arsenic on Perithecia of *Sordaria* (FA-14)

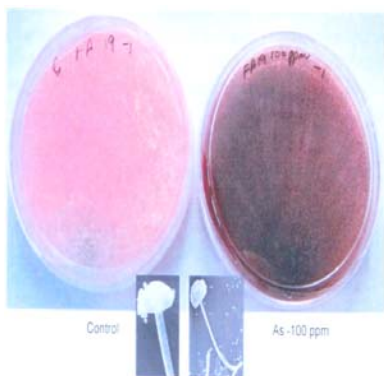


Fig 27: Stimulatory effect of arsenic on *Rhizopus* sp.

Genetics and Mechanism of Induced Male Sterility in *Andrographis paniculata* (Burm. F.) Nees and the Significance Thereof

Andrographis paniculata (fig 28) is predisposed for selfing due to its floral architecture and overlap of male and female phases. On account of its obligate inbreeding nature, small flower size, intimate proximity of minute reproductive parts and their vulnerability to mechanical injuries during manual emasculation, it is extremely tedious and laborious to emasculate the flowers to harness the benefits of intervarietal hybridization. To obviate some of these bottlenecks, IIM explored the possibility of inducing male sterility in order to emasculate the flowers genetically with a twin objective of optimizing its genetic amelioration, and also to enrich the germplasm resource base. *A. paniculata* was emasculated by induction of genic male sterility with γ -irradiation. Male sterility was conditioned by a single recessive genic mutation that acted upon the tapetal layer surrounding the pollen sac and was also manifested as hypertrophied non-sporogenous tissue, invading the anther locule. Female fertility remained unimpaired and fully intact. Inter-varietal hybridization resulted in positive heterosis in many yield attributes and metabolic pathway elaboration/ intensification. Cross mating facilitated as a consequence of genetic emasculation of APJ 013 with male fertile APJ 020 as a pollen donor, yielded F_1 progeny that exhibited positive heterosis in many yield attributes over both the parents. About 39 per cent increase in dry leaf biomass, 22 per cent higher seed output per unit leaf area, improved seed germinability (91.13 per cent) etc. are testimony to the immense

breeding value of induced genic male sterility in *A. paniculata*. The progeny obtained was also quantitatively different from both the parents with regard to bioactive constituents. There was appreciable enhancement in the concentration of all the constituents and the overall increase of more than two fold in the yield of total andrographolides (7.33 per cent) when compared with the mean value (3.215 per cent) of both the parents. Genic male sterility offers tremendous scope for qualitative and quantitative improvement of *A. paniculata* through intervarietal hybridization. Fig. 29 presents Semithin sections of bisporangiate fertile and sterile anthers.



Fig 28: Plant habit: Indeterminate shoot of *Andrographis paniculata* (a), pollen (P) clogged stigma (S) adpressed to transversely (TS) dehiscent anthers (A) provides for obligate autonomous selfing (Bar = 120 μ m) (b).

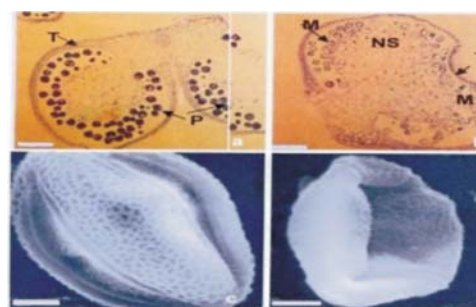


Fig 29: Semithin sections of bisporangiate fertile and sterile anthers: Stained viable pollen (P) and intact tapetum (T) of male fertile anther (BAR=100 μ m) (a), unstained aborted microspores (M), hypertrophied non-sporogenous tissue (NS) invading the locule of male sterile anther (Bar=100 μ m) (b), scanning electron micrographs of fertile pollen (Bar= 5 μ m) (c) and of sterile pollen (Bar= 5 μ m) (d)

Versatile Sexual Mechanism Ensures Robust Genetic and Chemical Polymorphism in *Withania Somnifera*

Reproductive excellence holds the key to any species for its sustenance, flourishing, genetic improvement and evolution. *Withania somnifera* (fig 30 and 31) presents a versatile sexual polymorphism of mixed mating. Experiments conducted by IIM indicated that individual flowers exhibit partial temporal dichogamy of protogynous type, under which receptive stigma remains exerted beyond the undeveloped staminal cone to receive cross pollen through insect vectors. In a probable situation of non-receipt of pollen through insect pollinators, autonomous fertilization is guaranteed by the upward staminal increase to form a cone connivent about the receptive stigma. Functional dimension and floral configuration suggests that crossing and autonomous selfing are mutually exclusive as the self-pollen arrives late during the floral ontogeny. Seed set efficiency and fruiting success are not influenced by pollen

genotypes (self/cross) under different pollination treatments (autogamy, geitonogamy and xenogamy). Preemergent reproductive success (PERS) averages 37 per cent with open pollination. DNA content (chromatin length 47.51 μm at somatic metaphase) is distributed asymmetrically among 24 chromosomes ($2n=48$). Meiotic system reveals high recombination index (71.2). In accordance with the theoretical predictions for mixed mating, intermediate levels of heterozygosity are maintained. This was illustrated by the proportion of polymorphic loci calculated as Shannon index employing RAPD. High pollen-ovule ratio (631.77), pronounced protogyny, copious nectar production and insect visitation provides for strong out crossing.

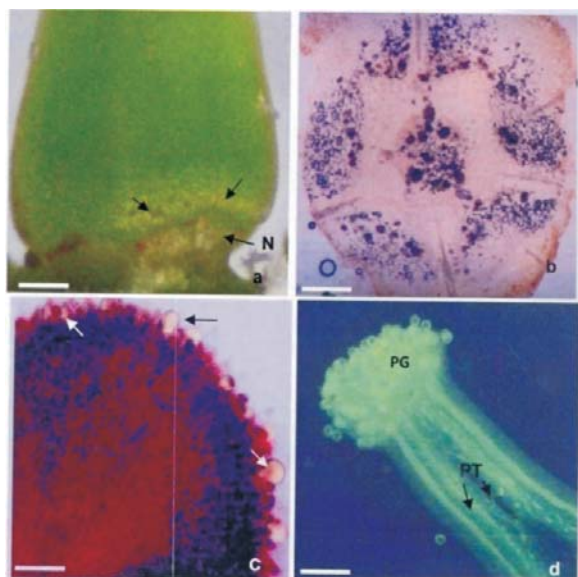


Fig 30: Nectariferous ovary base N showing nectar exudates (see, arrows) (Bar = 295 μm) (a), cross section of the nectariferous ovary base revealing nectar accumulation (dark spots) in parenchyma tissue (Bar = 286 μm) (b), stigmatic receptivity marked by lipoidal secretions all over (Bar = 105 μm) (c), fluorescence micrograph showing stigma clogged with germinating pollen grains PG and part of stylar region with fluorescing pollen tubes PT (Bar = 242 μm) (d)

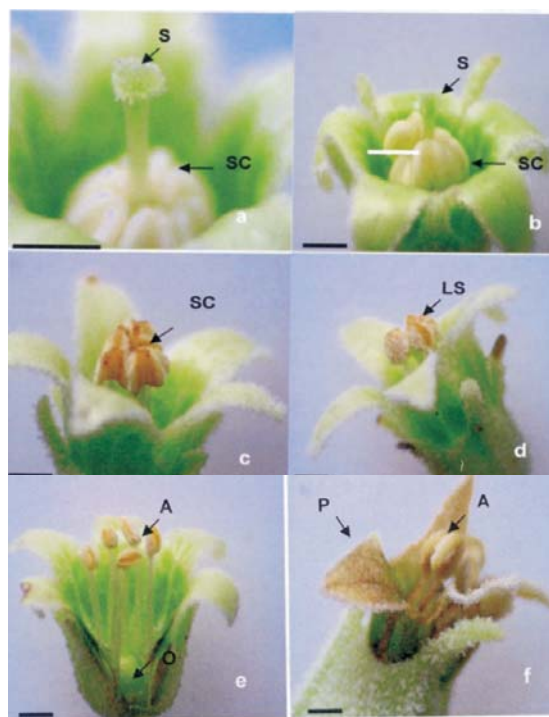


Fig 31: A flower of *Withania somnifera* just after anthesis showing papillate, globose, exerted stigma S beyond the staminal cone SC (a), relative position of receptive stigma S and staminal cone SC after two days of anthesis (b), staminal cone SC connivent about the receptive stigma after 3 days of anthesis (anther dehiscence stage) (c), arrow head showing pollen presentation through longitudinal slit LS on outer of the stigmatic side (d), ovary O after fertilization and reflexed-dehiscent anthers A (e), abscising petals P and anthers A after 6-7 days of anthesis (f). Bars = 1 mm.

However, small flower size, high seed to ovule ratio (0.76) and moderate fruit to flower ratio (0.49) are in conformity with predicts of 'reproductive assurance hypothesis'. Mixed mating and the efficient meiotic recombination system provide a reliable strategy that guarantees reproductive success and genetic polymorphism 'with' you or 'without' you pollinator environment. Both conceptually and empirically, manipulative hybridization has implications for breaking the metabolic blocks and production of novel bioactive molecules as the species displays an efficient genetic system.

Mechanism of Liver Toxicity of Anti Tubercular Drugs

Tuberculosis has become global menace particularly for developing countries. IIM research work shows that anti-TB drugs remain targeted at hepatocytes and the endothelium of the bile ducts leading to altered serum profile. Mild hyperlipidaemia, hypercholesterolemia, and hyperuricemia were the other pathologies observed. The results do not suggest any noticeable toxicity by RIF and PZA individually, but the effect seems to aggravate in presence of INH which seemed to be the major contributor in the overall toxicity profile. It has been suggested that the underlying mechanism of toxicity is related to:

- Disruption of membrane integrity and function.
- Imbalance in oxidant/ antioxidant balance.
- Bio activation mediated by cytochrome P450 2E1.
- Abnormal rise in intracellular calcium.

This model has also been used to develop plant based agents against anti-TB drugs induced liver toxicity. It is an attempt to access the biochemical, hematological, cellular and histological changes that occur due to daily administration of anti-TB drugs either alone or in combinations (i) rifampicin + isoniazid and (ii) rifampicin + isoniazid + pyrazinamide during 0 - 90 days in male Wistar rats.

Insight into Tnf-A Inhibition through in Silico Approach

In order to understand the exact mechanism of reaction TNF-alpha inhibition IIM has have performed the *in silico* studies on the target TNF- α involving docking studies on both forms of TNF-alpha i.e the trimeric form as well as the dimeric form. In silico experiments were performed using Ligfit module of cerius2. In the present study, two natural products new to literature (NP-1, NP-2) and one known compound (rolipram), shown to suppress TNF- α activity, in the wet lab, were taken to study the mode of inhibition of the selected target. The protein targets were downloaded from the PDB viz., 1TNF (trimeric form) and 2AZ5 (dimeric form) Analysis of the docking results and the molecular interactions revealed that the ligand NP-2 binds with the overall better affinity with TNF- α (fig 32), when compared with NP-1 and rolipram.

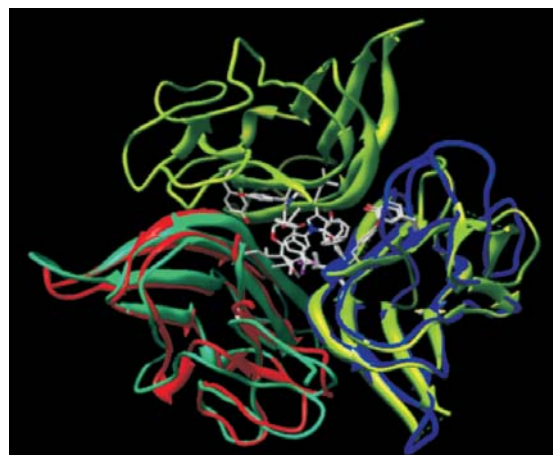


Fig 32: 3D-Structure of TNF- α and its bound ligand

It is also observed that NP-2 is involved in three H-bond formation with chainA of the dimer and one of them being with Tyr151. It may be inferred here that this H-bond prevents the dimer to form the active trimer again This explains the first mode of inhibition i.e the inhibitor functions actively by interacting with TNF- α trimer to promote the dissociation of a subunit to form TNF- α dimer (pre-dissociation dependent) and once this dimer is formed the ligand binds to it in such a fashion that

it prevents the target to return to its active (trimeric) form. Interaction of SAP2 with active site residues of 2AZ5 is shown in fig 33.

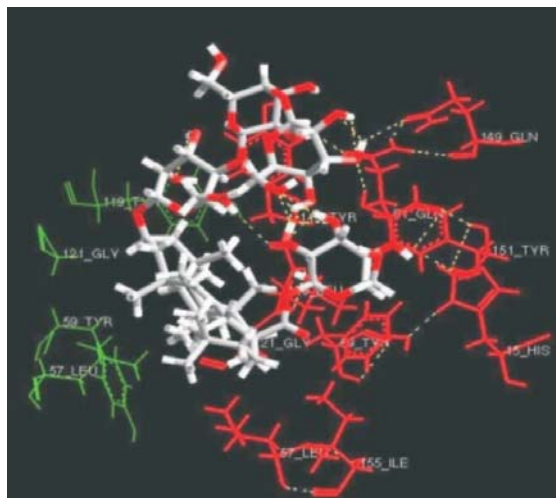


Fig 33: Interaction of SAP2 with the active site Residues of 2AZ5

Caerulomycin A: An Immuno-Suppressive Drug

IMTECH has isolated a bipyridyl compound from a novel species of actinomycetes *Actinoalloteichus spitiensis* from the Himalayan Kaza and Spiti regions. The molecule inhibits the proliferation of activated lymphocytes, especially CD4⁺ T cells (both Th1 and Th2) and B cells, which are the cornerstone of adaptive immunity. It also suppresses the production of cytokines. Further, it delays the onset of rejection of skin allografts in mice. The bioactive compound is identified and characterized as Caerulomycin A. The molecule is of immense interest because it exhibits better immunosuppression than the drugs that are currently in clinical use. The IPR has been licensed to Nostrum Pharmaceuticals, USA for USD 3 million (milestone payment) plus royalty. The molecule may have use in the survival of transplants and treatment of autoimmune diseases.

Understanding the Biology of *V. Cholerae* in the Context of its Survival and Pathogenesis

Vibrio cholerae is the causative agent of cholera, a form of diarrhoea, which continues to be one of

the major causes of morbidity and mortality in the developing world. *V. cholerae* comprises of more than 200 serogroup where strains belonging to O1 and O139 are capable of causing epidemic cholera while the rest clustered into non-O1, non-O139 strains are found to be associated with sporadic diarrhea. Genome analysis reveals that non-O1, non-O139 strains are very diverse from their O1 and O139 counterparts. IMTECH intends to understand the pathogenesis and quorum sensing mediated cellular events in non-O1, non-O139 strains of *V. cholerae*.

A yeast model has been developed by IMTECH by ectopically expressing one such effector molecule. The expression of the effector molecule affects the viability of budding yeast. This model will remain helpful for screening small molecule inhibitor against bacterial effector proteins (Ranjana Tripathy et al. communicated).

New Cultivars Registered

'Aruna', is a gamma ray mutant of 'Palekar' developed by NBRI, with drooping branching habit; leaves 6.8 x 3.8 cm, light green, margin curled inward; mature bracts - Azalia Pink (523/1), young bracts - Orange (12/1); recurrent bloomer; good for 'standard', cascade, hanging basket, mound and pot plant.

A canna cultivar 'Agnishikha' was registered as a new cultivar with NBPGR, New Delhi and accorded accreditation certificate.

As an outcome of ongoing R&D work on Gladiolus, two varieties 'Neelima' and 'Urvashi' that has been displayed the first time in the Rose and Gladiolus Show in 2006, have now been registered with the International Gladiolus Registrar, under **North American Gladiolus Council**, USA in 2008 (www.gladworld.org).

Moss House

In order to enhance the existing plant diversity and to make it more diversified, educative and purposeful, a **Moss House** (fig 34) has been developed by NBRI in its campus.



Fig 34: Different views of Moss House

Interaction between 14mer DNA Oligonucleotide and Cationic Surfactants of various Chain Lengths

A novel gene silencing approach based on the use of small synthetic oligonucleotides, such as antisense RNAs, siRNAs has been used by IGIB to inhibit the expression of a specific target gene. The results demonstrated that interaction between oligonucleotides and cationic surfactants, although qualitatively similar to long double stranded DNA, shows subtle differences that need to be kept in mind to improve small oligonucleotide delivery into the cells by using common delivery agents that have been used to deliver long pieces of DNA.

Nucleopolyhedrovirus (NPV) based Biopesticides for Management of *Helicoverpa Armigera*

There has been great demand for development of eco-friendly biopesticides in view of the increasing concern for adverse health and environmental effects of pesticides used in agriculture. Entomopathogenic viruses constitute an important group of biopesticides. The polyphagous lepidopteran pest *Helicoverpa armigera* has shown resistance against almost all chemical pesticides. IHBT has isolated and tested a highly efficacious local strain of nucleopolyhedrovirus (HaNPV) against *H. armigera*. The molecular characterization confirmed it to a new indigenous strain. The strain has shown higher efficacy than the market product. The biopesticide starts inducing larval mortality within a week after treatment with typical symptoms of larvae hanging by their abdominal legs. Various aspects of formulation development are being assessed for its commercialization and prospect of transferring the technology at farmers level through rural entrepreneurship. Integrating the formulation in IPM

programme may reduce the loads of chemical pesticides in the agri-food supply chain.

Genomics of Emerging Geminiviruses by Application of Φ -29 DNA Polymerase

Geminiviruses are one of the most important plant pathogens in the tropical world. Understanding the molecular biology of these viruses is pre-requisite for management. IHBT has conducted surveys in solanaceous crops growing areas particularly, tomato, potato and chilli. Initial detection was carried out by slot-blot hybridization and PCR based methods. Full genome amplification and characterization of important isolates were done using rolling circle amplification (RCA) method. A distinct bipartite Begomovirus species was found associated with severe leaf curl disease of tomato, whole genome of which was sequenced (GenBank Accession numbers AM884015 and AM992534) and a name 'Tomato leaf curl Palampur virus' was proposed. Whole genome cloning and sequencing of another distinct monopartite Begomovirus species and a satellite DNA- α infecting chilli plants was carried out through RCA. A name 'Chilli leaf curl India virus' was proposed for this species (GenBank Accession numbers FM877858 and FM877803). Whole genome of Tomato leaf curl New Delhi virus causing apical leaf curl disease was also cloned and sequenced through RCA (GenBank Accession numbers AM850115 and FN356024).

