

III. AUTONOMOUS BODIES

III-A. Council of Scientific & Industrial Research

1. INTRODUCTION

The Council of Scientific & 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 & technology; electronics; sustainable energy; materials for futuristic applications as well as affordable healthcare. CSIR is also focusing on efforts at improvement in the quality of life of underprivileged population through S&T interventions.

The following sections record some of the significant achievements of CSIR during the year 2007-08.

2. S&T CONTRIBUTIONS

2.1 AEROSPACE SCIENCE & TECHNOLOGY

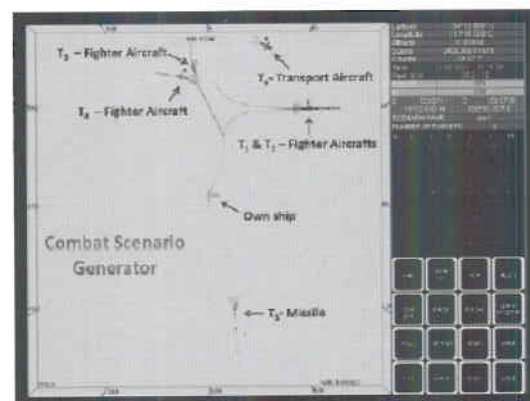
CSIR's presence in the aerospace science and technology is primarily through its National Aerospace Laboratory, which, along with CEERI, CMERI and a few other laboratories, has contributed significantly to the growth of this sector of strategic importance. Some of the recent important contributions are described below.

Multi-sensor data fusion

As an application of Level 1 data fusion to air defence, a seeker filter based on Interacting Multiple Model Modified Extended Kalman Filter (IMM-MAEKF) has been designed by NAL to

track air breathing targets. The challenge was to design the filter using RF seeker measurements, which are corrupted by non-Gaussian noise due to RCS fluctuations and glint noise, and also suffer from data eclipsing problems. The seeker filter was coded in C language for real time applications and integrated with the interceptor simulation code for closed loop performance evaluation using Monte Carlo simulations. The seeker filter exhibited robust performance under different interceptor-target engagement geometries, target aspect ratios, levels of process noise in the filter model and mode transition probability matrix.

As Level 2 data fusion development, a fuzzy-logic, Bayesian network-based hybrid situation assessment model has also been developed to serve as a pilot decision making aid for BVR (Beyond Visual Range) combat. Typical air-to-air combat scenarios required for validation of the model were realized using GUI-based



Combat scenario generator

DSIR Annual Report 2008-2009

software. An aircraft carrying Radar, Radar warning receiver, electro-optical sensor and infra red sensor models was used to detect a maximum of six targets (T1-T6) based on their field of view and received power. The states of all the targets in the scenario, at each instant of time, were estimated using measured data from the sensors using multi-sensor multi-target data fusion algorithms.

The estimated states processed by Fuzzy Event Detector (FED) were used as inputs to the Bayesian network for situation assessment.

Varsha 2C GSM: weather prediction software

This model, developed at NAL, can be run at different spectral truncations as well as physical grid resolutions. The physical parameterizations include the Kuo-Anthes cumulus scheme and Alpert gravity wave drag parameterization. There are two options for the long wave radiation computation: (i) the FelsSchwarzkoﬀ scheme and (ii) a new scheme devised for Varsha by TIFR, Bangalore. For the boundary

layer the options are: (i) the Monin-Obukhov scaling along with a gustiness parameter and (ii) the above mentioned boundary layer scheme based on the scaling arguments. This new boundary layer scheme is more appropriate for the tropics where the winds are generally low.

The Varsha GCM has been used for both simulations as well as forecasts of monsoon rainfall and other weather events. Simulations of the tracks of a number of tropical cyclones have been quite accurate. One month predictions of all India rainfall during the monsoon months is an initiative taken up at Flosolver and the results are being sent to the Indian Meteorological Department. It is to be noted that the heavy rainfall events over the S-W coast of India during the last two monsoon periods have been captured well in advance by the model.

Radome for the Doppler Weather Radar (DWR)

NAL has successfully designed and built the country's first state-of-the-art 12.88 m dia DWR



DWR mark II radome

Mark-II radome and installed it around the 9 m dia DW Radar at BEL-Bangalore site.

The novelty of this radome is that it is built with 66 panels, the joints are randomized and the panel sizes are larger as compared to those in the earlier Mark I radome, which had 146 symmetrical panels. This feature makes the radome electromagnetically more transparent and enhances the electromagnetic performance. Non-linear FEM analysis were carried out to establish factors of safety against buckling at wind speeds of 250 kmph (normal) and 300 kmph (gust); the panel thicknesses and flange thicknesses adopted met the safety factors required. A totally new tooling system was exclusively developed for large panel fabrication and the panels were fabricated using the room temperature vacuum bag moulding technique.

Design and development of metalized CFRP reflectors and feed components for satellite communication applications

Metalized carbon fibre reflectors (CFRP) offer the same properties as the metallic reflectors, and have the advantage of being light weight. This combination finds application in satellites. NAL has developed the process and technology for CFRPs, which have the required accuracies. Metallic master patterns were fabricated and a multi-part mould was developed. The resin injection technology for this class of complex shaped isogrid structured components was established. The CFRP brackets developed were

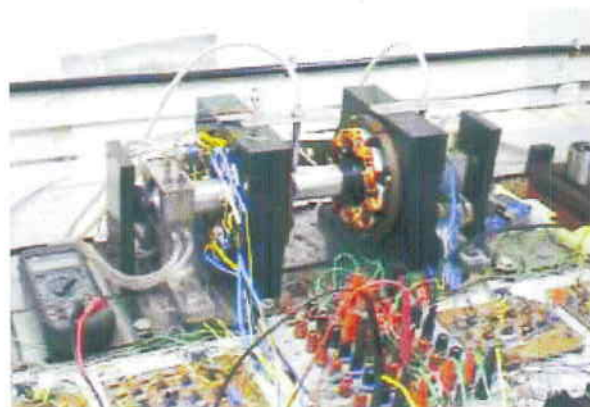


A view of metalized CFRP reflectors

subjected to several qualification tests by Space Application Centre, Ahmedabad and these fully met their requirements. Extensive metallization trials were carried out on CFRP substrates of different complex reflectors, feed horns and wave guides using innovative in-house techniques and samples. The internal metallization of the corrugated feed horn was achieved by a novel electro-less deposition technique. The vibration tests on the antenna brackets and the reflectivity measurements, made on aluminium coated CFRP components, were found to meet the specifications.

Novel 5-axis levitation magnetic bearings

Complete levitation of a rotor weighing 5 kg, supported on two radially active magnetic bearings (AMB) and two axially passive magnetic bearings (PMB), resulting in 5-axes levitation, has been demonstrated successfully at speeds up to 10000 rpm at NAL. A small rotor rig has been designed and fabricated for the purpose of demonstration. Most of the components of magnetic bearings such as the analog feedback controller, electromagnetic actuators and power amplifiers have been designed and developed indigenously. Commercially available proximity probes were used to monitor the rotor movement, which is required for feedback control action. The active magnetic bearings developed are working in the mode of attraction. A proportional and derivative type feedback controller has been employed to achieve stability. Design of the feedback controller is based on direct output feedback



Magnetic Bearing (5-axes levitation - Fully Airborne Rotor)

control scheme. The feedback controller parameters have been selected appropriately to generate required stiffness and damping in the AMBs for stable levitation of the rotor. The rotor radial vibration in the bearing has been controlled within 150 microns, wherein the bearing radial clearance is 1000 microns.

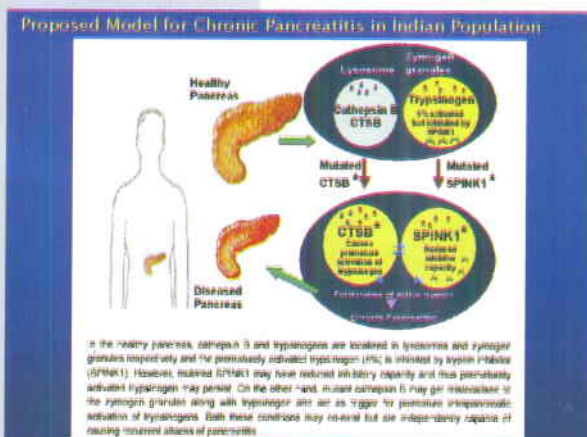
2.2 BIOLOGY & BIOTECHNOLOGY

The area of Biology and Biotechnology is of immense importance for CSIR with more than a dozen of its laboratories focusing on it and contributing through important technologies that are being commercialized and publications in world's top journals. These CSIR laboratories have created for themselves an R&D niche in the domain of basic research as well. During the year, some very notable achievements were reported as described below.

Genetic analysis of pancreatic disorders in the Indian population

Chronic pancreatitis (CP) is a disease with varied etiologies where pancreas is injured by enzymes normally secreted by acinar cells.

CCMB sequenced the complete lysosomal hydrolase Cathepsin B (CTSB) gene in an adequately powered cohort with a large number of well-characterized patients and healthy controls and identified several variants spread across the gene. A signal peptide variant, showed a statistically significant association with TCP with an OR of 2.15. Similar results were obtained on analysis of this SNP in another



Proposed model for chronic pancreatitis in Indian population

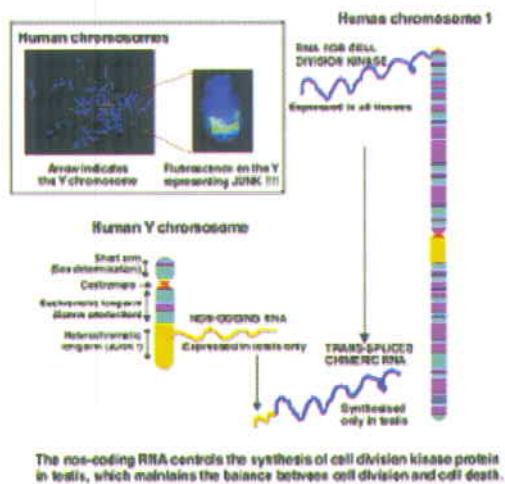
ethnically matched independent case-control cohort, which corroborated the earlier observations. On investigating the interaction of mutations in SPINK1 gene, no differences in the phenotype of pancreatitis or genotype with regard to presence or absence of N34S SPINK1 mutation could be found for the Leu26Val mutation. Thus, the proposed effects of Leu26Val in mutation of CTSB gene appear to be unrelated to changes in the SPINK1 gene. Since Leu26Val affects the propeptide region of cathepsin B, crucial for its transport, hence, it may affect CTSB trafficking since the mannose-6-phosphate dependent sorting of CTSB may mislocalize it to the zymogen granules, causing premature activation of trypsinogens.

This work provides the first human-based evidence for the 30-year-old cathepsin B hypothesis of pancreatitis and suggests CTSB gene as the second candidate gene, after SPINK1 gene, to be involved in the pathogenesis of TCP. Understanding the functional basis of mutations in these genes may help in development of predictive tests for susceptibility to chronic pancreatitis. The proposed model for chronic pancreatitis in Indian population is shown below.

First report of trans-splicing between a Y chromosomal and an autosomal transcript

The human Y heterochromatic block present at the distal end of the long arm has been intractable for genetic and molecular analysis, as it is repeat rich. There was no evidence available for transcription from this male-specific region of the Y (MSY). CCMB scientists have presented for the first time, evidence for a developmental stage- and testis-specific transcription from the MSY heterochromatic block. They isolated two novel RNAs, which localized to Yq12 in multiple copies with testis-specific expression and which lacked active X homologues. They observed that one of the above Yq12 non-coding RNAs trans-spliced with CDC2L2 mRNA from chromosome 1p36.3 locus to generate a testis-specific chimeric sv13 isoform. This was the first report of transcription from the Yq12 heterochromatic block and the first report of trans-splicing

between a Y chromosomal and an autosomal transcript. The Y chromosome does not recombine with the rest of the genome and, hence, is considered to be genetically isolated. This study published in (Genome Research 2007, 17: 433-440) also records for the first time Y chromosomal control of an autosomal gene. The model for the mechanism of control of autosomal gene is shown below.