Genetic Improvement in *Jatropha*

CSMCRI's continuous efforts in respect of *Jatropha* led to the identification of superior genotypes for semi-arid conditions of Gujarat. In the absence of sufficient information regarding the suitable germplasm of *Jatropha* for specific areas, it is necessary to identify the genotypes for different types of wastelands before embarking upon its commercial plantations. The plants may survive and look green but may not be productive enough to translate into viable economics.

A provenance trial was laid out in Randomized Block Design (RBD) and replicated thrice taking 10 plants per CPT in each replication. The trial was conducted in a semi-arid ecosystem where annual rain fall (400-700 mm) is 2-3 times less than evapo-transpiration (fig 35).

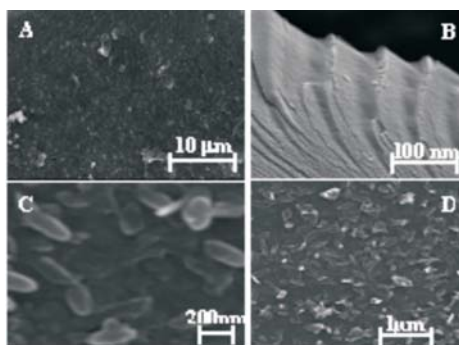


Fig 35: SEM images for: (A) SPK membrane after leaching out CPC, (B) cross-section showing the pores formed due leaching out CPC, (C) SPK-zeolite-2 membrane in high resolution

Patulin Causes DNA Damage Leading to Cell Cycle Arrest and Apoptosis through Modulation of Bax, P53 and P21/WAF1 Proteins in Skin of Mice

Patulin (PAT), a mycotoxin found in apples, grapes, oranges, pear and peaches, is a potent genotoxic compound. WHO has highlighted the need for the study of cutaneous toxicity of PAT as manual labour is employed during pre and post harvest stages, thereby causing direct exposure to skin. IITR has evaluated cutaneous toxicity of PAT following topical application to Swiss Albino mice. Dermal exposure of PAT, to mice for 4 h resulted in a dose (40–160 $\mu\text{g}/\text{animal}$) and time (up to 6 h) dependent enhancement of ornithine decarboxylase (ODC), a marker enzyme of cell proliferation. The ODC activity was found to be normal after 12 and 24 h treatment of patulin. Topical application of PAT (160 $\mu\text{g}/100 \mu\text{l}$ acetone) for 24–72 h caused (a) DNA damage in skin cells showing significant increase (34–63 per cent) in olive tail moment, a parameter of Comet assay (b) significant G 1 and S-phase arrest along with induction of apoptosis (2.8–10 folds) as shown by annexin V and PI staining assay through flow cytometer. Moreover PAT leads to over expression of p21/WAF1 (3.6–3.9 fold), pro apoptotic protein Bax (1.3–2.6) and tumor suppressor wild type p53 (2.8–3.9 fold) protein. These results suggest that PAT has a potential to induce DNA damage leading to p53 mediated cell cycle arrest along with intrinsic pathway mediated apoptosis that may also be correlated with enhanced polyamine production as evident by induction of ODC activity, which may have dermal toxicological implications.

In Silico Studies with Human DNA Topoisomerase-II Alpha to Unravel the Mechanism of In Vitro Genotoxicity of Benzene and its Metabolites

Exposure of humans to benzene present in the environment may lead to adverse chronic effects even at the genetic level. However, the mechanism of its genotoxicity is not well understood. IITR has assessed in vitro genotoxicity of benzene (BZ) and its major metabolites [p-benzoquinone (BQ), hydroquinone (HQ), catechol (CT), 1,2,4-benzenetriol (BT) and trans-trans muconic acid (MA)] at concentrations 0.5–50 μM , in Chinese hamster ovary (CHO) cells employing the alkaline Comet assay, cytokinesis blocked micronucleus (CBMN) assay, flow cytometric analysis of micronucleus (flow MN) and chromosome aberration (CA) test. The data revealed significant ($P < 0.05$) concentration-dependent response in all end points. HQ was found to be the most potent DNA damaging metabolite in the Comet assay followed by $\text{BQ} > \text{BT} > \text{CT} > \text{BZ} > \text{MA}$. Both CBMN and flow MN assays revealed a good correlation in their results, where BQ and MA exhibited maximum and minimum micronucleus induction respectively. The results demonstrated the utility of sensitive techniques like Comet assay and flow cytometry for determination of MN, to quantify in vitro genotoxicity at low levels and also suggested that partly non-repaired DNA damage could cause adverse health effects in human population exposed to benzene.

Responsiveness of Cerebral and Hepatic Cytochrome P450s in Rat Offspring Prenatally Exposed to Lindane

Prenatal exposure to low doses of lindane has been shown to affect the ontogeny of xenobiotic metabolizing cytochrome P450s (CYPs), involved in the metabolism and neurobehavioral toxicity of lindane. IITR has investigated the responsiveness of CYPs in offspring prenatally exposed to lindane (0.25 mg/kg b. wt.: 1/350th of LD50: p. o. to mother) when challenged with 3-methylcholanthrene (MC) or phenobarbital (PB), inducers of CYP1A and 2B families or a sub-convulsant dose of lindane (30 mg/kg b. wt., p. o.) later in life. Prenatal exposure to lindane was found to produce an increase in



the mRNA and protein expression of CYP1A1, 1A2, 2B1, 2B2 isoforms in brain and liver of the offspring at postnatal day 50. The increased expression of the CYPs in the offspring suggests the sensitivity of the CYPs during postnatal development, possibly, to low levels of lindane, which may partition into mother's milk. A higher increase in expression of CYP1A and 2B isoenzymes and their catalytic activity was observed in animals pretreated prenatally with lindane and challenged with MC (30 mg/kg, i.p.x5 days) or PB (80 mg/kg, i.p.x5 days) when young at age (approx. 7 weeks) compared to animals exposed to MC or PB alone. Further, challenging the animals of control group and prenatally exposed offspring with a single sub-convulsant dose of lindane resulted in an earlier onset and increased incidence of convulsions in the offspring prenatally exposed to lindane indicating the sensitivity of the CYPs in the prenatally exposed offspring. These results assume significance as the subtle changes in the expression profiles of hepatic and cerebral CYPs in rat offspring during postnatal development could modify the adult response to a later exposure to xenobiotics.

2.3 Chemical Science and Technology

CSIR has global recognition for its contribution in the areas of chemistry and chemical engineering. Over the years, its domain-specific laboratories such as NCL, IICT and others have not only published results of many seminal basic research studies, but have also developed a large number of processes and products for industrial use. During the period under report, the same trend has continued and some of the important developments are reported below.

A Simple Chemosensor for Hg²⁺ and Cu²⁺ that Works as A Molecular Keypad Lock

The sensor for biologically important ions such as Hg²⁺ and Cu²⁺ has been used at a molecular level as a fluorescent lock (Fig 36) that may be used for security devices, which would allow access using specific ionic keys as password.

CSMCRI has developed a simple chemosensor for biologically important ions such as Hg²⁺ and Cu²⁺ synthesized molecule, 1-Amino-8-Napthalene

Sulphonic acid Ester (ANSE), together with certain ionic inputs in a specific sequence, that could mimic the operation of an electronic keypad lock, e.g., a common security circuit used for numerous applications, in which access to an object or data is to be restricted to a limited number of persons. What distinguishes this lock from a simple molecular logic gate is the fact that its output signals are dependent not only on the proper combination of the inputs but also on the appropriate sequence in which these inputs are introduced. Thus, one needs to know the exact sequence of inputs or passwords that open this lock. This not only opens the way for a new class of molecular decision-making devices but also adds a new dimension of protection to existing defence technologies, such as cryptography and steganography.



Fig 36: The fluorescence chemosensor can be used as a basic molecular keypad lock

Syntheses of Exfoliated Hydrotalcites

CSMCRI has synthesized exfoliated hydrotalcites CoAl-LDH using different hydrolyzing agents such as urea or hexamine under different hybrid operative conditions such as hydrothermal, aging, ultrasound and microwave. Preliminary results showed encouraging results wherein under optimized conditions, exfoliated hydrotalcites could be successfully synthesized, although co-presence of crystalline HT-like phase is not completely avoided. Similar methodology is also extended for NiAl-LDH and exfoliated phase was successfully obtained under optimized synthesis conditions. Further, the exfoliated HTs did not settle upon standing even for days together (> 10 days). A pictorial representation of exfoliated HTs has been depicted in figure fig 37..



Fig 37: Laser light passing through CoAl exfoliated sample

Nanocomposite Polymer Electrolyte Membrane

CSMCRI has developed a method for preparing sulfonated poly (ether ether ketone) (SPK)-zeolite-zirconium hydrogen phosphate (ZrP) nanocomposite polymer electrolyte membrane (PEM) by in situ infiltration and precipitation. This has been claimed to be the first report of the infiltration of zeolites in the pores/cavities created by water soluble surfactant in the polymer electrolyte, for accommodating proton conductor (ZrP). Thermal, mechanical strength, oxidative and dimensional stabilities of SPK membrane were improved and water retention capacity was increased due to infiltration of zeolite and surface modification with ZrP, which are very essential for PEM. These nanocomposite membranes showed slightly lower proton conductivity ($2.91-3.35 \times 10^{-2} \text{ S cm}^{-1}$) and markedly lower methanol permeability in comparison to Nafion 117 (N117) membrane. Although, developed SPK-zeolite-ZrP nanocomposite PEMs offered no significant advantages over SPK or N117 membrane at 30°C, but at 70°C they exhibited nearly same conductivity to N117 membrane. Also extremely low methanol permeability of these PEMs enhanced their selectivity parameter about three times at 70°C in comparison to N117 membrane, and indicated suitability of these PEMs fuel cell applications at moderate temperature. Furthermore, these PEMs can be identified as potential candidate for providing new technological applications in high temperature electrochemical devices including ion separations, water electrolysis, and electro-chemical sensors.

IICT Certified as OPCW Designated Laboratory

IICT is the only non-defence laboratory in India that has been certified as an Organisation for the

Prohibition of Chemical Weapons (OPCW), designated laboratory. The Chemical Weapons Convention (CWC) is an international treaty that prohibits production, storage and use of Chemical Warfare Agents (CWAs) through its verification program. Verification involves on or off-site analysis of samples collected from suspected sites by the inspectors appointed by OPCW is responsible for the implementation of the CWC Treaty. One of the main responsibilities of the OPCW is to designate laboratories from the member states for the off-site analysis of chemical weapons and their degradation products. There are 190 member countries and 20 designated laboratories all over the world, and IICT is one of them. This is hence CSIR's important contribution to the country on the disarmament of the chemical weapons. To achieve the status of a designated laboratory, a laboratory must prove its analytical capability to analyze CWAs and related compounds (CRCs) in Official Proficiency Tests (OPTs) conducted by OPCW.

A Universal Reagent for Spectrophotometric Estimation of Polymer-Supported Functional Groups

A new universal reagent, 2-O-[2-(4,4'-dimethoxytrityloxyethyl)]- hydroxy acetaldehyde (DEA), has been synthesized by IGIB and used for the estimation of surface-bound aminoalkyl, aminoalkyl, hydrazinyl, and semicarbazide functions. The reaction completes in just 10 min in the case of aminoalkylated supports and 30 min in hydrazinyl supports, whereas it takes approximately 60 minute in both aminoalkylated and semicarbazide-modified polymer supports. DEA-treated supports, including glass slides and PP films on exposure to acid, liberates 4,4'-dimethoxytrityl cation, which was measured spectrophotometrically to estimate these functionalities. The method estimates accessible functional groups, useful for calculating the quantity of the ligands to be immobilized.

Solvent Free Synthesis of 1,4-Dihydro Pyridines

NEIST has achieved a simple, green and cost-effective protocol was achieved for the solvent free synthesis of 1,4-dihydropyridines [key intermediate for cardiovascular drug] catalyzed by $\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$

as a mild and effective catalyst at 60 °C in high yields (Fig 38). The product 1,4-Dihydropyridines thus formed were aromatized to pyridines by in situ generation of HOCl employing $\text{AlCl}_3 \cdot 6\text{H}_2\text{O} / \text{H}_2\text{O}_2 / \text{H}_2\text{O} / \text{EtOH}$ as an excellent reagent system under domestic microwave irradiation (MWI). Both the synthesis and oxidation steps were efficiently accomplished in one pot four-component fashion following the same protocol. The reaction fulfills the requirement of green chemistry and the concept may be utilized /explored in developing green methods and technology.



Fig 38: Scheme 1. Synthesis of 1,4-dihydropyridines

Chitam Gel

NIIST has invented biocompatible gel named 'Chitam gel' (Fig 39) for the preparation of a transparent, colourless, crystal clear, nontoxic, biodegradable, from xyloglucan and chitosan copolymer in a definite ratio and both the ingredients are from renewable resources. The gel is made by modifying the xyloglucan to form dialdehyde of xyloglucan and making a co-polymer with chitosan to form a gel which is stable at temperature -20 to 90°C, UV radiation and pH from 3 to 7. This gel has a viscosity of 4100 centi Poises at $28 \pm 2^\circ\text{C}$. The yield of the gel from the raw material is very high, since 10 gm raw material produces 1Kg of gel, which is 100 fold yield and hence cost effective. Chitam gel, due to its beta linkage, is not digested by digestive enzymes in humans and does not contribute to calorie intake and hence can be used as a zero calorie food ingredient, and supplement for functional foods (nutritional care), also in jam, jellies, beverages, ice creams and other ready to eat products, as it is rheologically and texturally stable with food ingredients such as citric acid, sucrose, sodium chloride, aspartame, colours and flavours. The chitam gel has also applications in the area of cosmetic and personal care products, as a make-up cosmetic or basic cosmetic such as face wash, milky lotion, cream or foundation, with excellent elasticity and ageing stability, giving refreshing feeling, free from stickiness and having

excellent usability, as a ultraviolet protective agent or as a tissue adhesive, and in pharmaceutical preparations including haemostasis, wound sealing, tissue engineering or localised or oral drug delivery as patches, capsules and tablets.

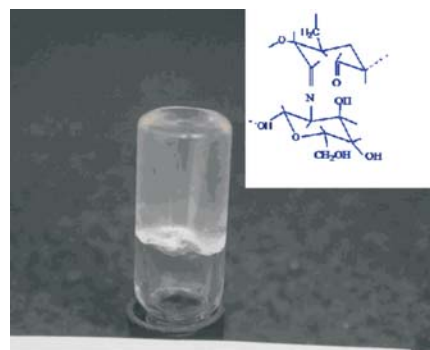


Fig 39: Chitam gel

Gold Nanorod Chains as Plasmonic Waveguides

NIIST has experimentally shown that the angle between the nanorods in noble metal waveguides has a significant influence on propagation properties. They studied the plasmonic properties of gold nanorod dimers, where two nanorods were linked together through small linker molecules. Such nanorods can be synthesized through bottom-up techniques and stabilized in water. Their integration into the final device structure can then be guided, for example through electrostatic techniques. The propagation of the surface plasmons across the dimers depends strongly on the orientation of the nanorods, as different orientations alter the overlap in electromagnetic fields at the gap between the nanorods. In order to study this dependency in detail, different linker molecules were used to bind the nanorods together. Rigid linker molecules tend to straighten the dimers, whereas more flexible linkers tend to lead to right angles between the nanorods.

For rigidly linked dimers, the plasmon coupling along the nanorods is strong and the plasmon resonance was determined to be at 840 nm. In flexibly linked dimers on the other hand the plasmonic coupling across the nanorods is weak and the resonance occurred at 732 nm. In the future, gold nanorod chains (Fig 40) could be used as plasmonic waveguides where the transmission

of light waves in principle can be controlled through the alignment of the nanorods.

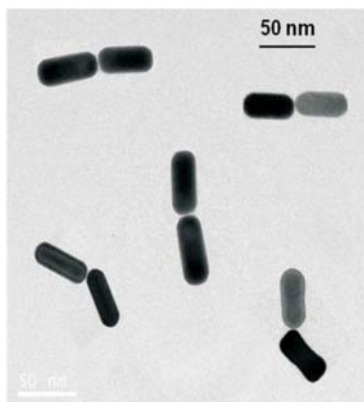


Fig 40: Microscopy image of gold nanorod dimmers

Clay-based Inorganic-Organic Hybrid Micro-Vesicles A Potential Candidate for Guest-Encapsulation Applications

NIIST has developed a facile process for synthesizing clay-based inorganic-organic hybrid (PCN) which yields micro-vesicles (3-10 micrometer) by solvent-assisted self-assembly properties and capable of encapsulating guest-compounds from their solutions by membrane diffusion or during vesicle formation (fig 41). The vesicle is thermally stable over 250°C, impermeable to water, permeable to alcohol and unstable in low-dielectric solvents. PCN vesicle can be a potential candidate for use as micro-storage system and may find micro-encapsulation/delivery applications in cosmetics, paints etc. Possibility exists for hydrophile modification of the vesicle so as to find pharmaceutical application also.

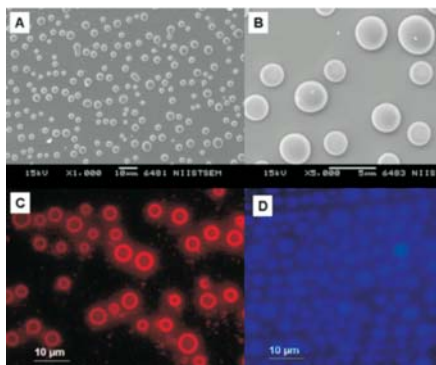


Fig 41: SEM images of Clay-based inorganic-organic hybrid micro-vesicles and FMI image of Fluorescence encapsulated vesicles

Potentiostelectrode based Sensors

NIIST has successfully designed and developed imprinted polymer inclusion membrane (IPIM) based portable and field monitoring sensors for pesticides (atrazine and phorate), organophosphate chemical warfare agents simulant/degradation product (pinacolyl methyl phosphonate/methyl phosphonic acid) and inorganic (uranyl ion) toxins. Further to that NIIST developed In-situ or Monolithic Format Cast Membrane (IMFCM) based on covalent and non-covalent strategies in addition to IPIM. The integration of above membrane with potentiometric transducer enabled rapid, reliable and selective detection and quantification of as low as 0.2 ppm of diethyl chlorophosphate.

Constant Phase Elements, Depressed Arcs and Analytic Continuation

The connection between the constant phase element (CPE) and the depressed arcs often observed in the Nyquist plane was critically analyzed using the analytic continuation principle enunciated earlier by Emmanuel. CECRI has pointed out a major inconsistency in a model presently used to explain these depressed arcs. A new model was advanced which removes this inconsistency and also has a clear physical basis. A set of exact analytical results were reported which may be used as diagnostic criteria for testing experimental impedance data against different models. Several Nyquist and Bode phase plots were generated as illustrations. The importance of this model for the characterization of coated metals highlighted.

This work will be useful to Corrosion Scientists who develop suitable coating systems for metals as a tool to investigate the effectiveness of coatings.

Modified Solid Polymer Electrolytes

CECRI has developed novel electrostatic method for preparing modified solid polymer electrolytes (SPE). Application of an electric field on an evaporating mixture of KYNAR, Ethylene Carbonate (EC), Propylene Carbonate (PC) and LiPF_6 dissolved in Tetra Hydro Furan (THF) resulted in a Solid Polymer Electrolyte whose charge transfer resistance was at least an order of magnitude lower than that formed without the application of an



electric field. Probably that the observed enhancement is due to an electric field induced orientation of dipoles in the polymer chain. This is the first time perhaps an effect of this kind has been observed. This innovation opens up a new direction in which properties of materials can be tuned by an applied electric field and will be of use for material scientists.

Binary Organic Cocrystals

Binary organic cocrystals involving substrates like β -cyclodextrin, succinic acid, dimethyl glyoxime, bipyridyl etc have been synthesized by CECRI using different methods including dry and wet grinding, microwave, ball milling and solvent evaporation methods. The formed cocrystal has been analyzed using its melting point, optical microscope, SEM, FT-IR, XRD, HPLC and DSC studies. Attempts have also been made to synthesize ternary and quaternary cocrystals.

The cocrystal research is an interesting and emerging area which finds application in the drug industry and is also interesting from a theoretical point of view. It is a highly interdisciplinary area including crystal engineering, chemistry, biology, physics and material science. Several cocrystals are being synthesized with improved physical, chemical and biochemical properties.

Cocrystal is formed between an Active Pharmaceutical Ingredients (API) (neutral or in the ionic form)/organic compounds and a cocrystal former that is a solid under ambient conditions. Cocrystallization alters the therapeutic effect of the compound without degrading the medicinal nature. Cocrystals improve drug properties without affecting the API's. Optimal properties of a compound are generally found to increase therapeutically. Properties of a cocrystal of importance are its dissolution rate, toxicity, hygroscopicity, oral consumability, bio-availability and stability. Cocrystals are found to be more stable than the API.

Hexaborides of Lanthanum

CECRI successfully established a lab scale process for the electro synthesis of LaB₆ by molten salt electrolysis. The process has been optimized on

different electrolytic parameters like current density, cell voltage and bath temperature. High purity crystals of LaB₆ have been synthesized by varying the reactants concentrations i.e., molar ratios of La: B and the best of them were identified and handed over to Bhabha Atomic Research Centre. Further studies are in progress on the mechanistic aspects on the deposition of LaB₆ compound by fundamental electrochemistry using an Electrochemical Analyzer. A Joint patent has been filed.

Recovery of Tungsten from Tungsten Scrap

CECRI has developed a process for recovery of tungsten carbide from cemented tungsten carbide scrap generated from tool industries and heavy alloy scrap generated in defence industries. The influence of current density, temperature concentration of electrolyte on the dissolution of cobalt has been studied.

In ammonium hydroxide electrolyte, the dissolution of tungsten along with nickel and iron increases with increase in current density. Potentiodynamic studies indicate that dissolution current is proportional to concentration. The dissolution of tungsten in presence of ammonium chloride additive is lower than that in presence of ammonium nitrate. X-ray diffraction pattern of ammonium para tungstate prepared through alkali digestion is at par with commercial ammonium para tungstate (APT).

The studies made and the knowledge acquired in the recovery of metals from secondary sources gives better insight into the problem for its future scale-up studies.

Alternate Materials for Functional Components in SOFC

To reduce the operating temperature of the SOFC system, investigations on alternative materials such as partially substituted lanthanum gallates and partially substituted ceria were carried out by CECRI.

Yttrium zirconium oxide (Y₂Zr₂O₇) (YZ), Y₂Zr_{2-x}CoxO_{7-δ} (YZC) and Y₂Zr_{2-x}Fe_xO_{7-δ} (YZF) pyrochlore materials Institute has prepared by self propagating hydrothermal glycine-nitrate

combustion method. The crystal structure, particulate properties, sintering characteristics and electrical properties of $Y_2Zr_2O_7$ (YZ) and $Y_2Zr_{2-x}MxO_{7-\delta}$ (where M = Fe, Co; x = 0.025, 0.05, 0.075 and 0.10) were investigated. Circular pellets were fabricated under identical conditions and sintered in air at different temperature levels ranging from 1,000 to 1,400°C. It is found that partial substitution of Co or Fe in the “Zr” sites improved the sintering characteristics of these oxides when compared with parent pyrochlore oxides. The substitution levels of Co or Fe (10.0 wt. per cent) resulted in increased conductivity values when compared with parent yttrium zirconate. The experimentally measured data which are important to see whether the YZ, YZC and YZF ceramic materials are useful as alternate electrolyte in IT-SOFC are examined.

Methodology for Treatment of Palm Oil Waste Water

CECRI has developed a cost effective treatment methodology for the treatment of palm oil wastewater (POW) obtained from a food processing industry. An electro-Fenton pre-treatment step followed by biological oxidation has been investigated and suggested for the recalcitrant contaminants present in POW. The initial COD about 6,700 mg/L of POW was subjected to electrolytic degradation for 2 hours and subsequently by biological oxidation. The biological oxidation was carried out using *Aspergillus niger* and *Pseudomonas putida* in anaerobic condition. Electro-Fenton process removed 48.35 per cent of the COD. It was subsequently decreased the COD to 86.12 per cent and BOD was reduced to 85.23 per cent by biological oxidation. In the combined process, a high reduction in TOC and TN was achieved. Experimental conditions have been optimized.

Superhydrophobic Multiwalled Carbon Nanotube Bucky Paper

NCL has prepared a superhydrophobic multiwalled carbon nanotube bucky paper. This material shows fascinating wetting behavior as a result of an applied electric field, which could be remarkably tuned by changing key variables like ionic strength, nature of electrolyte, and pH of the droplet. More significantly, the droplet behavior can be reversibly switched between superhydrophobic

Cassie-Baxter state, to hydrophilic Wenzel state depending on the manner in which the electric field is applied.

Autocatalysis in Biological Systems

Biosystems can be analyzed through identification of their constituent unit processes. This is analogous to the study of a chemical plant through an analysis of its constituent unit operations. Characterizing the effect of a particular unit process will help to identify its contribution to a system comprised of multiple interacting unit processes.

Component unit processes in biology can be identified through the example of autocatalysis. An autocatalytic reaction occurs when a product catalyzes a reaction and aids in its own creation (fig 42). Such processes are present in biological systems at all scales from the single molecule to ecosystems. NCL has unraveled modeling frameworks that are required for understanding them. Directions for further research such as the stochastic and deterministic study of coupled autocatalytic loops at various length and time scales, and modeling of interlinked unit processes have been delineated.



Fig 42: Modeling Framework to understand Autocatalysis

This approach is potentially a better means for analyzing the fascinating dynamics exhibited by biological systems, a critical step in understanding existing normal and disease states (systems biology), as well as in the de novo synthesis of biological networks (synthetic biology). A better understanding will also open up the possibility of using these principles in designing robust chemical and biochemical processing operations.



2.4 Physical and Earth Sciences

CSIR is the flag bearer of national standards including time, weight, distance, temperature etc. It also contributes towards the fields of gas exploration, oceanic studies etc.

Geodetic Measurements in the Kutch Region

The Global Position System (GPS) measurements carried out by NGRI for six years in different campaigns after the 2001 Bhuj earthquake have thrown light on the unusually low viscous strength of the mantle below the earthquake epicentral region. This may be the long lasting result of thermal weakening by the late cretaceous Deccan Plume responsible for the unusually active intrplate seismicity in the region. These studies throw light on the efficacy of GPS measurements in understanding the earthquake process of the intraplate seismic regions.

Automatic Gravity Optimization of Listric Faults

NGRI has developed a method for automatic gravity optimisation of listric faults using prescribed depth dependent density. The technique simultaneously estimate the parameters of listric faults having finite strike length as well as regional gravity background from a set of measured Bouguer gravity anomalies, wherein a parabolic density function simulates the decrease in density contrast of sedimentary rocks with depth within the structure. The novelty of this technique is that it automatically initiates both model parameters of a listric fault as well as regional gravity background from a set of measured Bouguer gravity anomalies and then improves them iteratively until the modeled gravity anomalies mimic the observed ones.

The automatic optimization technique has got immense application in both hydrocarbon and mineral explorations.

Post-Seismic Deformation in the Andaman and Nicobar Islands after Sumatra Earthquake of 2004

NGRI has carried out GPS measurements of postseismic deformation from 22 campaign-mode and one continuous GPS sites in the Andaman-

Nicobar region following the great Sumatra-Andaman earthquake of 26th December, 2004. The measurements show large horizontal displacements toward west to southwest, varying in magnitude from 10 to 40 cm, and with uplift reaching 16 cm, occurred in the region in the first year after the earthquake. The observed motion decreased logarithmically in the subsequent year. NGRI suggested that in the Andaman region, frictional afterslip occurred farther downdip of the coseismic rupture, while in the Andaman and Nicobar regions, the coseismic rupture and afterslip patch partly overlapped. The after-slip was mostly aseismic and did not contribute to the aftershocks. The aftershocks and postseismic displacements appear to follow a similar relationship, although with different decay times. The temporal dependence of the two differs only by a term linear in time. Thus the temporal evolution of the afterslip seems to be consistent with a mechanism governed by frictional afterslip. Available rates of interseismic and postseismic deformation and coseismic static offsets allow us to approximately estimate a return period of about 400 years for great earthquakes in the Andaman region (fig 43)

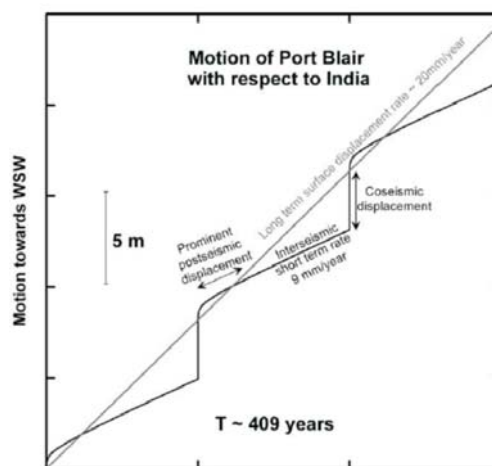


Fig 43: Estimation of a return period of great earthquake

The post deformation studies after Sumatra earthquake will provide clues to estimate interseismic interval of Great Earthquake in the Andaman and Nicobar Island and will help in calculating return periods of these great earthquakes.

Mass and Related Quantities of NPL became the Full Member of CCM/BIPM

International Committee for Weights and measures ‘The Certificate in Investment Performance Measurement’ (CIPM) in its 97th meeting, has confirmed that NPL has been accepted as a member of the Consultative Committee for Mass and Related Quantities (CCM/BIPM). The position of NPL among the other countries is shown by red arrow, in fig 44 depicting the international comparison.

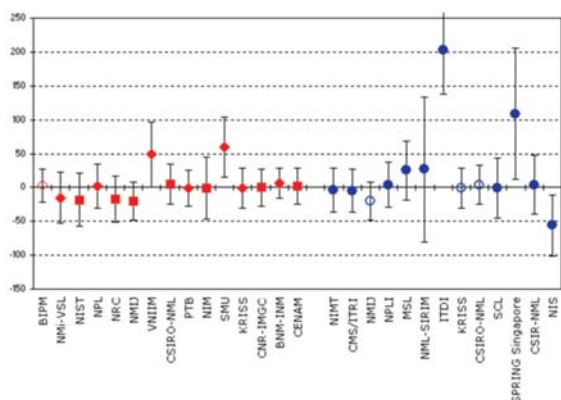


Fig 44: Members countries of committee for Mass and Related Quantities

Ferrofluid based Electric Power Generator

A ferrofluid bearing based portable electric power generating device has been developed by NPL using wind energy. The device is capable of generating minimum of 1.2-watt electric power using transverse magnetic motion as driven by normal wind speed of 4m/s having fan blades with swept area 0.126 m². The device has the efficiency up to 24 per cent at 4m/S. The torque required for rotation of magnets has been tremendously reduced by the use of ferrofluid bearings. The coefficient of friction has also been drastically reduced to 0.0008 between the rotating magnets and the stationary base plate to which the coils are connected. An alternating current has been produced and rectified using bridge circuit for providing continuous power source. Device has great potential of enhancing its power by increasing the number/size/field strength of permanent magnets or number/turns of coils or increasing the area swept by the rotating fan blades in case of

availability of higher wind speeds. An array of such devices can be able to generate more power to run heavy machinery. The unique property of magnets levitation by ferrofluid is used for making the power generator with improved output. The device is able to start functioning at very low wind speeds even at 2m/S as compared to normally available wind turbines.

White Organic Light Emitting Diode

The high power efficiency of White Organic Light Emitting Diodes (WOLED) together with their high quality is capable of becoming an ideal source for white light emission in general lighting applications (fig 45). NPL has developed such WOLEDs using emitter layers containing a mixture of blue light emitting Zn(hpb)2 with different red emitting fluorescent and phosphorescent dyes like DCM, Rubreen and Ir(btp)acac. Initial power efficiency ~ 0.54 lm/W has been achieved. It may be mentioned here that the international efficiency of WOLEDs, however, is in the range ~ 15-20 lm/W.

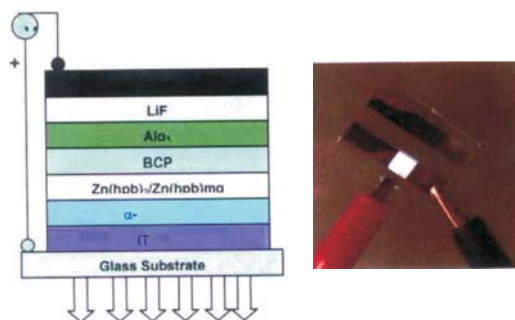


Fig 45: Schematic diagram of WOLED developed at NPL

Silicon Nanowires Arrays based Solar Cell

A simple method has been developed by NPL to prepare vertically aligned silicon nanowire (SiNW) array called “black silicon” on p-(100) silicon which have excellent light trapping properties and can be a potential candidate for the application as antireflection coating for silicon solar cells. Silicon solar cells (n+pp+ structure) can be made on such black silicon surface by conventional cell fabrication technology. The initial results show marked improvement in solar cell performance compared to the control cell made using planner technology.



The process needs further optimization of various parameters related with SiNW formation, diffusion, contact formation, etc. that may result in further improvement in cell performance.

Regional Warning Centre (RWC): Space Weather

As part of international space environment services (ISES), NPL provides space weather information/alerts (solar flares, solar winds, radiations etc) to the users (ISRO, defence and air services etc) through its space weather regional warning centres (RWC-India). The laboratory also predicts sunspots and sunspot cycle for satellite launch, its tracking and applications before and during the launch of any space vehicles such as Chandrayan. Space weather informations (fig 46) are essential for determination of its orbital parameters, its tracking, working of different electronic systems etc. All these are being provided to ISRO (MCF, Hasan and Istrac, Bengaluru) on daily basis for the last 15 years including for current Chandrayan mission.



Fig 46: Space weather Prediction

Impact of Tropical Cyclone on Biogeochemistry of the Central Arabian Sea

NIO has combined remotely sensed data with shipboard measurements to investigate biogeochemical changes caused by a moderate tropical cyclone in the central Arabian Sea in December 1998. The sea surface temperature decreased by approx. 4°C, whereas surface nitrate and chlorophyll concentrations increased by >5 μM and up to 4 mg m^{-3} , respectively, over a large area affected by the cyclone. Nutrient enrichment in the surface layer of the cyclone-affected zone

was estimated to have supported a new production of approximately 4.2 Tg C, approximately 5 per cent of the annual organic carbon export to the deep sea (beyond the continental margin) for the entire Arabian Sea. Entrainment of nitrous oxide from the thermocline led to more than doubling of its concentration in the mixed layer. The cyclone also resulted in an increase in nitrous oxide inventory within the oxygen minimum zone. The results imply that, should there be an increase in the frequency and intensity of tropical cyclones as a result of global warming, as projected in some recent reports, carbon production and respiration, and redox processes within the oxygen minimum zones, such as the production of nitrous oxide through nitrification/denitrification, and of molecular nitrogen through denitrification/ anaerobic ammonium oxidation, may be significantly impacted.

Geophysical Characteristics of the Ninetyeast Ridge – Andaman Island Arc/trench Convergent Zone

NIO has examined the convergence tectonics of the Ninetyeast Ridge (NER), upon the Andaman island arc–trench system through an analysis of ETOPO2 bathymetry, satellite-derived free air gravity and seismic data. Oblique subduction and the buoyancy forces arising from subduction of the NER rendered the subduction processes near the Andaman arc highly complex. The bathymetric expression of the NER is visible up to Lat. 10°N but seismic reflection data indicated that it extends up to about Lat. 17°N. The gravity anomalies are strongly positive over the exposed segment of the ridge but are subdued over the buried portion. There is a prominent break in the continuity of the trench gravity low, where the NER seems to impinge upon the island arc. Further, a strong curvilinear belt of negative anomalies just behind and running parallel to the island arc, associated with the forearc basin, is a dominant feature of the gravity map. An offset in the continuity of this strong negative anomaly occurs at about the same latitude where the NER seems to be converging upon the island arc. Seismic reflection data indicate that the NER is very close to the trench. Flexural modeling of the gravity anomalies for the subducting Indian Ocean lithosphere, loaded by sediments and the NER, indicates that the NER is at the starting phase of its collision with the island arc and may not have

started affecting the subduction process itself. It is inferred that the en-echelon block structure of the NER in the proximity of the convergent zone is a consequence of complex strike-slip and subduction-related tectonic forces.

Abiotic Oxidation of Pyrite by Fe(III) in Acidic Media and its Implications for Sulfur Isotope Measurements of Lattice-Bound Sulfate in Sediments

NIO has evaluated the relative importance of Fe^{3+} to dissolved oxygen in pyrite oxidation, and its implications for measuring an accurate sulfur isotope composition ($d^{34}\text{S}$) in trace sulfates extracted from sedimentary rocks. Results of pyrite

oxidation experiments (fig 47) showed that in a solution of acidic pH, the amount of sulfate formed is very similar under both oxygenated and oxygen-free experimental conditions which is suggestive of the dominant role of Fe^{3+} in pyrite oxidation compared to dissolved oxygen. One implication of this study was the influence of artifact sulfate on determination of sulfur isotopic composition of lattice-bound sulfate in phosphorite and carbonate sediments. $d^{34}\text{S}$ values of trace sulfates in some lesser Himalayan phosphorites studied in this work showed no significant influence of dissolved oxygen during sample dissolution.