Model for the mechanism of control of autosomal gene

Understanding evolutionary developmental biology across the species

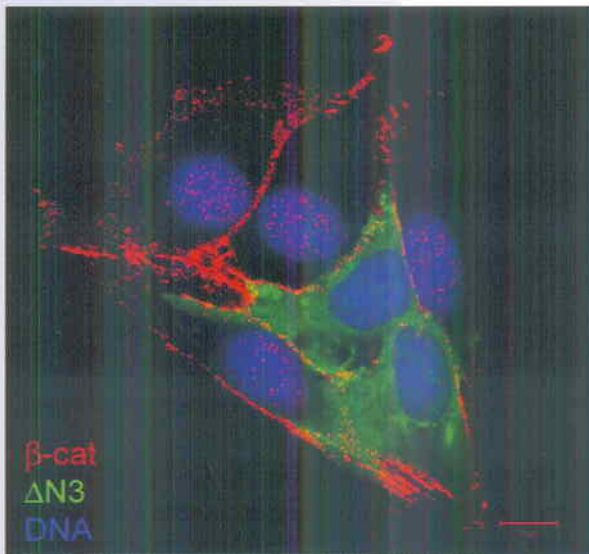
Developmental mechanisms very often show remarkable conservation across the species. Among the most conserved developmentally regulated genes are the homeotic or hox genes that exist in clusters. While it has been known that organization of the hox genes in the clusters is also conserved, the reason for this was unclear. Chromatin elements that are essential for regulation of *Drosophila* hox cluster include the cellular memory or *Polycomb* response elements (PREs). Such epigenetic regulatory elements have not been reported from mammalian systems. By testing the non-coding DNA from the *HoxD* complex of mouse, a functionally conserved repressive element has been identified by scientists at CCMB. It was found that mouse fragment interacts genetically with *PcG* and *trxG* mutations in transgenic context in *Drosophila*. These genetic interactions were found to be direct ones and provide the first demonstration of an

evolutionarily conserved mammalian PRE. Further, genetic interaction analysis indicates that while the core features of mouse PRE are conserved in *Drosophila*, the mammalian element acquires further complexities. One such feature is the interaction of mouse PRE with heterochromatin elements, which is not seen in common fly PREs. The studies also indicate that unlike fly PREs, mouse elements do not show pairing-sensitive silencing. It is interesting to note that while homologous chromosomes are paired during interphase, this is not the case in mouse in most cell types. These observations indicate that mammalian regulatory elements have, on the one hand, lost features that are relevant only to flies and not to mammals, and, on the other hand, evolved to acquire complexities that have led to the remarkable diversity of body forms along the anterior-posterior body axis that is determined by the hox genes. These studies open up ways to explore evolutionary developmental biology across the species using functional and comparative genomic approach with the help of *Drosophila* as a model system of choice.

Molecular biology of skeletal muscle growth and regeneration

CCMB's investigations into the molecular correlates of quiescence in a culture system that models skeletal muscle stem cells have given some interesting results. Their interest in the quiescent state is inspired by its potential importance in the survival and self-renewal of stem cells. In addition to soluble growth factors, adhesion-dependent signaling pathways regulate proliferation and differentiation. A key finding of this work is the delineation of a new pathway downstream of the RhoA GTPase, a critical regulator of adhesion-dependent signaling. While the role of the Rho effector mDiaphanous (mDia) in regulating the cytoskeleton and cell motility is well established, its involvement in controlling of gene expression is less well known. The results demonstrate that signals emanating from mDia co-regulate MyoD and the cell cycle via a complex pathway.

Further it has been shown that MyoD is not only a direct target of the serum response factor SRF,



Rho effector mDiaphanous (green) can block signal-induced nuclear localization of b-catenin (red). Nuclei are marked by DAPI (blue).

whose transcriptional co-activator is regulated by actin dynamics, but also an indirect target of TCF whose co-activator, b-catenin, is itself involved in cell adhesion and microfilament-membrane interactions. mDia acts as a nodal modulator of these two pathways, resulting in reciprocal regulation of SRF and TCF/LEF via reciprocal effects on the localization of their cytoplasmic co-activators, MAL and b-catenin, respectively. Thus, an intriguing cytoskeletal dimension in the regulation of MyoD emerges from the study of cultured myoblasts. It is conceivable that MyoD regulation in quiescent satellite cells in muscle is also triggered by mechano-chemical signals activated by damage to this contractile tissue.

Birth of deer (Blacky) by artificial Insemination

The black buck is a Schedule 1 animal and is thus in the category of endangered species like the charismatic lion, tiger, leopard, etc., which necessitates its conservation.

The technique of artificial insemination (AI), although routinely practiced in domestic animals, has not been commonly applied to wild animals. Semen collection and preservation along with AI technique can significantly contribute to the maintenance of genetic diversity and



Newborn "Blacky" with its mother

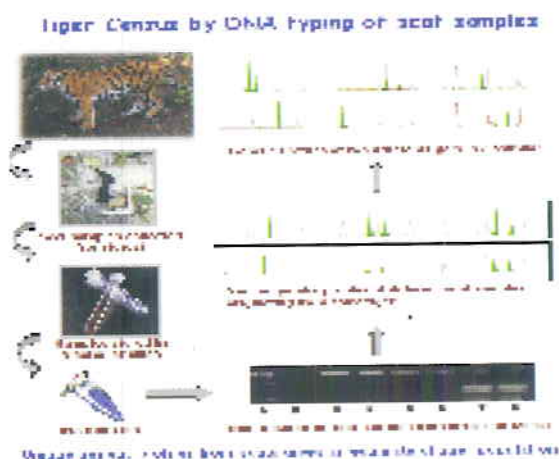
conservation of endangered animals. In ungulates, behavioural cues are not reliable indicators of estrus detection and, therefore, there was a need to synchronize estrus in the ungulates using hormones. CCMB scientists synchronized estrus in black buck by using an intra-muscular injection of estradiol valerate with norgestomet and an ear-implant containing norgestomet. The estrus-synchronized animals were then inseminated intra-vaginally using a cattle artificial insemination device containing freshly collected semen from an adult male.

The conceived animal delivered a live fawn on August 23, 2007, after 6 months of pregnancy. The cuddly newborn antelope has been named as "Blacky".

Counting tigers right

CCMB carried out a pilot study with fecal samples collected from two protected areas to check the possibility of carrying out studies in tiger populations by non-invasive genetic methods. The primary goal of the study was to identify individual tigers with unique DNA fingerprints and to find whether these unique DNA fingerprints could be used for identifying individuals in a protected area so that tiger population estimates can be generated.

A unique STR region has been identified in tigers for identifying individuals and the probability of obtaining similar fingerprints in closely related individuals calculated. It was found that with these STRs it is possible to distinguish between even closely related animals with 99% certainty. This part of the study was confirmed with



Tiger census by DNA typing of scat samples

captive tigers before embarking on DNA analysis of samples collected from the forest.

Field work was conducted at two locations in southern India, namely, Mudumalai Wildlife Sanctuary and at BRT Sanctuary. Scat samples were collected randomly and preserved in alcohol or desiccant silica. The CCMB scientists developed a DNA-based method for identifying the scat samples of tigers from those of the other carnivores. DNA was isolated from the scats that were collected from the study areas and the samples were positively identified as tiger samples with the DNA-based assay developed by CCMB. Samples were then subjected to 'DNA fingerprinting'. DNA-based sex identification of the samples was also done. The results of the DNA profiling show that samples collected from forests could be assigned to individuals. Following a random sampling method in the pilot study, an estimate of the Minimum Number Alive (MNA) at the time of sampling could be arrived at.

The results of this study indicate that it is indeed possible to conduct such surveys on a large scale and that it would be possible to estimate tiger population under appropriate sampling designs in protected areas in India. This could, therefore, become the method of choice for counting tigers in the future.

A novel universal approach to species identification for forensic application

Accurate identification of confiscated biological remains is an essential requirement of wildlife

forensics. Until recently, establishing identity of confiscated animal parts and products was a great challenge to law enforcement agencies because none of the methods known till date was efficient enough to reveal the identity of animal remains beyond a reasonable doubt. CCMB scientists have devised a universal solution for this problem by inventing a pair of novel primers mcb398 and mcb869 that can establish the identity of unknown confiscated remains at family, genus and species level beyond a reasonable doubt. It has potential to revolutionize the whole arena of wildlife identification and would be very helpful for law enforcement agencies and wildlife curators to control the human violation of wildlife resources. Another potential application of this technique may be in food fortification where there is a need to establish the identity of edible meat sources.

For the first time, CCMB scientists have given an approach, which, without knowing the history of a forensic sample, can establish whether the confiscated sample belongs to a human or an animal, if animal is one among the 221 species included in the analysis. Because of its universal nature, it can also be applied to the species, which have not even been included in the CCMB analysis. None of the techniques known till date has been able to do this. The patent of above technique had already been granted in US, South Africa and China. Currently, the technique is being used for wildlife forensics by LaCONES and more than 200 cases have been solved so far with its use.

Apomixis technologies for low-cost production of high-yielding hybrid seed

The development of technology for asexual seed production in food crops by a process called apomixis would allow production of high-yielding hybrid seeds at greatly reduced costs for the farmer. Apomixis is found naturally in some plant species, but not in food crops; so, the development of apomixis technology in food crops requires genetic engineering. A group of scientists at CCMB have demonstrated the engineering of a major functional component of apomixes.



Apomixis technology for low-cost production of high yielding hybrid seed

This finding, published in 'Nature', has very important implications for plant breeding and agriculture as the development of apomixis technology can lead to large increases in yield of up to 20-30% across many of the major food crops such as rice and maize. (Ref: Gamete formation without meiosis in Arabidopsis (2008). Ravi, M., Marimuthu, M.P.A. and Siddiqi, I. Nature, 451: 1121-1123, 2008).

Rosemary oil found useful against drug resistant bacteria

CIMAP has evaluated antimicrobial and drug-resistant modifying activity of the essential oil from *Rosmarinus officinalis* L against human pathogenic bacterial strains using disc diffusion and micro broth dilution assay. The oil was found to be more active against the gram positive human pathogenic bacteria compared to gram negative bacteria used in this study. The present finding suggests that characterization and isolation of the active compound(s) from the rosemary oil may be useful in the treatment of bacterial infections, including drug resistant infections.

Synergism between extract of *Phyllanthus amarus* and silymarin for liver protection

In search of the effective and standardized hepatoprotective combination therapy, Silymarin and standardized extract of *Phyllanthus amarus* were evaluated by CIMAP scientists against CCl₄ induced hepatotoxicity in rats. Silymarin is a flavonoid extracted from the milk thistle, *Silybum marianum*. It has been reported to

prevent liver injuries induced by various chemicals or toxins including ethanol. A standardized extract from the milk thistle, *Silybum marianum*, contains as its main constituents the flavonoids silybinin and silychristin. *Phyllanthus amarus* and related species contain phyllanthins, hypophyllanthins and polyphenoles with antiviral properties. Eight groups of rats were used to carry out combination studies. The animals of group A served as normal and were given only vehicle. The animals of group B served as toxin control and other groups of animals served as treated groups. The test materials were found effective for hepatoprotection as evidenced by blood parameters (alanine amino transferase, aspartate transferase, alkaline phosphatase, bilirubin, total protein, creatinine) and liver glycogen. The combination of Silymarin and *Phyllanthus amarus* exhibited synergistic effect for hepatoprotection. Silymarin with ethanolic extract of *P. amarus* showed better activity due to the higher concentration of phyllanthin in ethanolic extract in comparison to aqueous extract of *P. amarus* as estimated by HPLC.

Anti-cancer and hepatoprotective agent from *Withania somnifera* and biological evaluation of its ester derivatives

Detailed chemical investigation of *Withania somnifera* roots carried out by CIMAP scientists resulted in the isolation and identification of a cytotoxic and hepatoprotective agent, palmitic acid, which was converted to eight semi-synthetic ester derivatives. *t*-Butyl palmitate and amyl palmitate were 4-6 times more active than palmitic acid against adherent and suspension colon cancer cell lines. Interestingly, palmitic acid and its ester derivatives also showed hepatoprotective activity, which is being reported for the first time.

National quality referral laboratory for MAPs and herbal products

A new facility, National quality referral laboratory for MAPs and herbal products, has been developed. It has immense importance in quality testing using chemical finger printing methods and identifying our precious plant

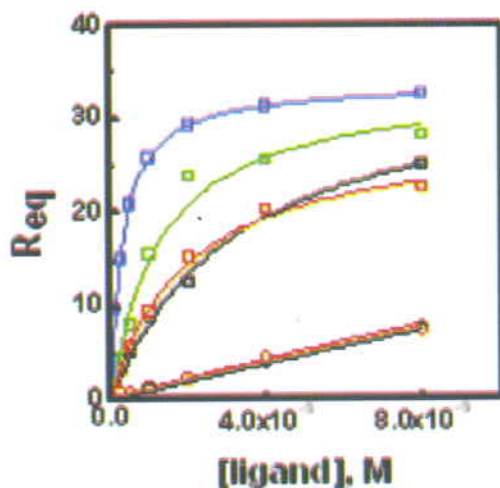
varieties as well as testing the quality of herbal products from farmers, and small and medium scale industries. To start with, CIMAP will offer quality assessment services on the following 7 medicinal plants: *Andrographis paniculata* (Andrographolide), *Artemisia annua* (Artemisinin, Artemisinic acid, Arteannuin B), *Aloe vera* (Aloin), *Brahmi* (Bacoside A), *Centella asiatica* (Asiaticoside), *Silibum* (Silymarin), and *Withania somnifera* (Withanolides).