Observational Evidence for Remote Forcing of the West India Coastal Current

Circulation in the north Indian Ocean is influenced by both local and remote wind forcing. So far, however, determining the contribution of these two forcing mechanisms at a location has been possible only in numerical experiments. NIO separates remote and local forcing in observations. Using field measurements (current, sea level, and wind) for a month during March-April 2003 off Goa in the near-coast regime of the West India Coastal Current (WICC), it was shown that the current was driven by local winds only at periods $<$ approx. 10 days, with remote forcing contributing at longer periods. The high-passed (HP; period $<$ 10 days) component of the along-shore current was strongly correlated with the HP component of the along-shore wind, the current lagging the wind by half a day. The low-passed (LP) components of the wind and current were not correlated: the former was unidirectional, but the latter reversed during the period of observation. The relationship between the HP wind and current was used to estimate the locally forced LP current, permitting an estimate of the remote current, the LP residual. This separation of locally forced and remotely forced currents showed that remote forcing contributed as much as local forcing to the WICC. The local current behaved like a classical eastern boundary current forced by local winds. The reversal in the remote current was due to winds 700 km farther south along the coast; frictional damping had an impact only at periods less than 10 days, there being no remotely forced HP current.

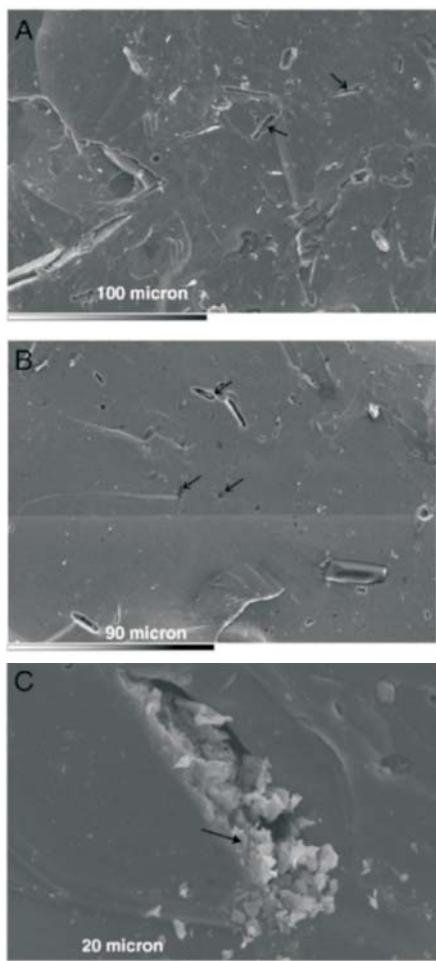


Fig 47: SEM images of reaction pits on pyrite surface after dissolution in FeCl_3 solution. The etch pits are elongated or partially rhombic in shape, while the elongated pits show no preferred orientation.



Technical Consultancy Service in the Area of Geotechnical Engineering

NEIST conducted Geotechnical investigations to collect and interpret geotechnical information on the ground designing the foundation to support a super structure. They are used to assess the suitability of a site for geotechnical engineering purposes such as foundations, ground improvement, roads, embankments, dams and drainage systems. Thus economical and safe designs of foundation are suggested depending upon the site conditions after carrying out field tests and detailed laboratory analyses on the collected soil specimens from the site and evaluating various engineering properties of soil.

2.5 Ecology and Environment

This is an area of research having immense societal and commercial implications; some of the CSIR laboratories have reported work of noticeable significance in this area, as described below.

Delineation of Bioremediation Protocol for High Phosphate Bearing Water Bodies

High concentrations of nitrate, phosphate and fluoride in ground waters have been reported due to the increase in fertilizer application. Phosphorus additions to water-bodies even in small amounts can be of considerable concern and environmental significance by producing accelerated growth of algae and aquatic vegetation, thereby causing eutrophication of the aqueous system like lakes and inland seas. To control eutrophication, phosphate removal from wastewater is often required before being discharged to the receiving water bodies. NBRI has found *Pseudomonas putida* as a best phosphate accumulating bacteria among the screened bacteria. Transposon 5 (Tn5) mutants of *P. putida*, deficient in phosphate accumulation, have been isolated and are being characterized at present at biochemical and molecular levels to elucidate mechanisms that play key role in phosphate accumulation processes. Bacterial strains from phosphate contaminated sites were isolated and cluster analysis of ERIC, PCR fingerprint of high phosphate accumulating *Pseudomonas* strains was developed to elucidate the microbial community structure.

Utilization of Wastes from the Steel Industry

Iron ore concentrates are produced in the Tata Steel's captive mines at Noamundi and Joda. During the production of the concentrates, the plant at mines site also produces iron ore tailing as waste. Physically, iron ore tailing is an assemblage of particles of size less than 150 micron. Part of these particles are iron rich and the rest contains more of alumina and silica. Quite a good number of construction materials such as solid and hollow bricks, pavement blocks of diiferent designs and vitrified ceramic tiles were developed by CGCRI from iron ore tilings. The main features of this CGCRI developed process is lower firing temperature and superior product properties which proved energy efficient.

Electric Arc furnace (EAF) slag is generated as by product in Essar Steel Plants. The slag when dumped at storage sites causes tremendous environmental pollution. The byproduct was utilized by CGCRI to produce commercial size tiles. The properties of the tiles so produced were found to have superior to those conforming the BIS specification. A proposal for setting up the bench scale manufacturing plant is being negotiated with Essar Steel.

Pollution Monitoring at Paradip Port

IMMT has asessed the level of pollution in the Paradip port area. Data on air, water, sediment, noise and biological environment were collected from the target area at planned intervals for study and interpretation. Studies indicated that average concentration of SO₂, NO₂ and NH₃ in the air was lower than that of the national ambient air quality standards. Higher level of SPM was observed due to dust and particulates from traffic, handling at tippler house, conveyer belt and emissions from vehicles bringing material to the site and from ships.

The harbour water was almost free of pollution. However, the concentration of chromium, lead and cadmium were high during loading and unloading operations, probably due to spillage of ores onto the harbour. Concentration of various elements in the sediment samples exhibited wide variations both in bulk and fine fractions. Biological parameters studied in the phytoplankton population

and species diversity indicated that about 18 species occurred in equilibrium with oligotrophic character and there was no eutrophication problem inside the harbour. Noise levels in both within and outside the port area were within the prescribed limits. However, places like general and multipurpose cargo berths, mechanical coal handling plant, market complex and Atharabanki gate showed relatively higher magnitude.

Toxic Potential of Municipal Solid Waste Leachates in Transgenic *Drosophila Melanogaster* (Hsp70-LacZ): Hsp70 as a Marker of Cellular Damage

Municipal solid wastes (MSWs) are one of the major sources of environmental pollution. Leachates from these wastes might contaminate the water sources and affect quality of environment. IITR has determined the possible toxic effects of leachates from MSW in transgenic *Drosophila melanogaster* (hsp70-lacZ). Third instar larvae exposed to 1.0-3.0 per cent of these leachates at different time intervals were examined for hsp70 expression, oxidative stress enzyme activities, proteotoxicity, tissue damage along with effect on emergence and reproduction. Maximum hsp70 expression was observed in the larvae exposed to highly acidic leachates. Overwhelming of hsp70 expression in the exposed larvae caused a concomitant decline in total protein content and a significant elevation in oxidative stress enzymes and lipid peroxidation (LPO) product. The leachates caused a significant delay in emergence of flies and affected the reproductive performance of the flies at the tested concentrations. The present study highlights the toxic potential of MSW leachates and the advantage of *Drosophila* as a model to evaluate the impact of leachates at organismal and cellular levels also; advocating Hsp70 as the first tier indicator of toxicity.

Contamination of Potable Water Distribution Systems by Multiantimicrobial-Resistant Enterohemorrhagic *Escherichia coli*

The contamination of drinking water by fecal coliform bacteria has been reported worldwide. Despite a high incidence of waterborne diseases, enterohemorrhagic *Escherichia coli* (EHEC) is an underacknowledged pathogen of concern to public health in India. IITR has enumerated coliform,

bacteria in potable water samples collected from six locations in Lucknow, a major city in northern India, using the most probable number method. *E. coli* (n = 81), randomly isolated by membrane-filtration technique from four sites, were identified by biochemical characterization. *E. coli* were not detected in samples from two other sites. A total number of, 15 randomly selected isolates from each site for virulence determinants of EHEC were screened using polymerase chain reaction (PCR). The isolates positive for virulence determinants (n = 18) were screened for sensitivity to 15 antimicrobials by the disk diffusion method. The results show that both stx1 and stx2 genes were present in 33.3 per cent of isolates, whereas others possessed either stx1 (11.1 per cent) or stx2 (55.6 per cent). The eaeA, hlyA, and chuA genes were present in 100, 23.3, and 16.7 per cent of isolates, respectively. Resistance to multiple antimicrobials was observed in potential EHEC. It is concluded that the occurrence of multiantimicrobial-resistant EHEC in potable water is an important health concern because of the risk of waterborne outbreaks.

Receptor Modeling for Source Apportionment of Polycyclic Aromatic Hydrocarbons in Urban Atmosphere

IITR reported source apportionment of polycyclic aromatic hydrocarbons (PAHs) in particulate depositions on vegetation foliages near highway in the urban environment of Lucknow city. The IITR used analysis/absolute principal components scores (PCA/APCS) receptor modeling approach. The multivariate method enables identification of major PAHs sources along with their quantitative contributions with respect to individual PAH. The PCA identified three major sources of PAHs viz. combustion, vehicular emissions, and diesel based activities. The PCA/APCS receptor modeling approach revealed that the combustion sources (natural gas, wood, coal/coke, biomass) contributed 19-97 per cent of various PAHs, vehicular emissions 0-70 per cent, diesel based sources 0-81 per cent and other miscellaneous sources 0-20 per cent of different PAHs. The contributions of major pyrolytic and petrogenic sources to the total PAHs were 56 and 42 per cent, respectively. Further, the combustion related sources contributed major fraction of the carcinogenic PAHs

in the study area. High correlation coefficient ($R^2 > 0.75$ for most PAHs) between the measured and predicted concentrations of PAHs suggests for the applicability of the PCA/APCS receptor modelling approach for estimation of source contribution to the PAHs in particulates.

Amenability of Electrochemical Techniques for the Treatment of Wastewaters Generated from Aluminum Industry

NML has studied amenability of electroflotation for the removal aluminum oxy-hydroxide precipitated from synthetic wastewater and water sample from Alcoa's Texas Alumina Refining Plant. The preliminary electroflotation tests conducted on synthetic effluent sample prepared from aluminum sulfate has revealed that nearly 85 per cent of Al could be removed from the wastewater using $\text{IrO}_2/\text{RuO}_2/\text{TaO}_2$ coated titanium within 2.0 minutes of electroflotation and over a pH range of 6.5-8.0.

The recovery of Al by electroflotation was observed to be around 65 per cent in the case of wastewater generated by Alcoa's Texas Alumina Refining Plant. The reason for low floatability was theoretically analyzed in terms of particle size, bubble size and zeta-potential. The organics present in the wastewater (COD) was removed to the extent of 85 per cent by electrooxidation using graphite material as anode. The process of electroflotation was found to be amenable for the removal of aluminumoxy-hydroxide precipitate. The plant wastewater could be reused after separating the pollutants. The extent of purification can be visualized from fig 48.



Fig 48: Plant wastewater Reuse

FOD Characterisation of the Damaged Compressor Blades of MIG-29 KB-3111

At air force station, Jamnagar during the post flight inspection of MIG-29 KB-3111 aircraft, the 1st stage

low pressure compressor blades were found damaged (fig 49 and 50). Preliminary investigation revealed that the blades were hit by foreign object.

The impact of foreign object leads to different kind of damages like tearing, bending, nick formation and dent marks at the leading edge. NML has investigated the damaged blades and found that the affected blades are made off different type of materials like Ti base, Fe base, Ni base and Al base alloys. From the location of damage over the blade surface it is evident that, the Foreign Object Damages (FODs) followed the projectile path of reducing radius in between the successive collision.

The foreign object debris is impregnated at the impact sites and primarily consists of Si, Al, K, Ca, Fe, S and Cl. Their elemental concentration varies within different stages as well as within an impact site. The FODs originated from a rock source which is complex combination of different mineral phases of varying stoichiometry. 8th stage gas generator blade, made of steel, is impacted by rock particles as well as Ti-alloy particles derived from the fractured pieces from forward stages.

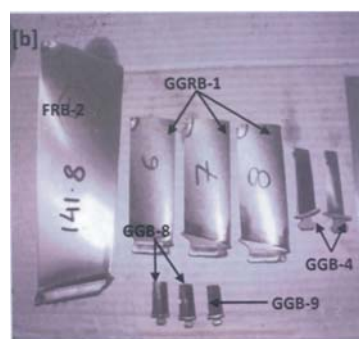


Fig 49: Compressor blades with damaged tip of FRB-2, GGRB-1, GGB-4, GGB-8 and GGB-9



Fig 50: Tip damage to fan rotor blade (FRB-1)

NML issued recommendations to avoid future occurrence of FOD in aeroengines and find out the origin and nature of foreign object. Created fractographic data base for hard body and soft body impacts on the compressor blades.

2.6 Electronics and Instrumentation

This is a sector in which CSIR contributes not only for societal advancement, but also for its strategic importance. Many of CSIR's processes and products in this sector have found applications in India's space, atomic energy and defence programmes. During the year some significant results obtained are described below:

Dip-pen-Nanolithography (DPN)

Continued miniaturization of microelectronic devices and circuits has been the motivation for research and development of new materials, technology and manufacturing equipment., invented recently, is a soft-lithography tool for writing molecules onto substrates in the form of nano-structures, which are one-molecule thick. CEERI has carried out experiments to write nano-dimensional patterns on gold surface. Ultra thin films of Cr/Au on silicon wafers (fig 51) were fabricated by sputtering. Commercial substrates were also used in the writing experiments. MHA (16-Mercapto Hexadecanoic Acid) molecular ink compatible to Gold substrate was used.

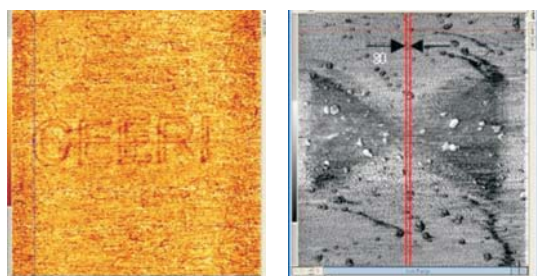


Fig 51: LFM image of word "CEERI" and nano-gap electrodes written using 16-MHA molecular ink on gold surface. Measured minimum line-width (marked)

Design Technology of Sub-system of Gyrotron

Gyro-devices like Gyrotron are used in the TOKAMAK system for plasma heating. Hence, thermal temperature distribution of Gyrotron is very

important. Mainly the Magnetron Injection Gun (MIG), interaction cavity and collector deal with high thermal loading. The operating mode of 200 kW CW, 42 GHz Gyrotron is TE03. CEERI carried out thermal analysis of this Gyrotron cavity using ANSYS software. Heat generated at inner cavity wall due to cavity ohmic wall loss has been cooled using liquid turbulent flow at 290 k. Water has been used as coolant liquid for cooling purposes. After cooling of the cavity, thermal distributions along with cavity structure are shown. Calculated wall loss at the cavity wall is less than critical limit i.e. less than 1×10^4 kW/m². Cooling arrangement of this cavity has been suggested with fins on the outer surface of the cavity.

Evidence for Monoalkoxide Species on the Surface of Palladium Nanoparticles Synthesized in Ethylene Glycol

Palladium nanoparticles consisting of metallic cores and encapsulating shells serve as an intriguing catalytic model system. This investigation was aimed at enhancing understanding of the surface composition of palladium nanoparticles synthesized in polyol and exploiting their encapsulating shells to understand the catalytic properties of the nanoparticles more rationally. CSIO investigated the surface structure of palladium nanoparticles by Fourier transform infrared spectroscopy (FTIR) and thermo-gravimetric analysis (TGA). FTIR spectra showed the presence of mono-alkoxide species with tilted geometry. TGA further confirmed the presence of these species along with some adsorbed byproducts formed during the reaction. Atomic force microscopy (AFM) shows the presence of diffused negatively charged coatings on the surface of the nearly spherical nanoparticles. The important application areas include Nano sensors and Catalysis.

Embedded Dual Fiber Bragg Grating Sensor for Simultaneous Measurement of Temperature and Load (Strain) with Enhanced Sensitivity

CSIO experimentally demonstrated an embedded dual fiber Bragg gratings sensor for simultaneous measurement of temperature and load (strain). Two nearly identical gratings are mounted on opposite side of an arch-shaped steel strip. The grating in

concave and convex position experiences equal blue and red shift respectively due to bending of the strip which is exploited in temperature and load (strain) discrimination. The temperature and load (strain) sensitivity of the sensor improves to 28.5 pm/°C and 2.8 pm/gm. The sensor can measure temperature and load (strain) accurately with small error of $\pm 1^\circ\text{C}$ and $\pm 1\text{gm}$ respectively.

FBG Sensor Technology

Different types of FBGs like Bragg reflectors (fig 52), overlapped and chirped gratings and uniform, chirped and concatenated LPGs have been designed and fabricated by CSIO. Some of these gratings have been supplied to various institutes for their research requirements and evaluation and their performance have been found comparable with the imported ones. Developed FBG and LPG sensors have been investigated for structure health monitoring, Petrol leak detection, Fuel adulteration measurement and results have been published.

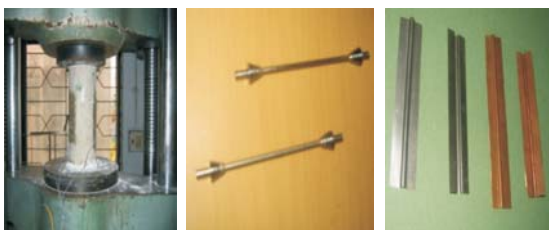


Fig 52: FBG Sensor for Structures

Improved Surgical Microscope for Cataract Surgery

CSIO has developed an improved version of a surgical microscope (fig 53) for cataract surgery. It enhances the surgeon's view of microscopic structures (e.g. nerves, blood lymphatic vessels and lesions). The opto-mechanical design of the microscope has been perceived specifically to meet the requirements of eye surgical applications like keratoplasty, keratoprothitics and cataract operations. The main feature of the surgical microscope is the special motorized focusing control by the foot paddle. Also to meet the high and safe illumination a fiber optical system has been used with switch to change over in case of failure during the operation. The salient features of the microscope include: (i) Sufficient large working

distance between operation field and Microscope, (ii) A true stereoscopic observation, (iii) Good resolution with adequate contrast; (iv) Brilliant and uniform illumination of the field of operation and (v) Adequate useful magnification range to guarantee a rapid change over from low power to high power. With the typical specifications of Common Main Objective (CMO): 200 mm, Tube Lens Effective Focal Length: 144 mm, Eye Piece Magnification: 12.5 X.