Development of Indian genome variation database (IGVdB)

IGIB has developed an Indian Genome Variation Database. This houses SNP frequency data in over 1000 genes from disease and drug response candidates in population representing the entire genetic diversity of India. This variation data on functional polymorphisms from disease and drug response candidates is being applied in genotype-phenotype correlation studies and will lead to development of predictive, predisposition and progressive markers.

Furan-based cyclic oligopeptides selectively target G-quadruplex

IGIB scientists have carried out a comparative analysis of the binding data of oligopeptide ligands, developed from a novel furan amino



SPR binding curves for 1 (black box), 2 (red box), 3 (green box), and 4 (blue box) to telomeric quadruplex and for 1 (black circle) and 2 (red circle) to DNA hairpin in 10 mM HEPES, pH 7.4, 100 mM KCl

acid, with G-quadruplex and double-strand DNA. The 24-membered cyclic oligopeptides are highly selective for G-quadruplex structures and can be used as scaffold to target quadruplex structures at the genomic level.

These ligands have low cytotoxicity and are able to efficiently exhibit the activity of telomerase, which makes them promising for exploration for anticancer therapy.

Genetic variants of human inositol polyphosphate-4-phosphatase, Type I (INPP4A) useful for prediction and therapy of immunological disorders

IGIB-developed method relates to allelic variants of the human inositol polyphosphate 4-phosphatase (INPP4A) gene and splice variants of the coding sequence, which encodes INPP4A enzyme known to be an important regulator of platelet activation; and it provides primers and methods suitable for the detection of these allelic variants for applications such as molecular diagnosis, prediction and prevention of an individual's susceptibility to asthma and / or the genetic analysis of the INPP4A gene in a population.

A method of preventing and/or treating asthma using parabromophenacyl bromide (PBPB)

IGIB has developed a method of preventing and/or treating asthma in a subject; it comprises a step of administering effective pharmacological amount of parabromophenacyl bromide (PBPB) to the subject and a method of modulating levels of biomolecules to achieve the same.

Biological neutralization of highly alkaline textile industrial waste water

IGIB has developed a novel process of neutralizing textile industrial wastewater by a bacterial strain isolated in India. The isolated bacterial strain is capable of bringing down the pH of wastewater from 12.00 to 7.00 units within two hours. The neutralization of alkaline textile industrial wastewater by such a biotechnological process is highly effective and economical as compared to conventional

neutralization by chemical means. This biotechnological process may find wide commercial application in textile industries discharging alkaline wastewater.

Enzyme-catalyzed in vitro modification and synthesis of nucleic acids

IGIB developed a simple, efficient and accelerated method for enzyme-catalyzed in vitro modification and synthesis of nucleic acids using microwave irradiation. The drastic reduction in the reaction time for the site specific cleavage, modification of DNA and oligonucleotides, and synthesis of nucleic acids is the main advantage of the new method. The reaction time is reduced to 5-70 seconds for restriction endonuclease digestion, ligation, dephosphorylation, phosphorylation, reverse transcription, in vitro DNA synthesis and in vitro RNA synthesis. Almost all the enzymatic reactions used in molecular biology as well as in other fields can be done by the invented procedure in an extraordinary short period, saving a lot of precious time and thus making the procedure economical and versatile.

Discovery of novel proteins with insecticidal activities against target insect pests

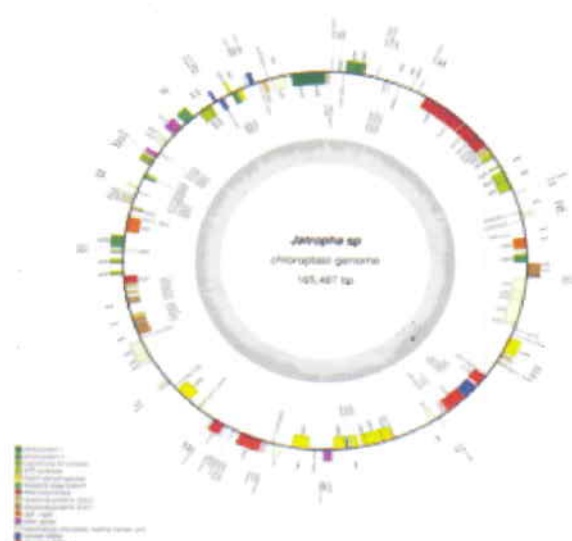
NBRI has identified three unique small neurotoxin peptides, viz., gigantoxin3 from sea anemone, magi2 from spider and lqqit2 from scorpion effective on sodium channels and toxic to crustaceans as potential toxins against sap-sucking insect pests. Synthetic genes coding these small peptides have been designed and developed.

Likewise, the lab has carried out evaluation of δ -endotoxins and protease inhibitors for toxicity to target pests, wherein with insect feeding assay base line susceptibility data of Bt-Cry1Ac and Cry2Ab toxins against target insect *Helicoverpa armigera* has been developed. The plant proteases isolated from *Capsicum annuum* and bitter melon have been found to be potential inhibitors of *H. armigera*. The full-length genes of *C. annuum* and bitter melon coding the identified proteinase inhibitors have been cloned.

Sequencing chloroplast genome of Jatropha curcas

NBRI has reported the sequencing of the *Jatropha* chloroplast DNA. Pyro-sequencing and subsequent assembly results show a total number of 335,359 reads with average read length of 250 bases. Of these, 121,320 reads were assembled into 17,479 contigs constituting 4,147,184 bases. 597 contigs were large [>500 bases] constituting 617,515 bases, out of which 86.76% bases had phred score of 40 and above, while 13.24% had quality score less than 40. Average contig size of large contigs was 1034 bases with the largest being 20,368 bases long. Phylogenetic study revealed that *Populus*, which is the closest taxonomic relative of *Jatropha*, also comes out to be its closest relative phylogenetically. Synteny studies revealed highly conserved relative positions of the genes between *Jatropha*, *Arabidopsis* and *Populus*. Annotiations and gene prediction results revealed some 31 gaps in whole genome. Primers were designed to fill up the 31 gaps and PCR performed with *Jatropha* chloroplast DNA as the template to amplify the missing sequence.

Filtering of all the contigs having phred score more than 20 was done by BLAST searching against the non-redundant nucleotide data base at NCBI. Only 31 contigs constituting about 164 kb showed significant homology to any



Circular map of *Jatropha* chloroplast genome

chloroplast genome. Ordering and orientation of the contigs was done by aligning it to Arabidopsis chloroplast genome. General structure of the genome complied with the general structure of all the chloroplasts having large single copy and small single copy separated by two large inverted repeats. About 120 genes commonly found in chloroplast genome were annotated, out of which 85 were protein coding genes and the rest 35 were structural genes.

Desiccation tolerance in Selaginella bryopteris

Resurrection plants like *Selaginella bryopteris* (L.) Bak, have the unique ability to survive desiccation to the air-dry state. Another unique feature of *S. bryopteris* is the ability of detached fronds to possess a similar level of desiccation tolerance as that of whole plants. Detached fronds from fully hydrated *S. bryopteris* plants were subjected to dehydration and rehydration by NBRI scientists. The detached fronds in hydrated state showed Fv/Fm (maximum quantum yield) values of around 0.8 indicating a fully functional photosynthetic system. After dehydration the plants showed net respiration



Selaginella bryopteris



Dehydration and rehydration of detached fronds of *S. bryopteris*

and drop in Fv/Fm values to 0.01. Both fluorescence and photosynthesis, which were reduced during dehydration, were regained totally after rehydration.

The water relation parameters (relative water content, hydraulic conductance) also showed a response similar to that of photosynthesis. Desiccation resulted in decreased activities of superoxide dismutase, catalase and ascorbate peroxidase; however, this decreasing trend continued even after rehydration of *Selaginella* fronds. Two-dimensional gel electrophoresis reproducibly detected 500 protein spots.

Nine protein spots showed significant changes in abundance. Eight of them were up-regulated and one was down-regulated. Further analysis of these proteins is under process. These preliminary results indicate that in *Selaginella bryopteris* plants, photosynthetic machinery is somehow protected during desiccation and becomes fully functional after rehydration.

New leads into the taxonomical study of plant taxa

A consolidated floristic account of bryophytes of Amarkantak and its adjoining areas has been prepared for the first time by NBRI, which includes 61 species belonging to 39 genera distributed among 25 families. Another first is a moss, *Fabronia secunda* Mont, reported from Govind Ghat area of Valley of Flowers (Garhwal Himalayas, Uttarakhand), which is a new addition to the bryoflora of western Himalayas. Two mosses, viz., *Barbula javanica* Doz. and *Anoetangium stracheyanum* Mitt. (Pottiaceae) have been identified as new to central Indian region, making new addition to bryoflora.

Studies on lichens have led to the discovery of eight species new to science, namely, *Caloplaca awasthii* Joshi, Y. and Upreti, *Caloplaca abuensis* Joshi, Y. and Upreti, *Caloplaca kashmirensis* Joshi, Y. and Upreti, *Caloplaca subpoliotera* Joshi, Y. and Upreti, *Caloplaca subbassiae* Joshi, Y. and Upreti, *Chroodiscus himalayanus* Nayaka and Upreti, *Caloplaca tropica* Joshi, Y. and Upreti, *Cladonia lutescens* Ahti and Upreti and thirteen species

new to Indian lichen flora of India, namely, *Caloplaca hueana* de Lesd., *Caloplaca pollinii* (A. Massal.) Jatta., *Caloplaca squamosa* (de Lesd) Zahlbr., *Caloplaca chrysodecta* (Vainio ex Rasanen) Dombr., *Caloplaca cirrochroopsis* Poelt and Hinteregger, *Caloplaca flavocitrina* (Nyl.) H. Olivier, *Caloplaca herbidella* (Nyl. ex Hue) H. Magn., *Caloplaca hlogina* (Ach.) Flag., *Caloplaca phloginopsis* Poelt and Hinteregger, *Hemithecum peplophora* (Wirth and Hale) Tewari and Upreti, *Fissurina subcontexta* (Nyl.) Nyl., *Phaeographis intricans* (Stirton) Staiger, *Phaeographis scalpturata* (Ach.) Staiger

Improvement of salt tolerance in transgenic arabidopsis by over expressing superoxide dismutase from *Potentilla atosanguinea*

Production of reactive oxygen species (ROS) such as superoxide radical and hydrogen peroxide is inevitable in plants experiencing stress. ROS cause colossal damage to the plants leading to reduced growth and development. One of the approaches to improve stress tolerance would be to mitigate the production of ROS through transgenic technology. IHBT has cloned the gene of superoxide dismutase (SOD), the

enzyme responsible for dismutating superoxide radical, from (*Potentilla atosanguinea*), a Himalayan high altitude alpine plant. SOD was over-expressed in Arabidopsis and the transgenic plants were analysed under varied level of stresses. Since salt sensitivity is most evident in Arabidopsis, the transgenic plants overexpressing SOD were analysed under salt stress.

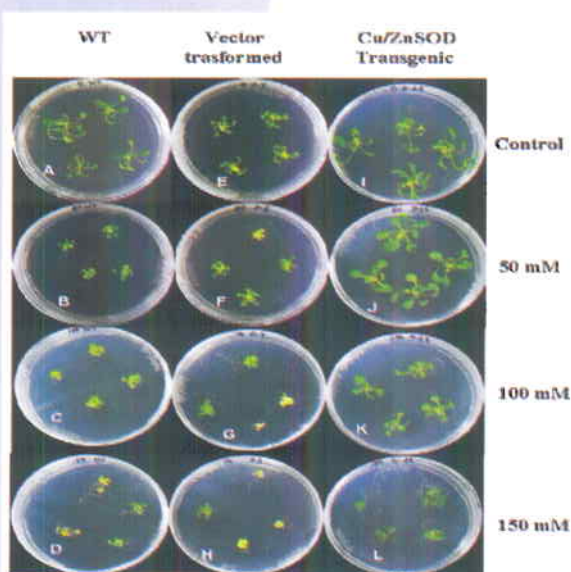
A significant difference was observed in the rate of germination of wild type and transgenic Arabidopsis under salt stress. In the medium at 150 mM NaCl stress, the germination of wild type was 25%, whereas the germination of transgenic lines was 79%. At higher salt stress (200 mM NaCl), while there was no germination in wild type, transgenic lines exhibited 20% germination. Further studies on early seedling establishment revealed that at 50 mM NaCl stress, wild type showed retarded growth, whereas transgenic seedlings grew luxuriantly. The differences were more pronounced on 150 mM NaCl stress.

After three weeks of plant growth on salt stress, root length, number of leaves and rosette areas were also measured as indicators of stress. Root length was more pronounced in transgenics than that in wild type plants in all the tested salt stress conditions. Also, the rosette area of transgenic plants was more in salt stress conditions compared to that in unstressed conditions.

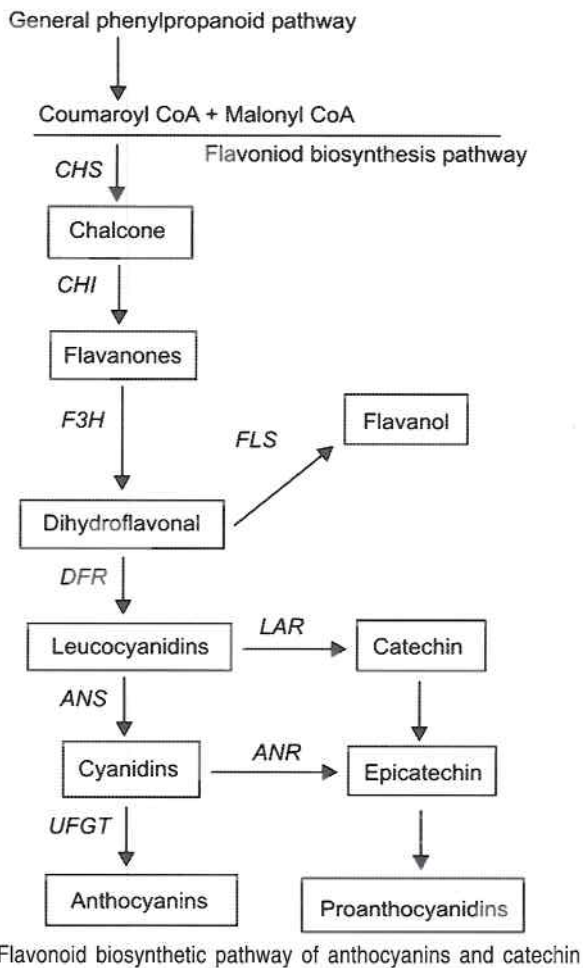
The results evidently suggest that manipulation of ROS could provide an effective strategy to improve tolerance to salt stress in plants and the same may be applied to other plants of interest and other stresses of concern.

Metabolic engineering for catechins biosynthesis in tea

Tea [*Camellia sinensis* (L.) O. Kuntze] leaves are the major source of catechins in human nutrition, the most prominent flavonoid compounds that are responsible for imparting characteristic astringency and bitterness to black tea. Catechins constitute around 25-30% in younger leaves of tea on dry weight basis. Catechins are gaining popularity, because in animal systems these have implications in



Effect of salt stress on the performance of wild type (WT) and transgenic Arabidopsis over-expressing superoxide dismutase



preventing several diseases such as cancer, neurodegenerative and other oxidative stress-related diseases including cardiovascular diseases.

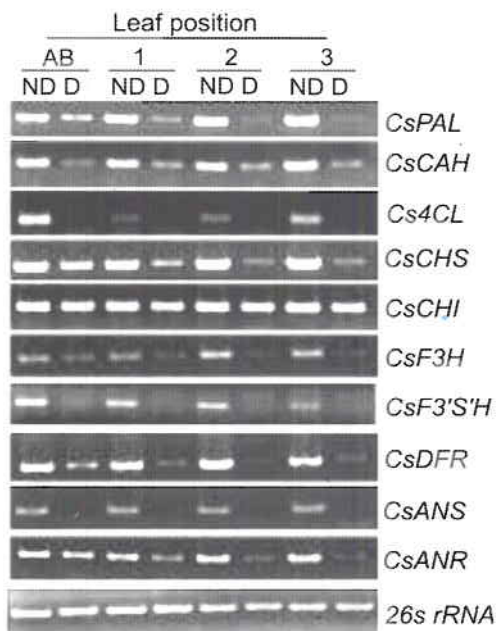
Catechins are known to be synthesized through flavonoid pathway in tea, for which no molecular information was available till IHBT deciphered the molecular regulation of its biosynthesis. Catechin biosynthesis in tea was essential for three main reasons: (1) compared to the other plants systems such as maize, petunia and arabidopsis, tea uses these pathways primarily for the synthesis of catechins apart from synthesizing anthocyanins and the other flavonoids; (2) unlike other plants, tea is an accumulator of catechins; and (3) for metabolic engineering of catechins, one must have the data on regulatory genes.

IHBT achieved first ever cloning of all the genes of the pathway leading to catechins biosynthesis. In general, genes of the pathway exhibited down-regulation in older leaf, during winter dormancy, drought stress and in response to abscisic acid and GA3, while up-regulation was observed in wounded tissue. Estimation of catechins suggested a positive correlation between gene expression and catechins content.

While 4-coumaroyl CoA ligase was the first gene to be affected under various treatments, chalcone synthase and anthocyanidin reductase were the least affected. These studies suggested that the expression of catechin biosynthesis genes is under the regulation of developmental stages and environmental stresses. These studies have opened path for metabolic engineering of catechin biosynthesis through the availability of genes and through identification of rate limiting genes.

Production of CMV-free Lisianthus for mass multiplication

Lisianthus (*Eustoma grandiflorum*; family *Gentianaceae*) is an important upcoming crop of the world. It originated from Central and North America and is grown both as a cut flower, border garden plant and as a pot plant. Recently, it has been introduced in India as a new flower



Expression analysis of all the genes of the pathway in tea. Cs before each gene represents *Camellia sinensis*



CMV tested lisianthus cvs: Blue and White in flowering stage

crop and is propagated through seed and tissue culture techniques. The crop is susceptible to infection by several viruses. The most common virus is *Cucumber mosaic virus* (CMV) which induces severe mosaic and distortion on leaves, stunting, colour break and malformation of flowers. Lisianthus plants were found showing symptoms characteristics of CMV infection. IHBT has standardized a protocol for CMV eradication through meristem tip culture and good quality virus-free planting material can be provided to farmers.

A demonstration unit for producing bamboo charcoal

Two kilns, made of bricks and mud, were constructed to demonstrate production of bamboo charcoal at IHBT. This has generated a lot of interest among the farmers and foresters because of its novelty and prospects of value addition to a bioresource, which remains unutilized or fetches very low price. More so in case of forests of Himachal where bamboo (*Dendrocalamus strictus*) clumps are suffering from congestion, because these could not be harvested. The forest department is rejuvenating the old plantations and the harvested culms can be used for charcoal making. This will also save the Oak trees in the forests from annihilation and provide an alternative to the farmers in the low lying areas where bamboo resources are not utilized properly.

International recognition to IHBT-Herbarium

The herbarium of IHBT has been duly recognized and is now listed in the "Index Herbariorum", which is a directory of public herbaria of the world, a joint venture of International Association of Plant Taxonomy (IAPT) and New York Botanical Garden (NYBG).

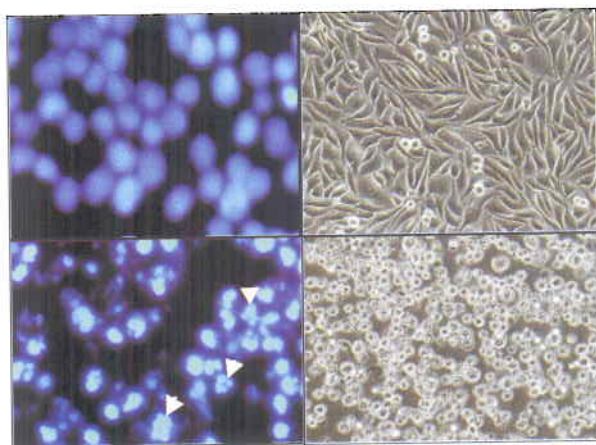
Withania somnifera formulation as chemo-immuno-therapeutic

Based on an elite variety of *W. somnifera*, developed at IIIM a standardized formulation using both leaf and root extracts has been developed containing withaferin-A and withanolide-A in equal proportions. Withaferin exhibited anticancer activity, while withanolide up-regulated Th1 immunity. Cancer patients are deficient in Th1-immunity, while cancer cells evade apoptosis. The formulation (WSF) holistically targets these deficient compartments of the disease. It has been found to be highly cytotoxic in a panel of human cancer cell lines, caused cell death through induction of apoptosis. The apoptotic cell death was mediated by activation of signaling pathways for which detailed molecular mechanism has been established. It was found highly safe in chronic toxicity when given at doses of 2000 mg/kg b. wt

for six months. The formulation effectively impaired Ehrlich Ascites tumor and Sarcoma-180 tumor in mice.

The formulation also up-regulated Th1-immunity in tumor bearing mice and tuberculosis infected mice housed in experimental BSL-3 laboratory. It increased T cell proliferation, increased the secretion of Th1 cytokines and increased the expression of co-stimulatory molecules CD40 and CD40L, besides activation of macrophages in tumor bearing mice.

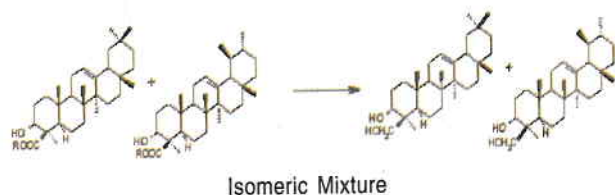
The formulation is suggested to be a potent therapeutic agent in several debilitating diseases like cancer, tuberculosis and HIV. Currently, it is being positioned as anti-cancer immunotherapeutic agent.



Influences of WSR on nuclear changes in HL-60 cells observed under fluorescence microscopy

A novel pentacyclic triterpenediol (TPD) from gum resin of Boswellia serrata with anti-cancer activity:

Based on the folkloric knowledge, IIIM isolated a novel pentacyclic triterpenediol (TPD) from gum resin of *Boswellia serrata*, which exists in nature as an isomeric mixture of 3a, 24-



dihydroxyurs-12-ene and 3a, and 24-dihydroxyurs-12-ene.

TPD induces oxidative stress in human leukemia HL-60 cells, which leads to the activation of the TNF family proteins (TNF-R1, DR4), thereby leading to caspase-8 activation and induces apoptosis through extrinsic pathway. Secondly, TPD causes disruption of mitochondrial membrane potential, renders Bcl-2 cleavage, Bax translocation, decrease in Bcl-2/Bax ratio, and release of AIF, Smac/DIABLO and cytochrome c from the mitochondria. These events are accompanied by down-regulation of survivin and activation of caspases -3, 8, -9, which cleave the ICAD and PARP and finally induce apoptosis through intrinsic pathway. It was found to impair tumor growth in mouse tumor models and did not affect the normal cells. It is now being positioned for clinical trials as an antitumor agent.

Essential oil of Cymbopogon flexuosus as a promising anti-cancer agent

For the first time, IIIM has discovered the apoptotic potential of an essential oil isolated from the lemon grass *Cymbopogon flexuosus* and its usefulness in the development of anticancer therapeutic leads. This plant is an East Indian perennial herb belonging to the family Poaceae and used in various food and aroma industry products. The *Cymbopogon flexuosus* oil (CFO) has isointermedeol (25%) as its main constituent.

Cymbopogon flexuosus oil (CFO) and isointermedeol induce apoptosis in human leukemia HL-60, utilize a wide range of molecular targets that include both apical receptors and mitochondrial dependent pathways. Both induced concentration-dependent strong and early apoptosis through an early surge of ROS formation with concurrent loss of mitochondrial membrane potential in HL-60 cells. Both CFO and ISO activated apical death receptors TNFR1, DR4 and caspase-8 activity. Simultaneously, both increased the expression of mitochondrial cytochrome c protein with its concomitant release to cytosol leading to caspase-9 activation, suggesting thereby the

involvement of both the intrinsic and extrinsic pathways of apoptosis. Further, Bax translocation and decrease in nuclear NF-kB expression predict multi-target effects of the CFO and ISO. It impaired effectively the tumor growth in tumor bearing mice. Abundant availability of *Cymbopogon flexuosus* oil with extensive use in aromatherapy, perfumery, nutraceutical products coupled with its suggested mechanism of cytotoxicity makes it a promising candidate to be developed as anticancer therapeutic.

Development of carbohydrate-based green methodologies

Carbohydrates are useful chiral synthons in natural product synthesis. They contain an abundance of hydroxy groups and it is often necessary to react only one (or some) of these groups at a time. Thus, orthogonal protecting group strategy plays a vital role in the chemical synthesis of biologically active oligosaccharides. IIM has developed a molecular iodine-catalyzed novel orthogonal protection strategy for the preparation of peracetylated ethylidene acetals or isopropylidene ketals under mild and stoichiometric conditions. The major advantages of this new strategy are: a) The outcome of the reaction can be controlled by variation in temperature. At lower temperatures, acetonide acetate and at higher temperature, peracetate are obtained as major products. b) The sugar building blocks are obtained by this method in a single step, while in the conventional method it is a multi-step process. c) It does not require or generate any strong acid resulting in a nearly neutral reaction medium, free from unwanted byproducts. d) Use of stoichiometric amounts of reagents makes it environment friendly.

2.3 CHEMICAL SCIENCE & TECHNOLOGY

CSIR is known globally for its core strength in the areas of chemistry and chemical engineering. Over the years, its domain-specific laboratories such as National Chemical Laboratory, Indian Institute of Chemical Technology 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 year under report, the same trend has continued and some of the important developments are reported below.