The Microscope has thoroughly undergone clinical trials in the Ophthalmology Department of Govt. Rajendra Hospital, Patiala for three months and the reports have been quite encouraging. The instrument was used for three days during an eye camp organized by Shah Satnam Multi Speciality Hospital, Sirsa and forty eight eye cataract operations were successfully performed during the CSIO developed microscope.



Fig 53: Surgical Microscope

2.7 Energy

An area of immense importance to CSIR, this area has got an added thrust during the Eleventh Five Year Plan period and a number of new initiatives are being launched. During the year under report, the work carried out in this area is described below.

Novel Electrode Materials for High Power Lithium-ion Battery Technology

For applications in Electric Vehicles (EV), batteries must sustain high rate current withdrawal and good cycle life. In respect to both, CGCRI-developed nanocrystalline $\text{LiNi}_{0.4}\text{Mn}_{1.6}\text{O}_{4-\delta}\text{S}_\delta$ has shown excellent rate performance and structural stability and hence will lead to high power batteries suitable for EV applications.

Lithium manganese oxide (LiMn_2O_4) is a promising cheaper alternative cathode to LiCoO_2 but it suffers from a severe crystallographic Jahn-Teller distortion resulting in a capacity fading that restricts its commercial use in high power batteries. CGCRI has been successful in stabilizing the crystallographic structure of LiMn_2O_4 by controlling the amount of Ni and S co-doping and thereby arresting Jahn-Teller distortion and Mn dissolution into the electrolyte.

Ni-doped lithium manganese oxysulfides with a nominal composition of $\text{LiNi}_{0.5}\text{Mn}_{1.5}\text{O}_{4-\delta}$ ($0 \leq x \leq 0.5$ and $0 \leq d \leq 0.1$) were synthesized by alanine assisted low temperature combustion process followed by calcination at 700°C in air. Quantitative X-ray phase analyses showed that the spinel structure of LiMn_2O_4 was retained for all compositions. A systematic change in microstructure was observed with increasing Ni content in the presence of S “ the shape of the particles changes from spherical (LiMn_2O_4) to icosahedron ($\text{LiNi}_{0.2}\text{Mn}_{1.8}\text{O}_{4-\delta}\text{S}_\delta$) to octahedron ($\text{LiNi}_{0.5}\text{Mn}_{1.5}\text{O}_{4-\delta}\text{S}_\delta$). UV-VIS spectroscopy showed that the band structure of pristine LiMn_2O_4 was strongly influenced by hybridization among Mn 3d and O 2p orbitals near the Fermi level and the band gap (1.45eV) gradually decreased with increasing nickel content reaching the minimum (1.35 eV) for $\text{LiNi}_{0.4}\text{Mn}_{1.6}\text{O}_{4-\delta}\text{S}_\delta$. Electrochemical results on 2032 coin type cells, fabricated with the synthesized powders as cathode and Li metal as anode, revealed that the substitution of S for O and Ni for Mn in LiMn_2O_4 enhanced the structural integrity of the spinel host, which in turn increased the electrochemical cycleability.

Demonstration of Planar Anode-supported Solid Oxide Fuel Cell (SOFC) Stack

CGCRI has developed and demonstrated a working SOFC stack based on the planar anode-supported SOFC design fig 54. Accordingly, large numbers of anode-supported single cells of dimension 10cm x 10cm x 1.5mm have been fabricated that show good power output at an operating temperature of 800°C ($\sim 1.0\text{W}/\text{cm}^2$ at a cell voltage of 0.7V). At single cell level, it has been shown that its capability is even better than international level. Similarly, glass-based sealants, an essential component for stack development, have also been developed

indigenously. Using the developed 10x10 single cells, glass-based sealants, and ferritic steel-based metallic interconnect and gas manifolds (Crofer22APU), several SOFC short stacks (3-cell, 6-cell and 10-cell) have been fabricated and demonstrated for the first time in India.

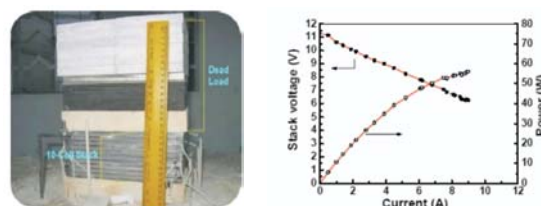


Fig 54: A 10-cell SOFC stack assembly developed at CGCRI and its electrochemical performance

Improvement in Fuel Efficiency by Reducing Kiln Car Mass

CGCRI has modified the present kiln cars in the tunnel and shuttle kilns used in the ceramic units around Khurja which incur huge expenses due to inefficient combustion. Designs of kiln cars with low mass materials which would reduce the dead mass of the cars absorbing major part of the heat during firing were tried for reduction of fuel consumption. New designs were developed and reduction in the mass of the developed kiln cars was also calculated. The new low thermal mass kiln car designs showed that there would be a reduction in mass by 25-40 per cent. It was estimated that the reduction in the mass would assure fuel saving by at least 10-15 per cent and enhance productivity by 5-10 per cent.

CGCRI Recognised as an Industrial Testing and Evaluation Centre

The CGCRI Naroda centre has been approved by the international inspection agency 'Intertek' and listed in their international directory for providing testing services for the ceramic raw material and product prior to export. Testing and evaluation has been one of the main activities of this centre in carrying out physical and chemical analyses of ceramics, glass, refractory raw materials and allied products that are received from industry and



government institutions. The service provided by this centre help the ceramic industries in maintaining quality standards of raw materials products. The Naroda centre has become an important service provider and has already established its position as a centre of excellence in testing activities.

2.8 Food & Food Processing

One of the earliest organizations to work in the area of food processing, CSIR has over the years developed several products and processes. During the year under report, the salient developments are as reported below.

Natural Flavourant from Swallow Roots

Decalepis hamiltonii is a monotypic genus found in the Deccan (South) peninsula, mostly in the forest regions of Eastern and Western Ghats. The swallow root has a strong aromatic odour and sweet taste, and it is used in traditional Indian medicine as an appetizer and blood purifier. The chemical compound responsible for the aroma and taste of *Decalepis hamiltonii* plant Swallow root is 2-hydroxy-4-methoxy benzaldehyde (HMB), which is an isomer of vanillin. CFTRI has developed a process for optimizing extraction and isolation of HMB from swallow roots. A process has also been developed for expanded horse gram to give an acceptable expanded ready-to-eat snack product. The product has 'reduced anti-nutritional factors' with improved protein digestibility. The product is crisp, crunchy and shelf stable. It can be used as such or as a snack after salting or spicing. It can also be added as an ingredient in cereal bar or chikki.

The process is ready for commercialization. The extract is crystallized in a low polar solvent to get the final product. HMB (2-hydroxy-4-methoxy benzaldehyde) from swallow roots finds application as a natural flavourant in beverages, dairy products and bakery products.

Bio-control Potential of Tortoise Beetle (*Aspidomorpha miliaris*) Coleoptera: Chrysomelidae) on *Ipomoea Carnea* in Assam

Ipomoea carnea, a plant native of South America, a noxious aquatic weed with rapid vegetative growth

and high invading powers spread in all districts and threatens native flora and fauna of aquatic fresh water habitats in Assam. It can spread rapidly in croplands and protected wildlife reserves, where it produce a huge biomass of 17.93 tons per hectare. Chemical pesticides are often recommended but found to contaminate water and would threaten to aquatic flora and fauna. Mechanical control method is too expensive. Therefore, biological control of this weed is the significant option for its management. NEIST studies found that *A. Milliasis* is a potential control agent for menacing weed spec in *I. Carnea* in India.

Review of Insect Pest in Tea

Globally, 1031 species of arthropods are associated with the intensively managed tea *Camellia sinensis* (L.) O. Kuntze monoculture. All parts of plant, leaf, stem, root, flower and seed, are fed upon by at least one pest species, resulting in an 11 per cent -55 per cent loss in yield if left unchecked. There has been heavy use of organo-synthetic pesticides since the 1950s to defend the plant against these pests, leading to rapid conversion of innocuous species into pests, development of resistance and undesirable pesticide residues in made tea. As a result of importer and consumer concerns, pesticide residues have become a major problem for the tea industry. Integrated pest management (IPM) may help to overcome the overuse of pesticides and subsequent residues. NEIST reviews the advances made in understanding of the biology and ecology of major insect and mite pests of tea, host plant resistance, cultural practices, biocontrol measures, and need-based application of botanicals and safer pesticides to understand the present status of IPM and to identify future challenges to improvement.

Vanillin: Value added Products from Agricultural Waste

NEIST has developed a novel process for the preparation of Vanillin (4-hydroxy-3-methoxy benzaldehyde). This invention particularly relates a novel method for synthesis of vanillin. The preparation of vanillin by a single-step oxidation of ferulate moiety of rice straw, a renewable agricultural waste in the presence of hydrogen peroxide, manganese sulphate, cupric chloride,

sodium acetate and sulphuric acid and water under reflux condition in 1-3 hours. The process does not involve any costly or hazardous chemicals. Apart from that, the water and inorganic compound can be recycled.

Value addition to Agri Food Products

Xylanases: Xylanases (E.C. 3.2.1.8; 1,4 - beta-D-xylan xylohydrolases) are the major cell wall degrading enzymes induced during germination facilitating the mobilization of endosperm reserves. Xylanases, with molecular weight 29 kDa from malted finger millet have been purified by CFTRI to homogeneity by conventional protein purification methods. By the analysis of the products liberated from larchwood xylan by ESI MS and H1 NMR the enzyme was identified as 'endo xylanase'. The xylo-oligo saccharides liberated have prebioactive activity and find application in the development of functional foods.

Peroxidase Enzyme for Bakery Products:

Wheat dough formation is a complex process which involves interaction between many components like proteins, carbohydrates, and enzymes. The polymeric glutenin provides elasticity and gliadin provides viscosity to the dough. Peroxidase is an enzyme which contributes to the cross linking of wheat proteins. The enzyme peroxidase was purified by CFTRI and its functional role in baking applications has been established.

Natural colours

The major colouring principles beta cyanin and beta xanthin present in beet root have been fractionated by CFTRI to homogeneity by aqueous two-phase extraction. Curcumin a natural yellow colourant from turmeric has been rendered water soluble by preparation of amino acid derivatives. These amino acid derivatives with high anti oxidant and anti mutagenic activities, could find potential applications in food and pharma industries.

Cyclic Peptides as Proteinase Inhibitors:

Protein inhibitors for proteinases are widely distributed in plants, being particularly abundant in storage tissues such as seeds and tubers. The

Bowman-Birk Inhibitors (BBI) have been extensively studied and their use as chemo-preventive agents is well-established. CFTRI has cloned the horse gram Bowman-Birk Inhibitor (HGI III) and overexpressed it. The over-expressed protein was purified to homogeneity by affinity chromatography. The expressed protein (pETHGI) was characterized and compared with the virgin seed inhibitor. Smaller cyclic peptides designed based on the inhibitory loop structures of HGI-III the major iso-inhibitor was cloned using pTWIN-1 vector. The protein was expressed in *E. coli* B ER 2566 and purified by chitin bead affinity chromatography.

2.9 Health Care, Drugs and Pharmaceuticals

CSIR has a formidable presence in this area with a number of laboratories contributing significantly by way of highly cited publications and commercially attractive processes/notable products. Some achievements during the year in this area are listed below:

DNA Organization of the Apicoplast Genome of the Malaria Parasite

The malaria parasite, *Plasmodium falciparum*, carries a non-photosynthetic plastid of secondary endosymbiotic origin called the apicoplast. The organelle is essential for parasite survival and is of interest for identification of novel drug targets for malaria. The *P. falciparum* apicoplast contains a 35 kb, circular DNA genome with limited coding capacity that lacks genes encoding proteins for DNA organization and replication. The role of a *P. falciparum* nuclear-encoded bacterial histone-like protein (PfHU) in DNA compaction in the apicoplast has been revealed by the current research work. PfHU associates with apicoplast DNA and is expressed throughout the parasite's intra-erythrocytic cycle. The protein displays a preference for supercoiled DNA and is capable of condensing *E. coli* nucleoids *in vivo*. The unique 42 aa C-terminal extension of PfHU influences its DNA condensation properties. In contrast to bacterial HUs that bend DNA, PfHU promotes concatenation of linear DNA and inhibits DNA circularization. Atomic Force Microscopy of PfHU-DNA complexes shows protein concentration-dependent DNA stiffening, intermolecular bundling and formation of DNA bridges followed by assembly of condensed

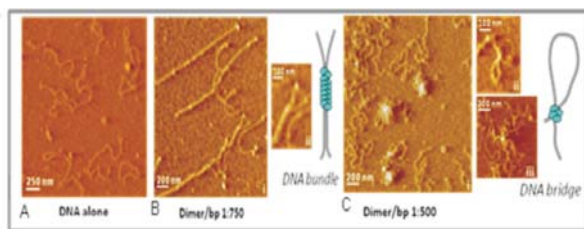


Fig 55: AFM images of PfHU_p - DNA complexes with increasing dimer/bp ratio. (A) DNA in the absence of protein. (B) Dimer/bp ratio of 1:750. Stiffened DNA strands (panel i) as well as DNA bundles (panel ii) are shown. (C) Dimer/bp ratio of 1:500. Formation of complexes with a small number of foci and extruding DNA loops (panel i), a DNA bridge resulting in DNA looping (panel ii) and a nucleoprotein complex with a single focus (panel iii) are seen.

DNA networks (fig 55). These results have provided the first functional characterization of an apicomplexan HU protein and give additional evidence for red algal ancestry of the apicoplast. CDRI revealed the role of a falciparum nuclear-encoded bacterial histone-like protein (PFHU) in DNA compaction in the apicoplast.

Characterization of Rv3868, an Essential Hypothetical Protein of the ESX-1 Secretion System in Mycobacterium Tuberculosis

Over 40 per cent of the *M. tuberculosis* genome codes for proteins of unidentified functions. These represent a wealth of information to be exploited, especially in the identification of novel therapeutics. Rv3868, a conserved 63 kDa hypothetical protein of the ESAT-6 secretion system is essential for the secretion of at least four virulence factors. CDRI's studies show that it consists of two domains joined by a linker. The N-terminal domain is a compact, helical domain of approximately 30 kDa and apparently functions to regulate the ATPase activity of the C-terminal domain and oligomerization. The nucleotide-binding site is situated in the C-terminal domain, which exhibits ATP-dependent self-association. It is also the oligomerization domain. The N-terminal domain is proximal to the C-terminus in the apo protein and exhibits a specific movement upon ATP binding. In silico modeling of the domains suggests that Arg-429 of a neighboring subunit

forms a part of the binding site upon oligomerization. Mutational analysis of binding site residues demonstrates that the Arg-429 functions as the important "sensor arginine" in AAA-ATPases. The studies also rule out a general chaperone-like function for Rv3868, and suggest that ATP-dependent "open-close" movements of the individual domains enable it to interact and transfer energy to co-proteins in the ESX-1 pathway.

First Total Synthesis of (+)-Varitriol: An Antitumor Natural Product from Sea

CDRI has synthesized a highly stereoselective (+)-varitriol, an antitumor natural product, for the first time from commercially available methyl D-mannopyranoside and 2,6-dihydroxybenzoic acid. (+)-Varitriol isolated from marine strain (named M75-2) of the fungus *Emericella varicolor* exhibits potent cytotoxicities toward a variety of cancer cell lines most notably with selected renal, CNS and breast cancer tested within the 60 cell line panel of the National Cancer Institute (NCI). Earlier two total synthesis of enantiomer of this natural product were reported. The furanoside part was synthesized from D-ribose suggesting synthesis of natural isomer could be possible from L-ribose which is highly expensive sugar. In contrast, CDRI developed cost-effective first total synthesis of this active natural product (+)-varitriol starting from inexpensive methyl D-mannopyranoside and 2,6-dihydroxybenzoic acid utilizing highly diastereoselective iodocyclization strategy for the synthesis of furanoside unit of varitriol (as depicted in fig 56). This methodology can be applied for the construction of novel isomers and analogues of this natural product to evaluate their anticancer activity to obtain better biological activity profile.

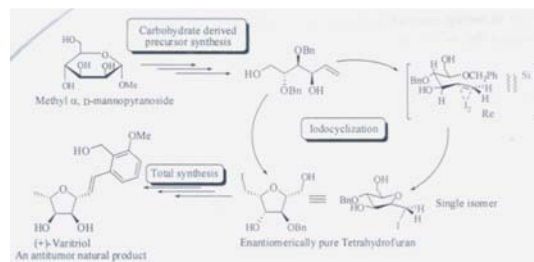


Fig 56: Total synthesis of Varitriol

Rationally Designed Spermicides for Selectively Targeting Human Sperm in Vagina to Ensure Safe Contraception

Killing ejaculated spermatozoa outside the male body in a rather *ex-vivo* condition during their very brief stay in vagina offers a simple and safe method of contraception. Nonoxynol-9 (N-9) is a surfactant spermicide that forms the active ingredient in most of the vaginal contraceptives available in the market. Recent clinical trials have shown that regular use of N-9 based contraceptives increases susceptibility to STDs and HIV, and WHO/FDA have issued a caution. CDRI's enduring efforts to design, synthesize and evaluate novel molecules with a specific, mechanism-based action on sperm cells resulted in the discovery of two spermicidal compounds (DSE-36 and DSE-37, disulphide esters of carbothioic acid) with extremely potent spermicidal action that killed 100 per cent human sperm at just 4 per cent of EC_{100} of N-9 while remaining practically inert to human cervical cells and *Lactobacillus* at spermicidal concentration. The ability of these novel spermicides to kill sperm almost instantaneously at innocuously low concentration that spares cervico-vaginal cells and *Lactobacilli* indicates their worth as improved active ingredients for vaginal contraceptive preparations compared with N-9.