Electrolytic process for the production of Mg-Li alloy

Weight reduction is one of the ways to improve the fuel efficiency of all type of vehicles. Space vehicles use this technique to maximize its dead load. Magnesium and its alloys play a major role in this sector. Lithium addition further decreases the density of Magnesium and some of the rare earth metals are also added in minor quantities to improve its mechanical strength. Currently, these alloys are produced by melting the pure metals in required amount under protected atmosphere. This is a difficult and a costlier process. CECRI scientists found that the same alloys can be obtained by depositing the required metal on the molten magnesium, which is kept as cathode. This process avoids the preparation of pure reactive metals like lithium etc.

The molten salt containing the reactive metal ions Li^+ was taken as the electrolyte. The eutectic composition of LiCl-KCl plus 30 wt% Calcium chloride to increase the density of the melt. The molten magnesium metal was made as cathode in a suitable manner and graphite was used as anode. The composition, current density



Mg- Li alloy pieces kept in kerosene

and the density of the bath were optimized for preferential deposition of the lithium metal. 150 A capacity cell was operated continuously for a few days. A few kilograms of Mg-Li alloy containing about 50 wt% of Li metal was collected and kept in kerosene. For this laboratory scale cell, better than 65% current efficiency was obtained.

Surface modification of carbon nanotubes

Surface modification of carbon nanotubes (CNTs) through covalent functionalization is vital for the development of high-performance composite materials, chemosensors, nanoelectronics, photovoltaic devices, as well as for a range of biomedical applications. The reaction of benzocyclobutene with CNTs was carried out by NCL scientists. A controlled functionalization of multiwalled carbon nanotubes through Diels-Alder [4+2] cycloaddition of various substituted benzocyclobutenes was studied and the extent of control over the functionalization, in bulk and in solution at different temperatures was investigated. The extent of functionalization can be controlled by using the appropriate temperature and mode of addition of the reagent and by controlling the reaction duration. The use of polymer containing pendant benzocyclobutene produces cross-linked organic nanoclusters covalently connected to the surface of the MWNTs.

Synthesis and evaluation of combretastatin A-4 analogues as novel anticancer agents

Combretastatin A-4, a natural product isolated from the bark of *Combretum caffrum* is highly cytotoxic against a variety of human cancer cells including multidrug resistant cancer cell lines. The molecule binds at or near colchicine binding site and inhibits tubulin polymerization ultimately leading to cell death. It displays selective toxicity toward tumor vasculature by inhibiting the blood supply to the tumor leading to cell death.

A new series of 2,3-diaryl-4/5-hydroxy-cyclopent-2-en-1-one analogues replacing the cis double bond of combretastatin A-4 (CA-4) by 4/5-hydroxy cyclopentenone moieties was designed and synthesized by NCL scientists. The

analogues displayed potent cytotoxic activity ($IC_{50} < 1 \mu\text{g/ml}$) against a battery of human cancer cell lines and endothelial cells. The most potent analogues A and B belonging to the 5-hydroxy cyclopentenone class were further evaluated for their mechanism of action. Both of the analogues led to cell cycle arrest at G2/M phase and induced apoptosis in endothelial cells. Antitubulin property of B was superior to A and comparable to CA-4. The compound B had better aqueous solubility, metabolic stability, and pharmacokinetic profile than CA-4 and also demonstrated significant tumor regression in the human colon xenograft model. The data suggests that cis-restricted analogues of CA-4 are a new class of molecules that have the potential to be developed as novel agents for the treatment of cancer.

Synthesis of multifunctional nano-particles of copper-aluminum oxide

Many conducting oxides of zinc, tin, titanium, etc. serve as active base materials for the newly emerging oxide electronics in addition to their applications in key frontier areas such as photocatalysis. However, all these are basically n-type systems (charge carriers are electrons). For many junction devices, energy conversion systems as well as catalysis applications p-type materials (charge carriers are holes) are also required. Cuprous oxide and copper-aluminum oxide are such materials. Making of nanoparticles of copper-aluminum oxide is hard to achieve at low temperatures due to incompatible chemical behaviors of copper and aluminum and high temperature synthesis yields particles of large size.

NCL scientists attempted the synthesis of nanoparticles at 50 °C by treating combined solutions of nitrates of copper and aluminum with novel alkalotolerant and thermophilic fungus, *Humicola* sp. It was found that a ternary phase of the system ($\beta\text{-CuAlO}_2$) gets formed in the form of nearly monodispersed 4-5 nm nanoparticles. It was also found that these nanoparticles exhibit blue luminescence (very important property for displays and bio-labeling) and also get heated up by radiofrequency

absorption due to their conductivity (important for hyperthermia treatment).

Spider silk template in the assembly of gold nanoparticles

Spider silk is a natural polymer made up of repeating amino acid motifs that are composed of fibroin proteins ($M_r \sim 200000-300000$), which are a combination of the protein spidroin 1 and spidroin 2 and primarily contain 42% glycine and 25% alanine as the major amino acids. Spider silk has attracted the interest of the scientific community mainly due to its unusual mechanical properties, higher resilience and tensile character, and elasticity.

NCL showed that spider silk is an excellent scaffold for the one-step synthesis and assembly of gold nanoparticles. Formation of a gold nanoparticle-spider-silk bioconjugate material is accomplished by simple reaction of the fibers with aqueous chloroauric acid. The gold nanoparticles thus formed are strongly bound to the spider-silk fiber surface enabling study of the electrical properties of the nanobioconjugate. Using the well-known contraction/ expansion behavior of the fibers in solvents of varying polarity. It was shown that exposure of the gold nanoparticle-spider silk bioconjugate to vapors of methanol and chloroform leads to changes in electrical transport through the nanoparticles and thus, the possibility of developing a vapor sensor. The bioconjugate showed excellent response time and cycling efficiency to methanol vapors. The activation energy of electron transport from one gold nanoparticle to another in the nanobioconjugate was determined from temperature-dependent electron-transport measurements to be approximately 1.7 eV. Thus the nanogold-spider silk bioconjugate can be viewed as a promising candidate for the development of materials for vapor-sensing applications.

Single electron transfer behavior of nanosized rhodium particles

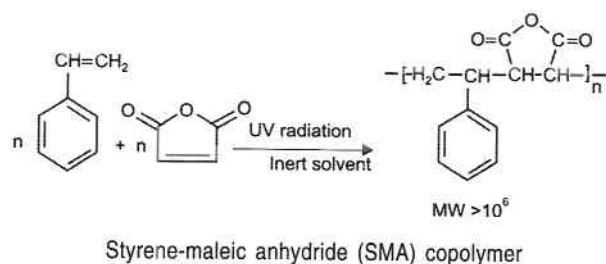
Ultra-small metallic and semi-conducting materials have great utility when their dimensions are few nanometers since their fundamental

properties can be controlled by both size and shape. However, most of these nano-materials with sizes less than 10 nm, are not stable for practical applications and, hence, protecting them against aggregation using certain special type of polymers and organic molecules like long chain amines, thiols and carboxylic acid is crucial for many of their applications. Sometimes a single molecule thick layer(monolayer) of organic molecules is enough to impart sufficient long term stability and such monolayer protected clusters (MPCs) of gold, silver, CdS, CdSe, etc., have found significance in the design of new molecular electronic devices. For example, many of them possess an uncanny ability to show discrete one electron transfer when subjected to a potential difference at room temperature, a phenomenon known as Coulomb Blockade, which is very promising for the next generation electronic devices.

NCL has developed a method to synthesize monodispersed rhodium (Rh) nanoparticles in a size domain of ~ 5 nm which exhibit variable oxidation states in electrochemical measurements. Here, limiting currents are controlled by diffusion of smaller nanoparticles towards electrode surface resulting in a series of evenly spaced redox peaks at room temperature. Rh nanoclusters can be viewed as mixedvalent ensembles of clusters with an intermediate state, where single electron process can be considered as diffusion controlled. The unprecedented behavior of such nanoclusters has the potential to lead to the fabrication of novel single electron transistor devices.

Ultrahigh molecular weight styrene-maleic anhydride copolymer prepared by UV irradiation

NEIST has developed a novel method for the manufacture of ultrahigh molecular weight



styrene-maleic anhydride (SMA) copolymer by UV irradiation, without the use of any photoinitiator. The alternating copolymer has molecular weight in the range of 2.30×10^6 to 2.70×10^6 . The copolymer shows a single phase transition corresponding to the T_g ranging from 145.0 to 166.4 °C. Ultrahigh molecular weight SMA copolymers are useful in high temperature-resistant engineering plastics and also as prophylactic in fertility control.

Industrially important organic compounds from renewable resources

NEIST has carried out a comparative study on delignification of rice straw using hydrogen peroxide and a *Trichoderma* sp. For that purpose, pre-treated rice straw was delignified using hydrogen peroxide to obtain cellulose. To reduce the amount of peroxide, a combination of *Trichoderma* sp. and peroxide was used. First the straw was partly delignified by the fungus to obtain a light brown coloured powder and fibre. The powder so obtained was further delignified by hydrogen peroxide to obtain light biscuit coloured cellulose, which was then treated with a bleaching powder solution to obtain colourless cellulose. It was observed that *Trichoderma* sp. produced cellulose in powder form and its use reduced the requirement of hydrogen peroxide for delignification by about 30%.

Gainful utilization of North Eastern high sulphur coals

The North Eastern region (NER) of India has substantial deposits of high sulphur (2-8%) coals with low ash and high volatile matter contents. Assam, one of the coal producing states of the region, has coal deposits with 75-90% of organic sulphur functionalities affixed to the coal structure, which are difficult to remove. NEIST has reported desulphurization of oxidized Assam coals by solvent extraction and alkali treatment separately. Two coal samples were selected to represent two categories: one with high organic sulphur and low ash (Baragolai) and the other with low organic sulphur and high ash (Ledo) coals of the region. The desulphurization routes comprise oxidation of two coal samples of various size fractions in an oxidative medium

followed by solvent extraction and alkali treatment separately. Oxidation of Baragolai and Ledo coals removes up to about 84 % of inorganic and 28 and 18.5 % of organic sulphur, respectively. After DMF extraction, desulphurisation increases up to 95 and 93% for inorganic sulphur and 31 and 23% organic sulphur of the oxidized Baragolai and Ledo coals respectively, while the alkali treatment shows complete removal of inorganic and a maximum of 33 and 26.4% organic sulphur for these coals, respectively. During oxidation, solvent extraction and alkali treatments, ash removal for both the coals is observed. Desulphurisation is found to increase with decrease in particle size. Decrease in atomic S/C ratio of oxidized samples shows the effectiveness of the process. Fourier Transform Infrared (FTIR) spectroscopy studies show formation of sulphones and sulfoxides (S=O) during oxidation and their removal by solvent extraction and alkali treatment.

Particle boards from non-conventional plant materials of NE region

NEIST has fabricated medium density particle boards from certain fibre yielding plants such as *Alpinia allughas*, *Hibiscus esculentus*, *Hibiscus sabderiffa* and *Cannabis sativa* using UF (urea-formaldehyde) and PF (phenol-formaldehyde) as binding materials. The optimum procedure for the preparation of boards was found by varying the parameters temperature, resin content, time and pressure. Some boards were also prepared from the mixture of coir fibre and the above mentioned plant fibres taken in different proportions under different conditions.

Nanostructures of Cu₂O (nanothreads, Nanowires and nanocubes)

NEERI has synthesized cuprous oxide (Cu₂O) nanostructures by anodic oxidation of copper through a simple electrolysis process employing plain water (with ionic conductivity 6 S/m) as an electrolyte. No special electrolytes, chemicals and surfactants are needed. The method is based on anodization pursuant to the simple electrolysis of water at different voltages. Platinum was taken as cathode and copper as anode. The

applied voltage varied from 2 to 10 V. The optimum anodization time of about 1 h was employed for each case. Two different types of Cu_2O nanostructures have been found. One type was delaminated from copper anode and collected from the bottom of the electrochemical cell and the other was located on the copper anode itself. The nanostructures collected from the bottom of the cell are either nanothreads embodying beads of different lengths and diameter (10-40 nm), or nanowires (length 600-1000 nm and diameter 10-25 nm). Those present on the copper anode were nanoblocks with a preponderance of nanocubes (nanocube edge 400 nm). The copper electrode served as a sacrificial anode for the synthesis of different nanostructures. A tentative mechanism for the formation of Cu_2O nanostructures has been suggested.

Eubacterial diversity of activated biomass from a common effluent treatment plant

A common effluent treatment plant (CETP) is a biological wastewater treatment facility that receives wastewater from different industries. The activated biomass in the CETP survives on a wide range of chemicals with no fixed wastewater characteristics. NEERI has carried out a diversity analysis of this activated biomass using culture as well as culture-independent techniques. Using culture-based techniques, strains belonging to 26 different genera from the phyla Proteobacteria, Actinobacteria and Firmicutes were isolated. The gamma-proteobacteria was the best represented class being 36.5% of the isolates. Bacterial diversity was also analyzed culture-independently by means of sequence determination of cloned 16S rRNA genes. Twenty-one different genera from the phyla Proteobacteria, Firmicutes, Planctomycetes and Bacteroidetes were identified. The activated biomass comprised members of five known phyla, represented by 37 genera, with the Proteobacteria constituting the most abundant phylum detected. However, a very large fraction of the diversity represented a hitherto unidentified bacterial population. More than half (50.2%) of the 16S rDNA clones represented unidentified non-culturable bacteria,

underlining the vast un-tapped diversity of CETP communities. Our results also indicate that both culture-based and culture-independent techniques should be combined to cover the microbial diversity of complex ecosystems.

Use of waste plastics and copper slag in building low-cost bituminous roads

A laboratory study on the use of waste plastics and copper slag (CS) in hot bituminous mixes to enhance pavement performance, protect environment and to reduce the cost of road construction has been completed. Waste plastic modified bitumen (WPMB) has been prepared by adding plastic waste (5% by weight of bitumen) in shredded form with suitable cross-linking agents to 80/100 bitumen and blending for 1 hour at 160°C. Physical properties of WPMB were found to be within the specified limits (as per IS: 15462-2004). Constituent materials such as Delhi quartzite aggregates, stone dust and lime along with the varying concentration of CS (as aggregate filler) were taken for preparation of Marshall specimens using 60/70 and 80/100 paving bitumen and WPMB. Optimum binder content was achieved at 5.2% (by wt of mix) in all the three binders used. Marshall specimens were also prepared with different proportions of copper slag (10, 15 and 20%) and used; the specimen with 15% CS was found to be the best.

Emulsion based cold-mix technology for structural layers and wearing courses in different climates

For the first time in India, CRRI has developed a cold-mix technology for use in structural layers and wearing courses of flexible pavement such as bituminous Macadam (BM), mix seal surfacing (MSS) and semi-dense bituminous concrete (SDBC), in desert, high rainfall and snow-bound areas.

Design guidelines to optimize the quantity of binder for use in construction of various wearing courses such as mix seal surfacing (MSS), premix carpet (PMC) and two-coat surface dressing (TCSD), with bitumen emulsion, are presently not available in India. These have now been developed through field trials and



View of construction with environment friendly emulsion based cold mix technology on Jammu-Srinagar road (NH-1A) in snow bound area



View of construction with environment friendly emulsion based cold mix technology in Aizwal city in Mizoram in high rainfall areas

performance monitoring of different wearing courses, viz., MSS, PMC and TSCD.

The tentative specifications of BM, MSS and SDBC have already been prepared as national documents and subsequently submitted to the Indian Roads Congress in July, 2007 for their finalization. The new technology will offer several benefits to the society, as listed below:

- Construction of binder course and wearing course (BM, MSS and SDBC), using bitumen emulsion, feasible in all weather, including wet condition.
- Environment friendly and energy efficient technology due to elimination of heating process for road construction.
- Up to 10 % economy in binder usage.
- Satisfactory performance of roads with emulsion even after 5 years of service.
- Reduction of crack propagation to overlay when emulsion is used.
- The cost of road construction with emulsion is about 10-15% cheaper than that with the hot mixes.

Methodology for emergency repair of airfield pavements

Emergency repair of airfields is required to be carried out in very short time and at utmost priority. CRRRI has developed a cost effective

scheme for emergency repair of bomb craters during war time using stabilized granular sub-base/base layers followed by a wearing course with cold mixes using cationic bitumen emulsion. Preliminary field trials based on the laboratory studies have been carried out at two air bases, one near Delhi and another in Rajasthan.

Asymmetric epoxidation of unsaturated hydrocarbons catalyzed by novel ruthenium complexes

The synthetic value of enantiopure epoxides is well established and substantial research on the synthetic methods for their production has been carried out. Although many chiral ligands are known today and used comprehensively for asymmetric catalytic reactions, there is still an increasing demand for new and improved ligands which can afford the following advantages: (i) it should be possible to prepare the ligand conveniently from the commercially available starting materials, and (ii) the catalysts prepared from the ligand should be highly selective, efficient and productive.

In this context, a new class of ruthenium catalyst complexes containing tridentate chiral Schiff-base ligands (TDL) have been synthesized by condensing D-glucose amine with 3,5-ditertiarybutyl salicylaldehyde (or 2-pyridylcarboxaldehyde) and characterized at CMERI. Development of the TDL chiral ligands,

derived from carbohydrates that are naturally occurring enantiomerically pure compounds ("chiral pool"), is of immense significance. This new family of chiral catalytic system runs under mild conditions. Since carbohydrates are naturally occurring enantiomeric pure compounds, TDL ligands are of significance with regard to chirality of catalyst complexes. The chiral ligands could be prepared in one step from commercially available starting materials. The efficacy of the present ruthenium catalytic system in terms of product yield is much better as compared to the moderate epoxide yield reported in literature for styrene epoxidation employing ruthenium catalyst complexes that contain Schiff base type ligands. The notable feature of this work is the remarkably high enantioselectivity (up to 94% of ee for 4-chlorostyreneoxide) observed in the epoxidation of alkenes with t-BuOOH.

Since, catalytic application of metal complexes containing sugar based ligands is rare, the results of the present studies would stimulate research in design and development of more sugar-based ligands and their corresponding metal complexes for catalytic application in various asymmetric syntheses. Further, the results of the catalytic and mechanistic studies carried out under this project would be of high predictive values to advance the chemistry of this important subject area. Analogous complexes of Mn and Cr also exhibited encouraging results.

2.4 EARTH RESOURCES & NATURAL HAZARDS ASSESSMENT

This is an area of unique strength for CSIR. Two of its laboratories, namely, National Geophysical Research Institute and National Institute of Oceanography have been consistently contributing by way of high impact basic science and applications-oriented science for a number of years and are globally recognized for their contributions. The important contributions during the year are listed below:

Estimates of inter-seismic deformation in northeastern India from GPS measurements

In this study carried out by CMMACS, estimates

of inter-seismic deformation in northeastern India were made based on GPS measurements at eight permanent stations (2003-2006) and six campaign sites (1997-2006). The Euler pole of rotation of Indian plate in ITRF 2000 determined from the present dataset is located at $51.7 \pm 0.5^\circ$ N, $-15.1 \pm 1.5^\circ$ E with angular velocity of $0.469 \pm 0.01^\circ$ Myr⁻¹. The results show that there is no present day active deformation over the Shillong plateau, and the deformation between the plateau and the adjoining sites on the foreland spur, north of the plateau in the Brahmaputra valley, is statistically insignificant. Convergence rate of the northeastern GPS sites with respect to the IGS station Lhasa along baselines that are normal to the Himalayan arc in this region is 16 ± 0.5 mm/yr. This represents the arc-normal Indo-Eurasian convergence rate across the north-eastern boundary, similar to arc-normal convergence rates determined in central Nepal along the Himalayan arc. GPS sites in Arunachal Himalaya indicate that 16 mm/yr shortening occurs both in the Lesser as well as Higher and Tethyan Himalayas. Baselines between sites on the Indo-Burmese Fold and Thrust Belt (IBFTB) and Shillong plateau indicate variations in the shortening rate from 1.5 mm/yr on the Tripura-Mizoram salient (TRS) south of the plateau, to 6 mm/yr in the Imphal Recess (IR) to the east and 8 mm/yr in Naga salient (NS) to the northeast. This suggests that the deformation in the IBFTB is segmented into N-S blocks along E-W transverse zones exhibiting dextral slip between NS-IR and sinistral slip between IR and TRS. Baselines between the IBFTB sites also show 10 ± 0.6 mm/yr convergence, pointing to the existence of a transverse zone between Aizawl and Imphal.

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 render 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 indicate 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 and 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.

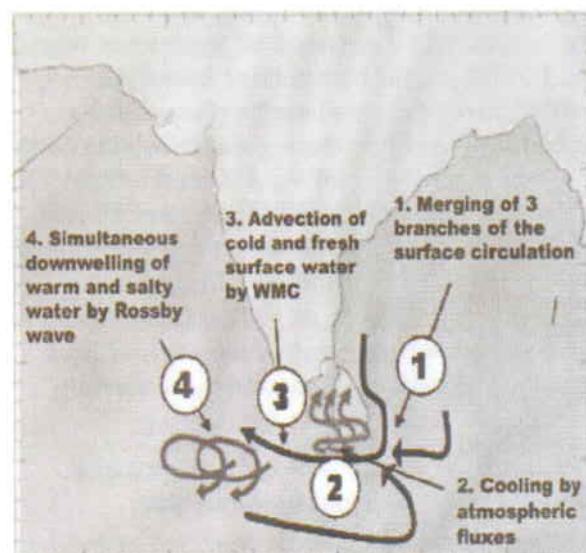
A simple multiple regression model for long range forecasting of Indian summer monsoon rainfall

In a study reported by NIO, the relationship between the Indian Ocean Sea-Surface Temperature Anomalies (SSTA) and the Indian Summer Monsoon Rainfall (ISMR) for the period 1983-2006 has been examined. High and positive correlation is noticed between ISMR and SSTA over southeastern Arabian Sea (AS) in the preceding January. Significant and positive correlation is also observed with the SSTA over northwest of Australia in the preceding February. The combined SSTA index (AS+NWA) showed a very high correlation of 0.71 with the ISMR. The correlation between East Asia sea-level pressure and ISMR is found to be 0.62. The multiple correlation using the above two parameters is 0.85, which explains 72% variance in ISMR. Using the above two parameters, a

linear multiple regression model has been developed to predict ISMR. The results are comparable with those obtained from the power regression and ensemble models of the Indian Meteorological Department. The rainfall during 2002 and 2004 could be predicted accurately from the present model.

Modeling the barrier-layer formation in the southeastern Arabian Sea

The effect of salinity on the formation of the barrier layer (BL) in the southeastern Arabian Sea (SEAS) was investigated by NIO using an ocean general circulation model. In agreement with previous studies, the runoff distribution and the India-Sri Lanka passage have a strong impact on the realism of the salinity simulated in the area at seasonal time scales. The model simulates a BL pattern in fairly good agreement with available observations. Eulerian and Lagrangian approaches show that the BL is formed by two complementary processes: the arrival of low-salinity surface waters that are cooled en route to the SEAS, and down-welling of waters, mostly local to the SEAS in the subsurface layers. The surface waters are partly of Bay of Bengal origin and partly from the SEAS, but are cooled east and south of Sri Lanka in the model. That the down-welled subsurface waters are warm and are not cooled leads to temperature inversions in the BL. The



Schematic of the barrier-layer formation process

main forcing for this appears to be remotely forced planetary waves.

Simulated seasonal and inter-annual variability of the mixed layer heat budget in the northern Indian Ocean

Continuing with the studies on ocean heating and its subsequent effect on seasons, NIO used a global ocean general circulation model (OGCM) to investigate the mixed layer heat budget of the northern Indian Ocean. The model has been validated against observations and shows fairly good agreement with mixed layer depth data in the northern Indian Ocean. The NIO separated its study into three sub basins: the western Arabian Sea (AS), the eastern AS, and the Bay of Bengal (BoB). This study reveals strong differences between the western and eastern AS heat budget, while the latter basin has similarities with the BoB. The penetration of solar heat flux needs to be taken into account for two reasons. First, an average of 28 Wm⁻² is lost beneath the mixed layer over the year. Second, the penetration of solar heat flux tends to reduce the effect of solar heat flux on the SST seasonal cycle in the AS, because the seasons of strongest flux are also seasons with a thin mixed layer. This enhances the control of SST seasonal variability by latent heat flux. The impact of salinity on SST variability has been demonstrated. Salinity stratification plays a clear role in maintaining a high winter SST in the BoB and eastern AS, while not doing so in the western AS. The presence of freshwater near the surface allows heat storage below the surface layer that can later be recovered by entrainment warming during winter cooling (with a winter contribution of + 2.1°C in the BoB). On an inter-annual time scale, the eastern AS and BoB are strongly controlled by the winds through the latent heat flux anomalies. In the western AS, vertical processes, as well as horizontal advection, contribute significantly to SST inter-annual variability, and the wind is not the only factor controlling the heat flux forcing.

Trajectory of an oil spill off Goa, eastern Arabian Sea: field observations and simulations

An oil spill occurred off Goa, west coast of India,

on 23 March 2005 due to collision of two vessels. In general, fair weather with weak winds prevails along the west coast of India during March, which assists the spill to move slowly and reach the coast. However, in 2005 when this event occurred, relatively stronger winds prevailed, and these winds forced the spill to move away from the coast. The spill trajectory was dominated by winds rather than currents. NIO used the MIKE21 Spill Analysis model to simulate the spill trajectory. The observed spill trajectory and the slick area were in agreement with the model simulations. This study illustrated the importance of having pre-validated trajectories of spill scenarios for selecting eco-sensitive regions for preparedness and planning suitable response strategies whenever spill episodes occur.