Caenorhabditis Elegans Functional Genomics in Toxicity Testing and Identification of Novel Drug Targets:

CDRI uses model organism functional genomics towards toxicity testing and identification of novel drug targets. Initial studies have led to creation of a novel *Caenorhabditis elegans* model for a specific viral protein-mediated pathogenesis. Using *E. coli* mediated transformation system, the viral protein of interest was systemically delivered to the intact organism via a pET-28a vector. Experiments were carried out using age synchronized nematodes and the systemic absorption of the protein via the gut of nematodes, was observed after carrying out immunohistochemistry of exposed nematodes v/s that of control. The synchronously raised population of nematodes was then observed for pathogenic effects caused as a result of protein expression.

Results indicated that the phenotype exhibited by the nematodes, might very well be in agreement to the pathogenic effects observed in case of humans. To further understand the epistatic correlation of the observed effects, CDRI carried out studies using a transgenic strain of *C. elegans* carrying an integrated green fluorescence protein (GFP) tagged to the FOXO transcription factor (DAF-16). *daf-16* is a *C. elegans* homologue of mammalian forkhead transcription factor (FOXO). FOXO is known to play critical role in immune function. Further, a key pathway- the DAF-16/DAF-2 pathway, is conserved between humans and *C. elegans*. The studies in the transgenic strain led to the observation that DAF-16 is upregulated in the presence of viral protein under study. This point towards involvement of DAF-16/DAF-2 (fig 57) pathway in the process of pathogenesis induced by the protein of interest.

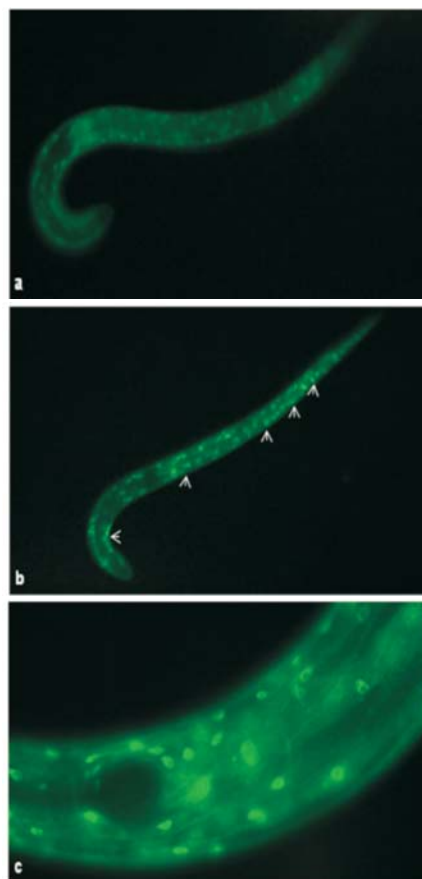


Fig 57: Expression of DAF-16 in a transgenic DAF-16::GFP strain (a) control, (b) viral protein treated (c) viral protein treated nematode at higher magnification



CDRI's Progress in the Development of Candidate Drugs under Clinical Trials

Compound 80/574 (anti-hyperlipidemic) is being developed in collaboration with Cadila Pharmaceuticals Ltd., Ahmedabad. Data compilation of the Phase III clinical trials of 175 cases has been completed. Final report is awaited from Cadila for future course of action.

Picroliv (Hepatoprotective) is being developed in collaboration with DIL, Mumbai. Phase III double blind clinical trials in patients of tuberculosis receiving MDT is to be concluded.

Compound 97/78 (antimalarial) is being developed in collaboration with IPCA Labs, Mumbai. Phase I clinical trials are in progress at PGIMER, Chandigarh. Thirteen healthy male volunteers have completed the study so far.

CDR-134 D-123 (antihyperglycemic) is being developed in collaboration with TVC Sky Shop Ltd., Mumbai found safe in phase I single dose tolerance study in 32 healthy human volunteers.

Compound 99/373 (antiosteoporosis-antiresorptive) is being developed by CDRI. Permission to initiate Phase I clinical studies has been received from DCGI and dossier sent to PGIMER, Chandigarh for Ethics Committee clearance. Phase I clinical trials are to be initiated.

Ayurgenomics: CSIR study carried out at IGIB, Delhi. Establishes Links between Ayurveda and Modern Science for Predictive and Personalized Medicine:

In a landmark study, it has been demonstrated by IGIB that normal individuals within the same ethnic population, clustered on the basis of clinical criteria described in Ayurveda, show variations in the basal levels of blood parameters used in routine for diagnostic purposes, as well as in basal levels of expression of genes. Here links have been found between Prakriti, a fundamental principle of personalized medicine of Ayurveda, and modern genomics for development of predictive and personalized medicine. The study reveals that it is possible to identify groups within normal individuals of the populations, which could be predisposed to

certain kind of diseases, and also might respond differently to drugs. Such integration of the principles of Ayurveda with genomics, appropriately termed as Ayurgenomics, holds great potential and promise for future predictive and personalized medicine at an affordable cost.

Enzymatic Membrane for the Detection of Cholesterol in Serum

An enzymatic membrane has been prepared by IGIB through co-immobilization of cholesterol oxidase (COD) and cholesterol esterase (COE) onto a new immobilization support. The enzymes were co-immobilized on this membrane by entrapment method. The pH stability and thermal stability of the co-immobilized COE and COD were found to be higher as compared to the free enzymes. In addition, this enzyme membrane was used several times for estimation of cholesterol by colorimetric method without loss of enzyme activity. This enzyme membrane was further attached to the oxygen electrode and a linear relationship was observed between the oxygen consumption and cholesterol concentration. This enzyme membrane can be stored at room temperature for 30 days without any loss of activity.

Quick and Reliable Estimation of BOD Load of Beverage Industrial Wastewater

An amperometric biosensor for determination of biochemical oxygen demand of using industrial wastewater has been developed by IGIB to overcome the time-consuming BOD monitoring procedures. Moreover, the sensor exhibits good repeatability (3.39–4.45 per cent) and reproducibility (1.85–2.25 per cent). An in-house developed software has been added to upgrade this sensor and to make it amenable for online monitoring of industrial waste water. This device takes very less time as compared to conventional method which takes 5 days.

Interaction of Cytochrome P4501 A1 Genotypes with other Risk Factors and Susceptibility to Lung Cancer

IITR investigated association of polymorphisms in cytochrome P450 1A1 (CYP1A1) and glutathione-S-transferase M1 (GSTM1) with risk to squamous

cell carcinoma of lung malignancy. The simple size was 200 lung cancer patients of King George's Medical College, Lucknow. Equal number (n=200) of age and sex matched healthy individuals were also enrolled in the study. The data revealed that the variant genotypes of CYP1A1*2A, CYP1A1*2C and CYP1A1*4 were found to be over represented in the lung cancer patients when compared to controls. CYP1A1*2A variant genotypes (combined heterozygous and mutant genotypes) revealed significant association towards the lung cancer risk (OR: 1.93, 95 per cent CI: 1.28-2.89, p=0.002). Haplotype analysis revealed that CYP1A1 haplotype, C-G-C increased the lung cancer risk (OR: 3.90, 95 per cent CI: 1.00-15.04, p=0.025) in the patients. The lung cancer risk was increased two-to fourfold in the patients carrying the genotype combinations of CYP1A1*2A and GSTM1 suggesting the role of gene-gene interaction in lung cancer. Cigarette smoking or tobacco chewing or alcohol consumption was also found to interact with CYP1A1 genotypes in increasing the risk to lung cancer further demonstrating the role of gene-environment interaction in development of lung cancer.

Blood Levels of Polycyclic Aromatic Hydrocarbons in Children of Lucknow

Polycyclic aromatic hydrocarbons (PAHs) are compounds produced by incomplete combustion of organic substances. These chemicals are known to have carcinogenic, mutagenic, and teratogenic effects. Children are exposed to these compounds through inhalation, dietary ingestion, and, also, soil at the playground. IITR, in collaboration with the Pediatrics Department, King George's Medical University (KGMU), Lucknow determined its exposure in children by estimating blood PAHs levels. Acenaphthylene, Anthracene, Phenanthrene, Fluoranthene, Naphthalene, Pyrene, Benzo(B) Fluoranthene, Benzo(K)Fluoranthene, and Benzo(A)Pyrene were determined by HPLC-FD/UV. On the basis of the individual compound, the median (50th percentile) of naphthalene (19 ppb) was highest, however, benzo(a)pyrene (4 ppb) level was found to be lowest among all detected PAHs. The median level of total noncarcinogenic PAHs (113 ppb) was higher than the total carcinogenic PAHs (32 ppb) in blood samples of children. A significant correlation was

found between period of time spent in the surrounding breathing zone of the cooking place and total noncarcinogenic PAHs ($p < 0.05$), while the blood carcinogenic PAHs level in children was found to be associated with lower status of their families ($p < 0.05$). It is speculated that there may be chances of health hazards through exposure to PAHs, those not yet declared hazardous and present at higher concentrations in the Indian environment.

Benzoate and Synthetic Colour Risk Assessment of Fast Food Sauces Served at Street Food Joints of Lucknow

IITR has evaluated the quality compliance of benzoate and food colours in the two common fast food accessories, namely tomato and chilli sauces, served at Street Food Joints (SFJs) and compared with counterpart branded products. Both sauces served at SFJs employed excessive amounts of benzoic acid in comparison with branded products ($p < 0.05$). In spite of a ban, presence of artificial colours such as Amaranth, Carmoisine, Erythrosine, Ponceau 4R, Sunset Yellow and Tartrazine were noted in a vast majority of SFJ sauce samples. All branded sauces, however, adhered to the prescribed limit of benzoate and contained no artificial colour. Intake estimates for benzoate and one of the colours, Sunset Yellow, in high consumers among children are likely to saturate 33 per cent and 20 per cent of the ADI at 95th percentile levels, respectively, which appears to be on the higher side. Street Food Joints (SFJs) cater to the demand of floating domestic/foreign tourist populations and serve as a source of employment generation. This sector needs some assistance to enable them to survive in the competitive markets but not at the cost of quality. Effective risk communication and food safety awareness measures designed for street vending outlets are required so that such lapses of street vending outlets could be minimized.

2.10 Housing and Construction

For a few of CSIR laboratories, civil and structural engineering including study of characteristics of buildings, roads, bridges, materials, etc., of various dimensions has been a domain of strong expertise. These laboratories carry out not only fundamental



studies of importance, but are also well known for offering S&T consultancy to various infrastructure related projects. Their achievements during the year are described below:

Bagasse-Cement Board

A new bagasse-cement board and panels have been developed by CBRI using sugar cane bagasse and cement. These panels and boards are suitable for use in buildings as paneling material and for making paneled door shutters. The product is cost effective and the technology can be adopted at any level for commercial production. Complete specifications have been filed for getting the patent. Typical prototypes of board and panel are shown in fig 58.



Fig 58: Bagasse-cement board and panel

Revelation of Structures, Lithology and Geomorphology on the Slope Stability

Kaliasaur Landslide

Kaliasaur landslide has been active for the last five decades. It blocks the National Highway-58 during every rainy season causing risk to life, hardships to people and huge revenue loss on repeated restoration. CRRRI carried out extensive studies to find out the control of geometry of the structures on topography, detailed geomorphologic mapping. The landslide area has been divided into various zones of stability based on the characterization of rock mass and slope mass using RMR (Rock Mass Rating) and SMR (Slope Mass Rating) techniques. Monitoring of the landslide for its behavior is continuously being done with the help of specially designed steel pedestals and DGPS (Differential Global Positioning System).

It is found that area is highly susceptible for slope instability and there are 3 types of failures viz.

plane/block failure, talus failure on the upper reaches and circular failure at lower reaches close to NH-87. Further, studies reveal that there are several natural as well as anthropological factors triggering landslide. It was also found that there are many natural factors viz. lithology, geological structure of rock mass, geomorphology, steep slopes, heavy rains etc. causing stability problems of the Amparav landslide. The anthropological factors such as deforestation, excessive irrigation, non maintenance of old remedial measures, construction of civil engineering structures without taking consideration of present slope stability status etc. are also equally responsible for the slope instability in the area.

Based on comprehensive studies, a set of remedial measures are suggested to control all types of landslides related plane/block failure, talus failure and circular to failure in the Amparav area.

Road Safety Audit of Mumbra Bypass on NH 4

The Mumbra bypass on NH4 from km 133/800 to 138/200 (Length 5.4 Kms) was opened for the traffic on 28th December, 2007.

Since its opening fatal accidents (e.g. four upto April 2008) have occurred on this stretch. With a view to evolve preventive measures and minimize the occurrence of accidents. CRRRI undertook a Road Safety Audit of Mumbra bypass on the request of PWD.

This report presents an account of the traffic studies (fig 59) and the findings of the Road Safety Audit along with the suggested measures to be implemented to prevent accidents on the stretch.



Fig 59: A view of the study section

Understanding Aggressive Driving, Road Rage and Mitigation

CRRRI undertook study to explore the causes of Road Rage through R&D in collaboration with Experts agencies like Delhi Traffic police, and National Institute of Mental Health and Neuro Sciences (NIMHANS), Bengaluru. To understand the mechanisms underlying young drivers' risk-taking behavior in traffic, Road Safety and Anti Aggression campaign is needed which attempts to integrate two of the research purposes, the personality trait approach and the social cognition approach.

Stepping forward for inculcating awareness and reducing violence among school kids Delhi Police are initiating an Anti Aggression Campaign "NAVCHETNA" under the chairmanship of Additional Commissioner of Police; Licensing Branch CRRRI is collaborating as a coordinator and active participant in this campaign. Over sixty schools are participating in this campaign. As a first step in this campaign First Aggression Management Workshop was organised to bring attitudinal change among the students and social climate so that normative behavior of children is constructive.

Remote Health Monitoring Scheme for Civil Engineering Applications

SERC developed a Remote Health Monitoring Scgene (RHM) which has the following salient features:

- The scheme operates in any mode of communication, i.e., RF/PSTN/GSM depending upon the availability of network at site.
- In a single platform, data can be acquired remotely from different types of sensors which are normally used for structural health monitoring.
- The scheme can acquire both high speed dynamic data and also slow speed static data.
- It can also send alarm messages to the user in case of any abnormal event and acquires data at a higher sampling rate automatically.

- Sensors with higher sampling rate and lower sampling rate can be seen in a single window.
- The developed scheme can be integrated with other data acquisition devices which are already in use at SERC. Additional data acquisition systems can also be integrated in the future.
- The scheme has capabilities for data synthesis/reduction using user defined algorithms to reduce the data transmission load.

This technology provides simultaneous monitoring of a number of structures, which are geographically located at different places from a single monitoring station. This technology can be implemented for efficient and economical handling for monitoring of civil infrastructural systems.

Analysis of RC Structural Components based on Damage Mechanics Concepts

SERC has modeled the shell structure of a large cooling tower and analysed it using ULTSTR module. The height and base radius of the tower are 150 m and 58.1 m, respectively. The base thickness of the shell is 750 mm. The shell is discretised using 650 layered shell elements. Each element is modeled as six plane stress concrete layers and two orthogonal steel layers on both faces. The response of the cooling tower is computed for wind loads specified by IS: 875 and IS: 11504 (both in terms of magnitude and distribution). In addition, self weight of the shell is also included in the analysis. Radial symmetry of the structure as well as loading has been exploited by modeling only one half of the structure. Appropriate boundary conditions are imposed at the plane of symmetry. The circumferential and meridional stress resultants per unit length of shell at a critical longitudinal section are plotted in fig 60.

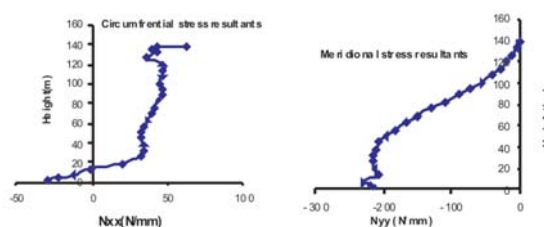


Fig 60: Circumferential and meridional stress resultants



Crack Width calculation at Different Load Levels of RC Shell Structures

A methodology has been formulated to calculate the crack width at different load levels of RC shell structures. For this, a bilinear tension softening model along with the results of direct tension test has been used. The expression has been implemented in program modules and integrated with ULTSTR module of FINEART program. The updated module has been validated by analyzing a reinforced concrete beam which has been experimentally tested at the concrete composite laboratory of SERC. Only one half of the beam has been modeled and analysed taking advantage of symmetry in geometry, support and loading conditions. The beam is discretised into 10 finite elements along the length while the cross section is represented by 6 concrete layers. Reinforcement at top and bottom are smeared into concrete layers at respective locations. Contribution of shear reinforcement is indirectly incorporated in the finite element model by enhancing the shear stiffness. The response obtained from numerical simulation is presented along with the experimental results in figure 61.

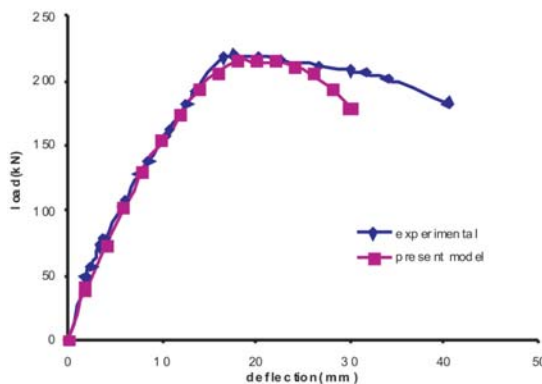


Fig 61: Load vs deflection at centre of the beam

The excellent nonlinear response prediction capability of the present model can be seen from the comparison. It is to be particularly noted that the present model performs fairly well even in the immediate vicinity of post ultimate range. The ultimate load predicted by the model is 212 kN where as experimentally obtained ultimate load is 215 kN. The model has also been used to predict the width of cracks present in all the elements.

Mathematical Modeling of Slip in a Buried Shear Fault

SERC has modelled a slip in a buried shear fault as an equivalent single couple along with a single distributed force. Towards this, general solution of a three-dimensional non-homogeneous wave equation is derived using triple Fourier series wherein excitation is assumed in symbolic form. A rectangular volume of rock is assumed with fault plane as x-y plane at some level and direction of the slip is along x-axis. The body force equivalents of the fault slip are calculated and used in the general solution of the wave equation. A potential function is defined as the representative of the severity of the ground motion felt at the site and maximization of the potential function is carried out to define the convex model parameters. The displacement history at the center of the fault is then generated. It is noted that fault displacement time history is required to model the slip numerically. However, monitoring of fault displacement is rare in most cases, at least, in India. Therefore, it is assumed that fault displacement is likely to be constrained by Ellipsoidal-Fourier-Bound convex model and an attempt is made to account for the uncertainty in fault displacement by such convex modelling.

Measurement Technique for Evaluation of MRTS

SERC conducted measurement of recently constructed MRTS Railway Bridge near Taramani in Chennai. The main aim of the load test is to evaluate the longitudinal force on a typical trestle. Instrumentations at various locations on rail, girder and piers were carried out to measure strains, deflections, accelerations, longitudinal force etc. Electrical resistance strain gage were used to measure strains due to bending and shear and also to measure longitudinal forces. LVDTs and accelerometers were employed to measure deflections and accelerations. A special strain gage based load cell was used to measure the longitudinal forces developed in the pre-stressed concrete girders. The bridge girder and rails were also instrumented with vibrating wire strain gages mainly to check the response of the bridge due to temperature variations. Static and dynamic load

tests were conducted. In dynamic load conditions, train running with different speeds varying from 30 kmph to 70 kmph was tested. Tests were also conducted to measure the tractive effort and braking effort case to get the longitudinal forces developed.

2.11 Information Dissemination and Products

Realising the exponential growth in the IT sector and knowledge-based societies powering the current century, CSIR laboratories have evolved strategies to derive the benefits from its rich data and information base. Several initiatives towards that have been taken as under:

'Indian S&T- 2008' (Supra Institutional Project).

NISTADS has brought out a comprehensive report on affairs of Indian S&T covering S&T policies, performance indicators and achievements.

The report focuses on six theme viz. S&T human resources; Financing for S&T; Structures, infrastructures and public space in S&T; Indian industry and S&T; outputs of research publications and patents; and rural India and S&T. Each theme is further divided into several sections and sub-sections. An extended summary of this report of about 200 pages and the full report of about 1,500 pages are available.

This research provides important insights into multiple modes of the functioning of the Indian S&T system. Inferences drawn in this report provides important comparative policies, effectiveness of respective instruments, the directions of S&T and the dynamics of S&T linkages with the Indian economy and society.

Energy Research and CSIR: A Policy Document for Future Research of CSIR in Energy Sector.

India's economy stands at a crucial "take-off" stage of Rostov's model. The rapid growth brings its own set of problems, one of the most important being how to cater towards the increased energy demand. At present India imports almost 22 per cent of its total energy requirements. The fluctuation in the global oil and natural gas prices risks the energy security considerably. CSIR has

to play a vital role in planning for the strategic energy research towards the sustainable development. NISTADS has brought out a report which provides an input to the policy makers and technologists in the form of a strategic framework.

Research and Development Roadmap of Advanced Materials and Processes Research Institute

NISTADS has brought yet another significant report on R&D roadmaps of one of its constituent laboratory. The report was to suggest a three pronged strategy i.e. societal, industrial and strategic areas of material science research for AMPRI which must be in line with local, national and global needs. Besides, suggestions to improve the management strategies in terms of evaluation, manpower hiring and project management are also part of the report. In order to assess the strength, weaknesses of AMPRI an attempt was made to compare it with reputed organizations of similar stature like Institute of Material Research (IMR), China and National Institute of Material Sciences (NIMS), Japan.

Women and Science in India

NISTADS has carried out a study related to 'Women in Science' in India. The issues relating to gender and science for a developing country like India using available data and facts would be presented, along with the findings of an empirical study. The study discusses the Indian case in relation to the global scenario. It examines the issues and importance of gender vis-a-vis other characteristics in determining scientists' research related work, research performance, academic rank and professional recognition in the Indian context. An analysis of the data relating to around 500 physical scientists reveals:

- The number of women scientists is marginal (women constitute only 18 per cent),
- There are differences in the social-class background of men and women scientists. This implies that only girls from elite and urban areas were able to choose science as a career,



- Female and male scientists do not differ in terms of research-related attitudes,
- The female scientists do not differ significantly from male scientists in terms of research contributions.

2.12 Leather

Central Leather Research Institute (CLRI) of CSIR is the largest leather institute in the world. Through inputs of S&T and extension activities it has been transforming the leather industry to a modern, vibrant, environment responsive industry. CSIR's pioneering inputs have been at all stages of the industry's activities starting from techniques for flaying of dead animals to storage of skins, using 'no' or 'less' salt, to appropriate time saving and low pollution tanning and processing techniques, to 'low chrome' and 'no chrome' tanning chemicals, to modernization by computerization of net operations in tanning, to new techniques for generating value added specialty leathers, to computer aided designs for footwear, garments, and goods, fashion colour forecasting export certification and not the least of all in creating the human resources needed for the leather industry and the R&D in the sector. It had successfully mounted a pioneering Leather Technology Mission for the sustainable development of the Indian leather industry with vast grass-roots coverage.

Bacterial Wound Infection

Bacterial wound infections are major problems hindering the normal healing process. CLRI has prepared Collagen bilayer dressing with ciprofloxacin from succinylated type-I collagen. FT-IR spectroscopy, SEM analysis, in vitro drug release pattern, antimicrobial activity and in vivo efficacy of the dressing were studied. The results suggest that sustained release of ciprofloxacin from a collagen bilayer dressing eliminates bacteria at the site of infection, leaving a pathogen-free wound environment, and it can be used as a dressing for an on-site delivery system.

Molecular Self-Assembly and Host Guest Interactions

A new tool based on the work of adhesion has been developed by CLRI to quantify adsorption of proteins on solid surfaces. This tool may be used effectively in designing the surface coating using proteins and protein-composite films. Influence of

shear viscosity in promoting fibrillar assemblies in these proteins has been analyzed and a first model for visco-elasticity in protein self-assembly processes has been made.

It is known that proteins could be stabilized against denaturation during storage if they are embedded in an amorphous sugar matrix by drying with sugar. The study addressed the molecular mechanism of dehydration of biomaterials like enzymes-lysozyme, lactase, invertase and lipids immobilized in an amorphous sugar matrix -trehalose.

Variety of copper (II) complexes (Fig 62) have been synthesized as potential metallonucleases and demonstrated that redox chemistry of the metal ion is the most important factor that decides the efficiency of nuclease activity of the metal complex.

The physical and optical properties affected by UV radiation on collagen stabilized using chromium (III) have shown that chromium (III) treated collagen has better stability against UV radiation than native collagen.

The role of amino acid sequence length in the designing of collagen like peptides has been investigated. It is found from the study that to form collagen like peptides minimum of five triplets (15 amino acids) required. These results are immensely useful to design new collagen like peptides from first principles.

Use of hydrogen bonding interaction in the design of self-assembled molecular nanostructures akin to that of carbon nanotubes and fullerenes has been demonstrated. A unified criterion for the formation of nano-structures from a particular basic molecular building block has been formulated from the studies on bowls, balls and sheets of orthoboric acid, metaboric acid and cyanuric acid clusters.

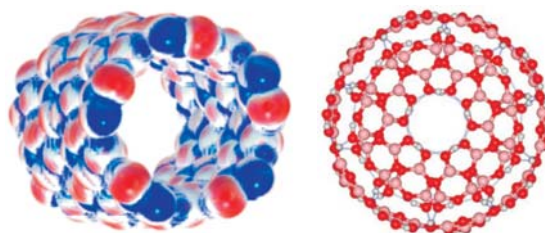


Fig 62: Copper II Complexes

Evaluating and Enhancing the Atom Economy, Atom Efficiency and Energy Efficiency of Leather Processing

Dehairing and fiber opening processes has been achieved by CLRI using an enzyme and sodium metasilicate. The process exhibits significant reduction in COD and TS loads by 55 per cent and 24 per cent, respectively.

Twenty four natural shades were developed using combination of seven natural colorants (Fig 63) such as Rhine, Rhine M, Indus, Pacific, Caspian, Henna and modified Logwood by mordanting with three metal ions. Developed colors have potential value in the global leather market in the context of environmentally benign leather processing.

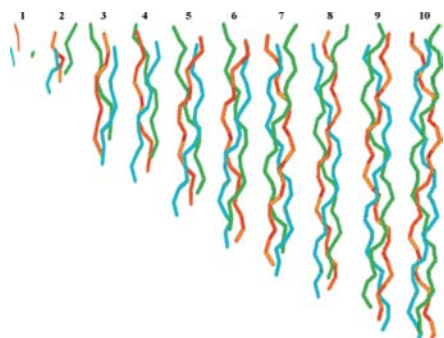


Fig 63: Natural shades using combination of several natural colourants

Modified leather process (reverse process) by treating the delimed pelt with post-tanning chemicals first, followed by chrome tanning, has been developed. The modified process significantly reduces the usage of chemicals (41 per cent), and water (62 per cent) leading to the reduction in COD and TS loads.

Oxidised dialdehyde sodium alginate (DSA) has been successfully shown to act as a potential tanning agent, which results in leathers that are easily biodegradable.

2.13 Materials, Minerals, Metals and Manufacturing

CSIR laboratories have played a significant role in the development of special materials for aerospace, defence and sophisticated industrial sectors, viz., electronic materials such as luminescent phosphors

for display, piezoelectric materials and devices, high purity alumina, conducting polymers, aerospace materials such as high density carbon-carbon composites, lead-free x-ray shielding materials, high performance industrial materials such as silicon carbide, silicon nitride bonded silicon carbide, silicon carbide whiskers; special glasses for optical fibres, infrared range finders and sol-gel techniques for glass coatings, and superconducting materials.

Significant contributions have also been made in various aspects of mining operations, especially in coal mines (excluding heavy mining equipment), subsidence prediction and control enabling extraction of coal locked up in pillars and underneath surface structures and water bodies, for designing appropriate mine ventilation systems and for the mine disaster management in the country. CSIR is uniquely positioned in this area both through Network and Non-network projects. The progress achieved is presented in the following paras:

Helo dunking System through Investment Casting

CMERI has fabricated the components of drive arms and support arms for helo dunking systems using rapid prototyping adopting Stereo Lithography Apparatus (SLA) process. The top domes have also prepared through quasi-hollow SLA quick cast patterns followed by ceramic sheeling and Investment casting of 356-Al Alloy.

It is an important step for manufacturing of intricate geometry as well as thin section cast component and weight reduction of Helo Dunking System through RP Integrated Investment Casting (Fig 64). It has strategic defense applications for suitable transducer housing in naval application under sea depth of 300-500 m.

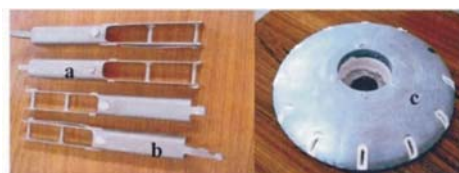


Fig 64: Investment cast (a) support arm (b) drive arm and (c) Top dome components



Development of Hybrid Solar Powered Rickshaw

CMERI has developed a Solar Powered Electric three-Wheeled vehicle, name as SOLECKSHAW (Fig 65). It is aimed for use as a means of transport for carrying two passengers and a driver. This vehicle can be driven either by pedaling or by electric motor or in combination of both. This vehicle is deemed fittest for transporting people through small distances, especially in busy streets of cities. As there are no toxin emissions, a clean environment is ensured.

Novelty of the present invention is use of Brushless Direct Current (BLDC) hub motor instead of Permanent Magnet Direct Current (PMDC) motor. The electric drive and mechanical transmission systems have been separated by installing BLDC motor directly on to the front axle and the mechanical drive on the rear axle. Use of BLDC motor has eliminated torque enhancing devices and additional mounting structures, which are required for PMDC motor. This system has also eliminated use of many mechanical devices like clutch, spring loaded frictional plate and couplings.



Fig 65: Soleckshaw

Improved Cabinet Dryer for Ginger and Turmeric

CMERI has developed an Improved Cabinet Dryer with higher drying rate. Ginger, turmeric and chilli are the major cash crops of Mizoram and other North-East (NE) states of India. The quality of the products is very good in terms of aroma content and the pungency. But at present there is no proper post harvest processing technology. Open sun drying is generally being practiced. The availability of the sun being very uncertain, this development is very important.

A major portion of the produce perishes and the farmers are compelled to sell the remaining in the local market at very low prices. Hence, the dryer is likely to be useful.

Washing unit for Freshly Harvested Ginger/Turmeric

CMERI has also developed a continuous type washing unit (Fig 66) where waste water is being filtered and re-circulated.



Fig 66: Washing Unit for freshly harvested ginger/turmeric

Photonic Crystal Fibers or Microstructured Fibers

CGCRI has developed for the first time in India a special variety of photonic crystal fiber (PCF) having very high nonlinearity and demonstrated its operation in generating wide band supercontinuum (SC) source required for various applications e.g. optical coherence tomography, spectroscopy, metrology etc (Fig 67). In a SC situation, the fibre can change a brief pulse of light (pico or femtosecond) with a narrow range of wavelengths into a spectrum hundreds of times broader and ranging from visible light to the infrared. SC is one of the most exciting areas of applied physics today and the ability to create it easily will have a significant effect on technology.

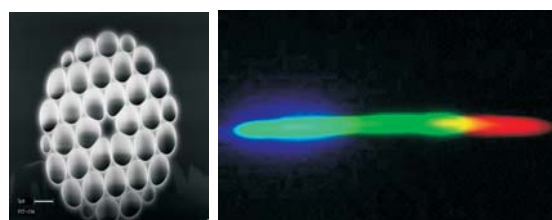


Fig 67: SEM picture of photonic crystal fiber

Patterning of Inorganic (sol-gel) thin Films by Soft Lithography and Self Organization

Soft lithography represents a strategy based on self organization and replica moulding for carrying out micro, meso and nano fabrication. CGCRI used soft lithography technique to pattern sol-gel films of various types (silica, titania, mixed sol etc.). A gel film, in the liquid state is imprinted with a soft stamp (Sylgard 184). Due to capillary action, the liquid rises along the walls of the confining stamp, resulting in a perfect negative replica of the stamp pattern. The AFM (Atomic Force Microscopy) scan in fig shows morphology of the imprinted silica gel film created by CFL. The figure displays line width of $\sim 400\text{nm}$ and periodicity of $\sim 800\text{nm}$. These structures will be used by CGCRI for the fabrication of planar waveguide based optical sensors. AFM image of 1-D grating is shown in fig 68.

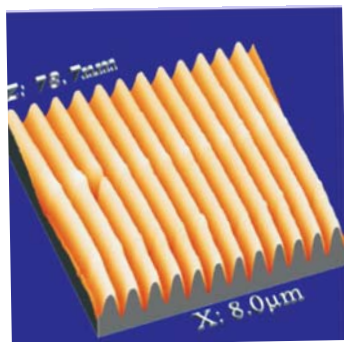


Fig 68: AFM image of 1-D grating structure
A novel combination of self organization and soft lithography was also utilized to create ordered 2 – D patterns using a simple 1 – D (stripe) patterned stamp.

A novel combination of self organization and soft lithography was also utilized to create ordered 2 – D patterns using a simple 1 – D (stripe) patterned stamp. For this purpose, a stripe patterned polycarbonate substrate was used to coat the film, which was subsequently imprinted with another stripe patterned stamp, where the direction of the stripes on the stamp were perpendicular to those of the stripes on the substrate. The topographic contrast in the initial morphology of the film due to the substrate pattern, in combination with the capillarity driven self organization of the soft gel film under the confining stamp result in ordered 2 – D structures as shown in fig 69.

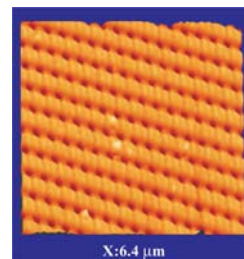


Fig 69: 2-D ordered structure

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Hydroxyapatite (HAp) based Bio-ceramics through Bio-mimetic Route

In the case of accidents, hard tissue replacement is necessary. In orthopaedic surgery, implants prepared from titanium and stainless steel alloys are often coated with synthetic (stoichiometric) hydroxyapatite, HAp to provide direct bonding by osteo-integration and thus enable cementless fixation without an intervening fibrous layer. The plasma spray is the most preferred coating method; however, it has several inherent drawbacks such as extremely high temperature that prevents incorporation of biologically active molecules in the coating. CGCRI has made innovative use of globular/fibrous proteins to treat the implant surfaces at room temperature. The proteinaceous content of mineral coating plays a major role in determining its biocompatibility and bio-resorption.

Stabilization of Au⁰-Nanoparticles by Phosphine based Ligands and their Characterization

The synthesis and characterization of metal nanoparticles have attracted great attention due to their potential applications in the field of electronics, opto-electronics, biosciences and catalysis. Organic ligands are considered as one

of the best supports for the synthesis of metal nanoparticles, particularly for noble metals. NEIST studies on the elucidation of structural suitability and ligand donor site environment for stabilization of Au⁰-nanoparticles. In this context, a series of mono [Ph₃P, P₁]-, di [CH₂(PPh₂)₂, P₂]- and tri [CH₃C(CH₂PPh₂)₃, P₃]- dentate phosphines and their corresponding chalcogen i.e. S functionalized ligands such as mono [Ph₃PS, P₁S₁]-, di [CH₂(P(S)Ph₂)₂, P₂S₂]- and tri [CH₃C(CH₂P(S)Ph₂)₃, P₃S₃]- systems are used to synthesize Au⁰-nanoparticles (fig 70). The synthesis of Au⁰-nanoparticles was accomplished by using a room temperature, two phases, one pot reaction involving the reduction of HAuCl₄ precursor by NaBH₄ in presence of various ligands.

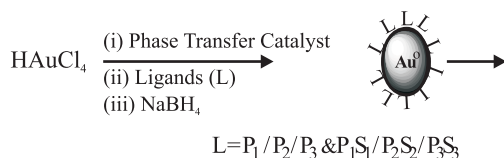


Fig 70: Schematic diagram of gold – nano particles

All these ligands are found to be excellent stabilizer for Au⁰-nanoparticles having small core diameter and narrow size distributions. The phosphine ligands form smaller Au⁰-nanoparticles than their corresponding functionalized phosphines, which may be due to the stronger interaction of Au⁰ (Soft) with P (Soft) than Au⁰ (Soft) with S (less softer than P). All the synthesized Au⁰-nanoparticles were characterized by UV-Visible spectroscopy, TEM, HRTEM, Powder XRD, FT-IR, NMR and Thermal analysis.

Green Technologies for Iron Ore Processing

IMMT jointly with NML, NEIST and CEERI has developed three processes viz. (i) Process flow sheet to beneficiate BHQ with 38-40 per cent Fe to produce pellet grade concentrate with 64 per cent Fe by recovering 40 per cent of yield; (ii) Process to recover most of the iron values in the form of super grade fines with more than 65 per cent Fe from the existing washing plant tailings with 58-60 per cent Fe with high alumina and silica; (iii) Process technology to beneficiate low grade fines (-10.0 mm) available in Orissa for effective utilization as pellet feed.

Microbial Processes for Recovery of Nickel and Cobalt

IMMT has studied bioleaching of chromite overburden of Sukinda mines. The studies reveal about 35 per cent nickel could be extracted using acidophilic microorganism in one ton column and about 25 per cent extraction could be achieved in ten ton heap in about nine months duration.