Relict benthic foraminifera in surface sediments off central east coast of India as an indicator of sea level changes

In an interesting study, NIO has attempted to reconstruct sea level variations along the central east coast of India during the late Pleistocene and early Holocene. A total of 39 surface sediment samples were collected from the water depth range of 27-2,777 m, which were studied for foraminiferal content. The samples from the depth range of 36-110 m showed the presence of relict foraminiferal tests along with recent foraminifers. The relict foraminiferal assemblages of *Amphistegina*, *Operculina*, *Calcarina* and *Alveolinella* in the selected surface samples are characteristic of coral reef environment and have been inferred as evidence for past low sea levels. Based on extrapolation of previously published radiocarbon dates from the region, a pliable sea level curve for the period between approx. 9,000 and approx. 14,000 years BP has been proposed.

Occurrence of gas hydrates along the continental margins of India, particularly the Krishna-Godavari offshore basin

The presence of gas hydrates along the Indian continental margins has been inferred mainly from the bottom simulating reflection/ reflector (BSR) and the gas hydrate stability zone

thickness map of India. NIO has carried out multidisciplinary investigations in the Krishna-Godavari offshore area along the eastern continental margin of India, which is known for its hydrocarbon potential. Processed multibeam data provided a high-resolution seafloor mosaic with a fine scale geo morphology. Deep tow digital side scan sonar, multi frequency chirp sonar and 3.5 kHz sub-bottom profiler records depict various kinds of gas escape features over the regions where BSRs are prominent. Geochemical analyses of the 5 m-long cores showed a general "decrease" trend in the porewater sulphate concentration, while the gas chemistry revealed an "increase" trend of methane concentration with core depth. Total organic carbon varied from 0.6 to greater than 2.0% and CaCO₃ from 5.0 to greater than 29%. These observed geophysical, geochemical and microbial proxies suggested the likely presence of gas hydrates in the Krishna-Godavari offshore area. Recent drilling work carried out confirmed the presence of massive (greater than 80 m thick) accumulation of gas hydrates, and fully developed gas hydrate system in the Mahanadi offshore area and the Andaman Sea.

The rapid drift of the Indian tectonic plate

NGRI has developed a seismic technique "the S-wave receiver function" and used it to estimate, with unprecedented accuracy, the lithospheric thickness of several continents - India, Africa, Antarctica and Australia, which were all part of Gondwanaland. It was found that the cratons in South Africa, Antarctica and Australia are more than 180 km thick, whereas Indian lithosphere is only about 100 km thick, even though the crust is the oldest (Archaean) in age and that the most likely time for India to have lost its continental roots was when a large upwelling of especially hot rock- a mantle plume- hit Gondwanaland during or immediately after its break up, leading to a much faster drift of Indian plate at the rate 18-20 cm/year.

The study has appeared in one of the world's topmost journals, *Nature*, and provides a new dimension to the classical plate tectonics theory. Strong evidence is provided to indicate how the plate thickness correlates with the speed of plate

motion. For the first time, an explanation has been provided for the fast drift of the Indian plate in the initial period after the Gondwanaland break up.

Deep electrical crustal structure in Antarctica

Applying a new Geophysical tool, "Marine Magnetotellurics (MMT)" technique, in the Gulf of Kutch region of Gujarat in coordination with the Scripps Institute of Oceanography (USA), NGRI has carried out wide band Magnetotelluric (MT) investigation to map the deep electrical structure and compare the co-seismic activity around the Schimacher Oasis, Antarctica with other regions across the globe. ADU 06 system was deployed for data acquisition of continuous magnetic and telluric signals during December 2006 to February 2007. Three stations have been occupied around Schirmacher oasis close to Sankalp and Mardid hill. The station Sankalp is located on continental shelf ice area and the other two stations are located on land near Mardid hill. Continuous MT data has been collected for about one month at Sankalp and two months at Mardid Hill.

Fractals of Geophysics

Modern concepts of fractals and chaos theory have been applied to examine earthquake time series for understanding the nature of earthquake dynamics and, hence, to characterize the model behaviour. An NGRI study has mainly focused on examining the impact of foreshocks and aftershocks on the nature of the earthquake dynamics with the help of modern nonlinear forecasting approach. The monthly frequency earthquake datasets obtained from one of the most seismo-tectonically crucial regions of northeast India, bounded by latitude 20-28°N and longitude 88-98°E, were used in the study. These datasets spanned a time period of 1920-1988. Results indicate that earthquake data free from aftershocks and foreshocks show better predictive behaviour than the original data (i.e., data combined with aftershocks and foreshocks), thus revealing a significant effect of foreshocks and aftershocks on the model characterization of earthquake dynamics.

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The Bengkulu earthquake of 12th September 2007 of magnitude 8.4 Ms estimated by the NGRI observatory was studied immediately for its Tsunami wave generation and propagation within 1 hour after the earthquake. The modeling results showed that the directivity of the Tsunami was towards the open ocean in the southwest direction and that India would be safe from the Tsunami. This result was obtained 2 ½ hr before the predicted arrival time at Chennai and the findings were discussed with the media even before the Tsunami warning for the Indian region was withdrawn.

Another study was done for understanding the great earthquakes, which are known to nucleate at mid-crustal level beneath Main Control Thrust (MCT) zone and rupture the Himalayan décollement to appear at mountain front at Himalayan Frontal Thrust (HFT). Some paleoseismic studies in the HFT zone have recorded the signatures of the same. Trenching experiments have been carried out across the geomorphic expression of a fault scarp in HFT zone and the features associated with the surface rupture have been documented.

The wavelet analysis of bathymetry of western offshore has also been carried out. The profile covers Western Basin, Laxmi ridge, Laxmi Basin, Panikkar Ridge, continental slope and continental shelf. The spectral analysis of data has been done to correlate the origin of different regions. The fractal dimension shows that spectral behaviour of crust of Laxmi Basin is similar to that of continental shelf and slope, which indicates the nature of crust of Laxmi Basin as continental.

2.5 ECOLOGY & ENVIRONMENT

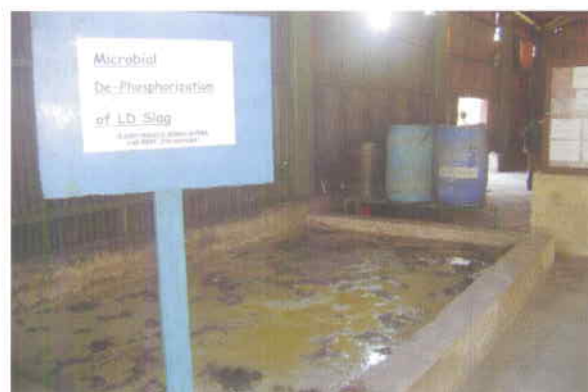
This is an area of research having immense societal and commercial implications; some of the CSIR laboratories have reported work of noticeable significance in this area, as described below:

Microbial removal of phosphorus from LD slag

Linz-Donawitz (LD) slag contains lime, which

varies from 40 to 50%. Due to the presence of calcium in higher quantity, it can be used as a flux in blast furnace provided the phosphorus content is reduced to <0.5. This also increases the cost efficiency of the steel plant. Hence, removal of phosphorus from LD slag was carried out at IMMT with the help of phosphorus solubilizing microorganisms - *Pseudomonas aeruginosa*, *Pseudomonas putida*, *Bacillus sphaericus*, *Bacillus polymyxa* and an unidentified bacterium isolated from soil.

Chemical analysis of representative samples received from a steel plant showed the presence



Five ton heap leaching plant jointly set up by IMMT and VSP for microbial phosphorus removal from LD slag at Visakhapattanam Steel Plant

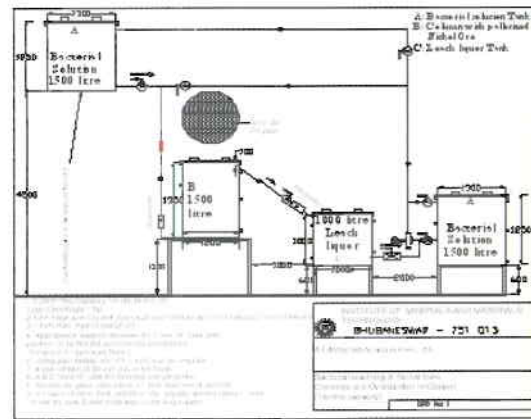
of 1.73% P_2O_5 . Experiments were carried out under different conditions with varying pulp densities of LD slag, size fraction and microorganisms.

IMMT scaled up experiments at 1 ton scale, which showed up to 40% phosphorus removal using *Bacillus polymyxa*. Scanning electron microscopy was performed to observe the phase distribution of calcium, silica, phosphorus, manganese, ferrous and aluminium in the original and biologically treated LD slag samples. Micrographs showed the presence of calcium, silica and phosphorus in the same zone. Phosphorus was present in the calcium silicate matrix. In case of biologically treated samples, concentration of phosphorus in the calcium silicate matrix was less when compared to that in untreated LD slag. Based on these findings, a 5 ton biobeneficiation plant has been set up by IMMT in association with Visakhapattanam Steel Plant.

Microbial process for recovery of nickel and cobalt from chromite overburden of Sukinda mines

Chromite overburden samples from five sites of Kaliapani Mines, Sukinda were studied by IMMT to estimate percentage of nickel. A representative sample from this bulk was subjected to size classification in original condition as well as after thermal treatment at 600°C. It was observed that massive goethite phase containing Ni changed to spongy hematite after thermal treatment.

A sample containing 1 ± 0.1 % nickel and 0.032-0.045% cobalt was selected for further study. A laboratory stock culture of a mesophilic acidophilic consortium (predominantly *Acidithiobacillus ferro-oxidans*) was used in the microbial recovery experiment. Shake flask/column leaching experiments were carried out under different conditions such as variation of pulp density and ferrous sulphate concentration. The leach liquor containing nickel was subjected to precipitation followed by solvent extraction to get nickel hydroxide. About 60-65% nickel and 62-71% cobalt were extracted in the shake flask experiments at 10% pulp density with 10g/L



One ton capacity column for bacteria leaching of nickel from chromite ore overburden



Ten ton bioleaching plant for nickel ore at IMMT

ferrous in 45 days. Time, temperature and pH had maximum influence on extraction of nickel and cobalt. Pulp density and inoculum size and ferrous sulphate had no direct effect on nickel extraction. About 72% nickel and 69% cobalt

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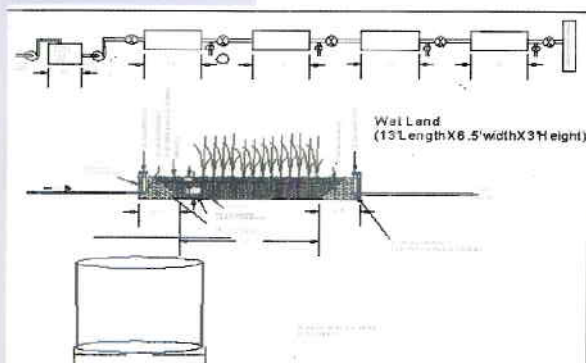
was extracted from extended 1kg scale column experiments under similar conditions.

1 ton and 10 ton capacity facilities have been created in the lab.

Currently, chromite overburden leach liquor bearing 2.25 gpl Fe, 2.17 gpl Ni, 1.57 gpl Mn, 0.36 gpl Co, 0.13 gpl Zn, 0.34 gpl Cr and 2.37 gpl Al is being treated where almost quantitative removal of Fe, Al and Cr has been achieved with CaCO₃ treatment. This solution will undergo solvent extraction for separation of zinc, manganese and cobalt from the solution to get pure Ni bearing solution, which will be concentrated by solvent extraction and sent for electro-winning of Ni.

Remediation technology package for sustainable management of wetland ecosystems

An experimental design, using FRP tanks, to develop technological packages for management of wetland has been worked out by IMMT. To start with, the effluents discharged into the



An experimental remediation technology design for wetland management

IMMT sewerage were analyzed. Anaerobic and aerobic bacterial cultures from nearby natural wetlands were isolated and purified for experimental use. Potential hydrophytes, especially *Salvinia cucullata* and *Ichhornea crassipes* were collected and grown in the FRP tanks and their absorption rates monitored.

Use of constructed wetlands will provide real economic benefits by conserving water for industrial and agricultural use and reducing toxic contamination of the environment.

Agro technology for *Jatropha curcas* (*Jatropha*) cultivation

On the basis of multi-year evaluations, a promising strain of *Jatropha* with respect to seed output as well as oil percentage has been identified by IMMT and christened as ORISSA-2. Pruning was carried out during winter season when leaf shedding took place and 12-15 branches were obtained from each plant. Unpruned trees exhibited 8-9 branches/tree. Extensive germination experiments indicated that maximum germination percentage can be obtained by soaking the seeds in cow dung slurry (1 kg dung in 5 lit well water). Age of unknown seeds can easily be determined using this strategy. Germinations greater than 90%, 60%, 40%, or 30% mean that the seeds are respectively, 1, 2, 3, or 4 year old. This is also confirmed by tetrazolium biochemical method (0.1% 2,3,5-triphenyltetrazolium chloride-dehydrogenase-triphenylformazone). A new multi-location trial was carried out involving high yielding genotypes collected from 17 states.