Leaching of cobalt was observed to be 40 per cent and 31 per cent in 1 ton and 10 ton respectively. The percentage of metal extraction still showed an increasing trend even after 9 months of leaching. The leach liquor was processed through solvent extraction and electro winning route to get high purity nickel (fig 71).



Fig 71: Process technology for production of natural fabric colourants

Preparation of Anti-Reflecting Titanium Dioxide Films

IMMT has prepared antireflective, nanometric anatase grade titanium dioxide films employing pulse laser ablation based deposition method. The films have been characterized by physical techniques. Decrease in transmittance of TiO₂ films with increased reflectance has been observed with increase in annealing temperature (figs 72 and 73). Films with as low as 10 per cent reflectance have been made which are suitable for anti-reflection coating applications. Contact angle measurement of typical films shows that the films are of hydrophobic nature.



Fig 72: Cast titanium dioxide products used in the process

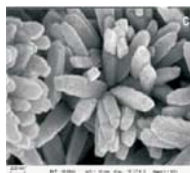


Fig 73: SEM micrographs of the titania films showing rod like structure

Silver Nanoparticles

Silver nanoparticles have been prepared by using two types of silver salt and silver complexes. UV-visible spectrophotometric studies have been carried out for the absorbance study of the silver nano sol at different time intervals. The particles show absorbance in the range of 420–450 nm. A red shift was observed with increase in the time.

Attempts were also made to prepare silver nanoparticles in dry powder form. Characterization of the products by SAXS shows that the particles are spheroidal and bipyramidal in nature and size varies between 2–39 nm (fig 74). Antibacterial properties of these powders tested against some typical water pathogens indicated that these powders have affinity towards anticatreal action for gram negative bacteria. Based on this, attempts are being made to use the same to develop the water filters.

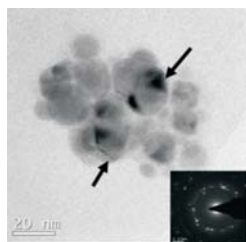


Fig 74: TEM micrograph showing spheroidal and bipyramidal shaped silver nano particles with single and multiple twin structures. Inset picture shows SAED pattern of the same showing nano particles orientation in (110) direction

Development of Aluminium Alloys for Aero-Space Applications

IMMT has prepared Aluminium alloys of composition Al–8.6Zn–2.6Mg–2.4Cu–xCe (x = 0–0.3 wt per cent) were prepared by metal mould casting method followed by forging and heat-treatment.

The effect of Ce addition in Al-Zn-Mg-Cu alloy has been rigorously investigated through optical and transmission electron microscopy and the mechanical properties have been evaluated through tensile and nano-indentation tests. The effectiveness of minor addition of Ce in refining the dendritic cast structure has been demonstrated. It was observed that the matrix consists of closely spaced GP zone and fine grain boundary precipitates. The shape of the precipitates changed from spherical to needle. Size increased from 5–50nm with increase of cerium from 0.1–0.4 per cent. Around 10 per cent improvement in tensile strength was noted with 0.3 per cent Ce addition, which saturated with further Ce addition. Similar behavior was observed for the Young's modulus measured through nano-indentation tests.

Unit for Production of Fabric Dyes

IMMT has standardized and patented processes for obtaining stable fabric dye material from a variety of plant materials. The stability of the colour on various fabrics have also been tested in association with the small-scale fabric manufacturers. A 50 kg/batch dye extraction unit has been designed and developed to supplement IMMT's process technologies for the production of these natural fabric colourants (fig 75). The machine has been installed and tested for leakage and cooling performance. The design will be finalized on successful testing with raw materials. Looking into the market potential for natural fabric dyes, it is expected that the machine will have wide commercial acceptability.

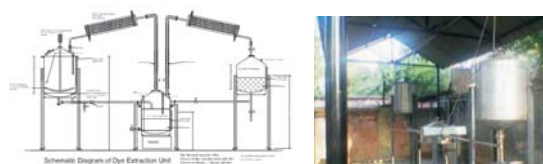


Fig 75: Unit for production of fibre dyes

Cost Effective Mine Water Reclamation Technology for Providing Safe Drinking Water

NML has developed a simple process for treating coal mine water to make it suitable for drinking. The special feature of the process is the use of a metal hydroxide suspension, developed at NML,



for lowering the TDS, especially the dissolved cations and anions. A pilot plant prototype has been designed based on the process which is currently being installed at NML. Expression of interest has been sought from interested vendors for installing a 50000 litres/day pilot plant based on the developed process at one of the BCCL collieries in Dhanbad.

2.14 CSIR 800

Utilization of Certain Wild and Cultivated Plant Species available in North Eastern Region for Extraction of Fibres

Assam and the other states of North Eastern Region of India are rich in bio-diversity. There are many varieties of wild and cultivated plants available in this region possess good quality fibre. NEIST collected some of the cultivated fibre bearing plants viz *Hibiscus cannabinus*, *H. sabderiffa*, and *H. esculentus* from the nearby areas of Jorhat Assam. The fibres were extracted by chemical and biochemical process. These fibres after giving certain mechanical and chemical treatment were found suitable for making cordages and yarns. The quality of the fibres were tested and found adequate physical strength properties for making twines, threads and yarns for making fabrics.

Rural Development Program on Cultivation of Medicinal and Aromatic Plants

Cultivation and processing of aromatic and medicinal plants including mushrooms have opened new opportunities for income generation in rural sector. IIIM has developed and standardized cultivation and processing technologies in the case of lavender, lavandin, rose, clarysage, rosemary, rose geranium and tagetus (fig). These high value plants have excellent cash-benefit ratio.

A new variety of true lavender (*Lavendula angustifolia*) evolved through vigorous selection having high content of lavender oil (>1.6 per cent) and high content of linalool (>25 per cent) and linalyl acetate (> 48 per cent) content. Linalool and linalyl acetate are the two markers and criteria for its quality parameters. Detailed quality profile developed based on international standards. Value added products of lavender like lavender water

were also standardized. Lavender oil and its value added products developed by the institute have been accepted well by the user industry both at national and international market.

IIIM at its branch laboratory in Srinagar, under Public Private Partnership mode has involved three progressive farmers to cultivate these essential oil bearing plants over a large area of land. At present, 100 hectare land has been utilized for cultivation of rose and lavender.

These aromatic plants have been selected on the basis of harvesting periods under temperate climate conditions so that 6-7 essential oils and their value added products can be produced in one distillation plant. Thus this bio business is better protected from market fluctuations at national and international level. Training and demonstration of lavender cultivation is shown in figs 76 and 77.



Fig 76: Cultivation of lavender in open fields and fruit orchards



Fig 77: Training and demonstration of lavender cultivation

Nodal Agency for Quality Control on Honey Export

India exports nearly 12,000-15,000 metric tonnes of honey valued at about Rs. 1,000 crores. Due to the presence of metal residues and pesticides residues, many a times the consignment gets

rejected. In view of the excellent quality control and quality assurance facilities at IIIM, Jammu, Agriculture and Processed Food Products Export Development Authority APEDA (Ministry of Commerce, Govt. of India), has selected QC/QA Department of this institute has a national referral laboratory for the export of honey to European and other countries. Under this assignment IIIM, Jammu has the liberty to pick up samples from other testing houses and check their testing abilities and results such that the quality control for exporting the honey is ensured and international alerts due to any shortcomings in the quality of honey being explored.

There has been no international alert or failure in the export of honey from India due to the strict vision of IIIM, which was reflected in the report given by European Commission, Health and Consumer Protection Directorate General.

Aroma Biovillage Touches a New Height

CIMAP's Aroma Biovillage concept on 'Economic enabling of salt affected belt and agricultural lands in Sultanpur and Raibareli districts of Uttar Pradesh by establishing Aroma Biovillages through technology intervention' completed one successful year.

Suckers of menthol mint (*Mentha arvensis*) were distributed to farmers. Some farmers adopted sucker planting and the remaining farmers raised nursery of mint and planted 35-40 day old seedlings after preparation of the field occupied by winter grain crop and vegetables. About 32 quintal of suckers (cv. Kosi and Kushal) were distributed to 130 farmers covering an area of 54 ha. During this period, a total of six field distillation units have been installed in nodal clusters of the two districts. Training was imparted on planting, crop management, distillation, oil collection, vermicomposting of the distillation waste etc. Vermicompost pits have been constructed in all the biovillages. Linkages have also been made for marketing of farmers' produce.

Seeds of palmarosa (*Cymbopogon martinii*), and basil (*Ocimum basilicum*) and slips of lemongrass and vetivers were also provided to the farmers having salt affected problem soils.

Cultivation of Lavender and Saffron at Lahaul

Promotion of high value crops in the region is one of the important activities of IHBT, Palampur. During the year, several training programmes were organized at the institute and at fields of farmers to popularize cultivation of medicinal and economically important crops in H.P. and Sikkim.

Farmers of Lahaul valley at Lahaul and Spiti were imparted Training on agro-technology of lavender on 17th June, 2008 (fig 78). As an initial support, Lavender plants were also distributed to the farmers. Further, a demonstration plot on saffron (*Crocus sativus*) was established at Khinning village in Lahaul valley for the first time as it was felt that this region is congenial for the growth of saffron.



Fig 78: Training on cultivation of medicinal plant and laying out demonstration trial on saffron

Cultivation of Rose and Lavender at Holi, District Chamba (HP)

The Demonstration plots on commercial cultivation of aromatic plants (damask rose and lavender) were established for the first time in the tribal area of village Garoh, sub tehsil Holi, district Chamba in the month of June, 2008. Selected sites were brought under cultivation with the aim of apprising farmers of the region regarding its cultivation techniques and to motivate them towards crop diversification for higher income generation. A two day training was also imparted on 14th-15th August, 2008 (fig 79).



Fig 79: Training on medicinal plants and its value addition at Sikkim



2.15 Comprehensive Traditional Knowledge Digital Library (CTKDL)

During the year, there have been significant developments in the CTKDL project. One of the major achievements has been the signing of the Access Agreement with European Patent Office (EPO) for providing the access to the TKDL database for search and examination purposes. This will enable the prevention of grant of wrong patents similar to turmeric and neem on the traditional medicine knowledge existing in India at the EPO. Some of achievements in the project are given below:

Current Status of Project

Traditional Knowledge Digital Laboratory (TKDL) has been created for over 2.03 lakh traditional medicinal formulations (Ayurveda: 81,500 formulation, Unani: 1,09,000 formulations, Siddha: 12,500 formulations) from 140 traditional texts existing in local languages such as Sanskrit, Hindi, Urdu, Arabic, Persian and Tamil, in patent application format in English, French, German, Spanish and Japanese. TKDL database contains 34 million A4 sized pages. Under TKDL Yoga, approximately 900 Yoga postures have been transcribed.

Access of the TKDL database to International Patent Offices

Access to the TKDL database has been given to European Patent Office (EPO), one of the International Search Authorities after its signing in February, 2009 the Access Agreement for getting access to the TKDL database. EPO is a regional office with 35 member states such as UK, France, Germany, Italy, Poland, Norway, etc. Hence, protection against misappropriation will be applicable even to the regional offices under the ambit of EPO. This has been the first time that such an agreement has been signed, which will defensively protect the traditional medicine knowledge of a country. EPO after using the TKDL has defined it as a unique encyclopaedia, a powerful tool, and a precise database and capable of establishing prior art.

2.16 Technology Transfers by CSIR Laboratories

Low Cost Oxygen Monitor

The technology of Low Cost Oxygen Monitor (LCOM) was transferred by CSIO on 25th April, 2008 to M/s RAMS Automation, Chennai. It is a microcontroller based Oxygen monitoring system used in oil fired boilers using LSM-11 bousch lambda sensor. Its accuracy is + 1 per cent of the measurement range. It has the in-built correction algorithm for temperature variations and self calibration algorithm facility. The system is highly useful for measuring the oxygen percentage in the stack gas monitoring which in turn improves the combustion efficiency of the oil fired boilers used in various industries, ultimately leading to a cleaner environment

Artificial Knee Joint Technology for Artificial knee joint transfer to M/s PB Motors and Mono Blocks, Rayya, District Amritsar (Punjab).

Technology for Electrochemical Process for the Production of TEAH, TPAH and TBAH

CECRI Developed Electrochemical process for the production of Tetra Ethyl Ammonium Hydroxide (TEAH), Tetra Propyl Ammonium Hydroxide (TPAH) and Tetra Butyl Ammonium Hydroxide (TBAH) from the respective Bromides was transferred to M/s Tatwa Chintan Pharma Chern Pvt. Ltd. Gujarat.

Fuel Cell System

A self-supported Direct Borohydride-Hydrogen Peroxide Fuel Cell System was transferred by CECRI to M/s Genek Science and Technology Pvt. Ltd., Mumbai

Promotion of Commercially Important Lilium at Lahaul-Spiti (H.P.)

Agro-technology on the production of cut flower and planting materials of Asiatic hybrid lily was transferred to farmers through training and field demonstration. In Lahaul-Spiti a demonstration plot of cut flower crop of Asiatic hybrid lily was established by IHBT, Palampur (fig 80). The impact of this ToT was realized by farmers through the

sale of cut flowers worth Rs.27,000/per 100 m² area at Delhi flower market. The income gained was approximately ten times more than that of presently cultivated crops like potato and pea in Lahaul-Spiti. Encouraged by the high returns, new growers of this area are now taking interest in initiating cultivation of lilies for augmenting their income.



Fig 80: Demonstration plot of Asiatic hybrid lily at Lahaul-Spiti

Novel Integrated Process for the Recovery of Sulphate of Potash from Sulphate Rich Bittern

A novel integrated process for the recovery of sulphate of potash (SOP) from sulphate rich bittern has been developed. The process requires bittern and lime as raw materials. Kainite type mixed salt is obtained by fractional crystallization of the bittern, and is converted to schoenite which is subsequently reacted with muriate of potash (MOP) for its conversion to SOP. End liquor from kainite to schoenite conversion (SEL) is de-sulphated and supplemented with MgCl₂ using end bittern generated in the process of making carnallite. Decomposed carnallite liquor produced is reacted with hydrated lime for preparing CaCl₂ solution and high purity Mg(OH)₂ having low boron content. It is shown that the liquid streams containing potash are recycled in the process, and the recovery of potash in the form of SOP is quantitative. The technology has been licensed by CSMCRI to M/s Archean Group of Industries, Chennai.

Treatment of Brackish Water containing Excess Fluoride using RO

Brackish water having TDS in the range of 2,000 to 2,100 ppm was spiked with 4 to 5 ppm of fluoride. This water was treated with membrane based RO technique which reduces fluoride up to 0.9 ppm and simultaneously rejects water enriched with fluoride in the range of 13 to 18 ppm. The fluoride enriched reject water was treated with a chemical to reduce fluoride up to 0.9 to 1.3 ppm in the filtrate for final discharge (fig 81).



Fig 81: RO hybrid plant for the treatment of feed water and reject water containing excess Fluoride

The technology has been licensed by CSMCRI to M/s Tata Project Ltd. Secunderabad.

Cultivation of Kappaphycus Alvarezii Seaweed.

Fisher families can earn their livelihood by cultivation of this seaweed (fig 82).



Fig 82: Cultivation of Kappaphycus alvarezii on raft in sea

The process relates to a tissue culture method for cultivation of marine algae. The method comprising of (i) establishing axenic viable algal material by sequential treatment thereof in sterile sea water supplemented with domestic liquid detergent, incubating the treated material, (ii) culturing the

axenic explants on agarified medium for induction of callus; (iii) excising and sub-culturing the calli from the axenic explants on fresh agar plates to obtain differentiated densely pigmented oval or spherical shaped micro-propagules (iv) sub-culturing the pigmented calli in agarified medium to achieve enhanced somatic embryogenesis and micro-propagule formation in pigmented filamentous callus, (v) transferring the filamentous calli with somatic embryos for morphogenesis and development of young plantlets; and (vi) cultivating algal biomass on a large scale by growing the young plantlets in enclosed perforated polythene bags.

The technology has been licensed by CSMCRI to M/s Aqua Agri Processing Pvt. Ltd New Delhi.

Pilot Plant for Beneficiation of Iron Ore Tailings at Essar-Kirandul

Essar Steel Ltd. erected a 0.6 m diameter flotation column of 8 meter height in the premises of its iron ore beneficiation plant at Kirandul on the basis of design furnished by IMMT. The fabrication and erection job was also supervised by the IMMT. Test run of the plant was carried out by using the tailings generated from the existing beneficiation plant. The tailing slurry containing 30-40 per cent solids was conditioned with required dosages of reagents in the primary conditioner and then transferred to a secondary conditioner by gravity process. The slurry was diluted with additional waste to achieve a pulp density to 1.2. The unit, with a solid feed rate of about 2 tph, was satisfactorily run for about six hours. Continuous operation has also been streamlined. Figs 83 to 85 show the pilot plant.



Fig 83: Product output at the top of the column



Fig 84: Conditioner and agitator with feed pump



Fig 85: Pilot plant – 0.6 m diameter flotation column

Setting-up Chromite Ore Beneficiation Plant at Sukinda

IMMT had earlier developed the flow sheet for recovery of chromite values from the chromite ore beneficiation (COB) plant waste. A detailed project report was furnished to M/s Jindal Stainless Limited for setting up a 500 tpd chromite recovery beneficiation plant from the tailings of the existing COB plant at Sukinda (fig 86). IMMT is currently rendering consultancy service to JSL in setting up the plant. Assistance is also provided to JSL in the operation of a 20 tph chromite beneficiation plant.



Fig 86: Chromite ore beneficiation plant at Sukinda

This plant treats tailings having a feed of 18-20 per cent Cr_2O_3 to obtain the desired beneficiated concentrates.

Electrolytic Reduction Cell Assembly for Technology Demonstration Plant

Heavy Water Plant, Talcher is developing a solvent extraction process for purification of merchant grade phosphoric acid, where reduction of ferric iron to ferrous form was necessary within the flow system. IMMT has provided technology for this purpose where the ferric ion is successfully

reduced electrochemically. HWP is erecting a technology demonstration plant (TDP) at Trombay for which the electrolytic reduction system has been designed by IMMT. The TDP is under construction and is expected to be operational shortly.

Removal of Arsenic from Groundwater

A treatment process for the removal of arsenic from groundwater using a ferruginous manganese ore, has been transferred to an entrepreneur, Pacific Technical Services, Chennai, who will be installing a demonstration unit in West Bengal for further proliferation.

Since, the minerals identified as potential water purifiers are common, abundantly available and inexpensive; they offer an excellent low cost option for obtaining safe drinking water. This should be especially useful for iron contaminated water which is a common phenomenon all over the country.