Clean bioprocess for quality fibre production & energy recovery

Traditional extraction method of plant fibres, especially the coir fibre and jute is being continued even today in spite of its serious adverse impact on environment and quality of products. After many decades of research for a clean bioprocess, NIIST has developed an environment and labour friendly process for the extraction of plant fibres, which enables faster production of better quality fibres. The technology demonstration of coir fibre extraction

was done at 0.5 ton level with concomitant generation of 500 M3 of methane rich biogas per ton of fibre. Commercialization of this new technology can eliminate the water pollution and methane emission from the traditional extraction.

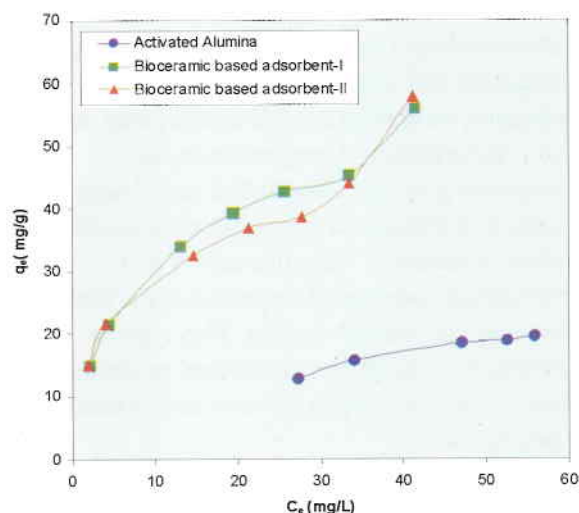
Effective utilization of byproduct phosphogypsum

About 4.5-5 tonnes of byproduct phosphogypsum (BPG) are generated from phosphoric acid manufacturing unit of a phosphoric fertilizer plant. The waste poses a major disposal problem. Studies have been conducted to utilize BPG as a raw material for manufacture of value added products. Byproduct phosphogypsum is basically calcium sulphate associated with 2 molecules of water. NEERI has developed wallboard from BPG, which is fire and heat resistant. Bagasse has been used as a reinforcing material. The wallboard has proved successful in jolting test and its compressive strength conforms to the Indian standards. There being a demand of ammonium sulphate as a fertilizer, studies have also been conducted to convert BPG to ammonium sulphate. Principles of Merseberg process have been applied in preparation of ammonium sulphate from BPG. Nitrogen content in ammonium sulphate was within the range of 20-21%, which conforms to the fertilizer control order.

Defluoridation of industrial wastewater using new adsorbent media

NEERI has developed bioceramic based composite adsorbent media for defluoridation of wastewater. The bioceramic based composite adsorbent media show excellent defluoridation properties as compared to activated alumina. The newly developed adsorbents show high fluoride uptake capacity and selectivity under a wide range of pH, which is of immense practical importance.

A continuous flow experiment was also conducted to evaluate the column performance for fluoride removal by the bioceramic and biopolymer based composite adsorbents and activated alumina. Bioceramic based adsorbents I and II show significantly high breakthrough



Comparison of defluoridation of industrial wastewater using activated alumina and bioceramic based adsorbent media (initial concentration of fluoride in wastewater=47 mg/L; contact time= 24 hr)

capacities of 3.47mg/g 16.53mg/g as compared to activated alumina (0.044mg/g). From the laboratory experiments it was observed that such type of adsorbent media can be used for defluoridation of wastewater at industrial level.

2.6 ELECTRONICS & 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 have found applications in India's space, atomic energy and defence programmes. During the year some significant results obtained are described below:

Analysis and design of corrugated long-period gratings in silica-on-silicon planar wave-guides.

CEERI has carried out a detailed theoretical analysis of light transmission through a corrugated long-period waveguide grating made in silica-on-silicon planar waveguide. Grating period of ~ 280 nm was considered in order to achieve a strong rejection band in the wavelength region of 1.5 μm. Phase-matching graphs were studied to find the relationship

between the resonance wavelength and the grating period. The effects of the variation of the waveguide and grating parameters on the resonance wavelength were investigated in detail. Polarization-dependence on the waveguide gratings was studied and finally the design was optimized by proper choice of the grating parameters, which resulted in a polarization-independent rejection band in the operating wavelength region. This type of waveguide gratings has significant potential for various integrated-optic devices and sensing applications.

Design technology of sub-system of Gyrotron

Design of a triode type Magnetron Injection Gun (MIG) for a 200kW, 42GHz Gyrotron with an operating voltage of modulating anode at 29 kV and accelerating voltage at 65kV has been reported by CEERI. Operation mode of this Gyrotron is TE₀₃ and it would be used in a TOKAMAK system for plasma heating. The MIG has been designed using commercially available code EGUN and three in-house developed software codes MIGSYN, GINTMESH and MIGANS.

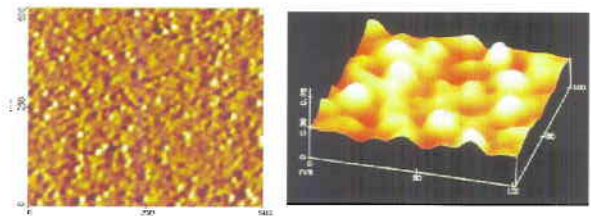
The development of design technology for electron gun, interaction structure is general in nature and would help the R&D in Gyrotron. The techniques developed were used to design various sub-components for 42 GHz, 200 kW Gyrotron.

Nanostructures, nanoelectronic devices and enabling technology development.

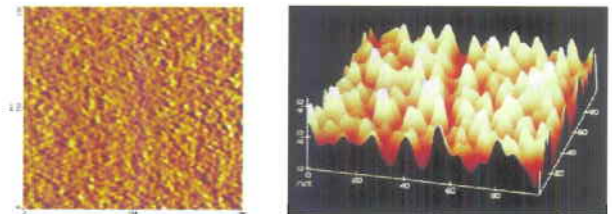
CEERI has reported synthesis of silicon nanoparticles by CMOS compatible LPCVD and PECVD processes for applications in new class of nanoelectronic devices such as single electron transistors, single electron memories, next generation photovoltaic devices, etc.

Silicon nanoparticles have been synthesized on SiO₂/Si substrates by thermal decomposition of silane at high temperatures for very short duration in LPCVD process. PECVD is a low-temperature synthesis process. In synthesis experiments, diluted silane gas has been used in

Argon plasma at relatively low temperatures for very small durations. Syntheses have been carried out at different temperatures and for different durations of time. These nanoparticles have been imaged using Atomic Force Microscope and analyzed for size and density. The images show hemi-spherical shaped nanoparticles on substrate surface. Size and density estimation have been performed by image processing using a special software. The estimated size of particles and typical density are in the range of 6-16 nm, $\sim 2.2 \times 10^{11}/\text{cm}^2$ for LPCVD process and 5-20 nm, $\sim 7.0 \times 10^{11}/\text{cm}^2$ for PECVD process, respectively. AFM images of nanosilicon particles are shown below.



Silicon nanoparticles synthesized by PECVD process at 350°C



Silicon nanoparticles synthesized by LPCVD process at 575°C

MEMS capacitive ultrasonic transducers

Ultrasonic transducers are useful in areas of non-destructive testing and echo-graphic imaging systems. Capacitive micro-machined ultrasonic transducers (cMUT) offer many prime advantages over piezoelectric transducers, such as low impedance mismatch, higher temperature threshold, higher transmitting frequency, higher sensitivity and low cost. The capacitive ultrasonic cell consists of a thin conducting or metalized membrane stretched over a conducting back plate. At present, there are three technologies for fabrication of MEMS devices, namely, bulk micromachining, surface

micromachining and wafer bonding technique. The wafer fusion bonding technique was used by CEERI due to its advantages over others, such as lesser number of processing steps, which saves the processing time. After testing of these devices using Laser Doppler Vibrometer, fabrication process technology was finalized and desired performance of devices was achieved. Vacuum-sealed cavities were fabricated for cMUT of 1x1, 5x1, 5x5 and 10x10 arrays in which size of a single cell was 50 μ m hexagonal (edge length). The frequency response of the cMUT devices, fabricated by wafer bonding, indicates 2.240 MHz resonance frequency, which is close to the designed frequency of 2.3 MHz. Device structure was further analyzed by Focused Ion Beam etching and SEM imaging for silicon membrane thickness and gap below the membrane.



Cluster of capacitive ultrasonic cells

Trapped miner locator system

The underground mining environment is hazardous and prone to several disasters including roof collapse, inundation and gas leakage among others, which frequently trap miners who do not have any mechanism to contact the ground personnel or the management. With the CEERI-developed technology, it is easier for the management to keep track of each and every miner wirelessly without interfering in their day-to-day operations. It is a two-way mechanism in the sense that the

miners can also send alarm to the management from their work place in case of any possible mishap. The units comprise a base station and a wireless miners' kit. The base stations are installed in the underground and miner's kits are attached to the belts of miners. The base station keeps track of the miner's location through the interactions with the miners' kit. The technology has been successfully field-tried at Khetri copper mines and is currently awaiting DGMS (Director General of Mine-Safety) approval for use in the underground coal mines.

Design and development of Ku-band 140 W space TWT

A Ku-band 140 W Space TWT has been designed and developed jointly by CEERI, Pilani and BEL, Bangalore. A prototype of the TWT has been developed and tested in CW mode. It delivered targeted stable power and gain, i.e., 140 W CW output power in 10.9 to 11.7 GHz frequency band and more than 50 dB gain. Collector efficiency was more than 75% and overall efficiency was 55%. The simulated and experimental results show very good matching over the desired frequency mode.

Design and development of graphite electrodes multi-stage depressed collector

The graphite collector technology is the state-of-art technology for Space TWT and is possessed only by USA. This technology is very useful for enhancing the overall efficiency of Space TWTs.

CEERI has designed and fabricated complete graphite electrodes multistage depressed collector assembly using copper-impregnated high density graphite (DFP-1C) and it was integrated with Ku-band TWT prototype. Two appendage pumps (at collector and gun ends) were integrated. The TWT was RF-tested in CW mode and the desired 140 W output power and more than 50 dB gain over the full operating band of 10.9 to 11.7 GHz was achieved.



Front view of graphite electrode MDC assembly



Rear view showing feedthroughs



TWT with graphite collector on RF test bed

Thermal detector comprising a wire made of a negative coefficient material

CSIO has developed and fabricated a 15 m long continuous thermal detector using a mixture of manganese-band spinel and lanthanum oxide powder. The addition of La_2O_3 leads to decrease in thermistor constant and activation energy values, thus giving freedom to fabricate thermal sensors for various temperature applications. A 3 m long continuous thermal detector for application in the temperature range 275-350 oC was fabricated and later coupled to form a continuous unit of 15 m length. It has applications as thermal sensor for aerospace programme of the country.

IR based snow surface temperature measuring probe

An IR probe has been developed by CSIO that is useful for measuring the temperature of snow surface without the need for a physical contact with the snow surface. The instrument has been designed around very precise optical and electronic components. This type of system has been developed for the first time in the country. The system can operate round the clock in harsh weather/environmental conditions in snow-bound areas, e.g., in a temperature range of - 40o C to +50o C with high relative humidity & wind speed of the order of 200 km/hour. This instrument has been installed in Siachen region and J&K region and interfaced with a data collection platform. The recorded temperature data is being transmitted hourly through satellite from Siachen and J&K region to central base station at SASE, Chandigarh. This instrument can measure temperature with a resolution of 0.1o C and consumes very low power.

Technology demonstration of an energy management system for textile dyeing units

The textile industry accounts for around 1/3rd of the total export earnings and provides employment to over 35 million people. It is an energy intensive industry, consuming 3.0 million tons of coal, 0.6 million tons of furnace oil, 0.2 million tons of high speed diesel and around 5000 million units of power in the organized sector



Titanium-coated ophthalmic surgical instruments

alone. The overall energy saving potential in this sector is estimated to be 23%.

CSIO has developed an energy management system based on the Lon Works technology, which has been licensed to provide comprehensive recording structure for benchmarking of energy consumption.

After analyzing the day-to-day fluctuations in the energy consumptions and specific energy consumptions (SEC), it was observed that the best SEC for a period of one month was 1.11 units/ kg and the average SEC for a period of one year was about 1.33 units /kg. There is a saving potential of 0.2 units /kg, which comes out to be about 4.5 lakh units/annum equivalent to a financial benefit of Rs. 22.5 lakhs.

Protective biocompatible coating on ophthalmic surgical instruments

Commonly used materials for surgical instruments and orthopedic implants are 300

series, 400 series and precipitation hardened stainless steel (SS), which is corrosion resistant and biocompatible. These instruments experience corrosion after prolonged use and autoclaving process. High alloy steels release heavy metal ions, which have negative influence on the immune system. In contrast, high strength, low weight, better biocompatibility and outstanding corrosion resistance properties of titanium and titanium alloys have led to their wide acceptability for making surgical instruments and orthopedic implants.

CSIO has developed a surface engineering process to enhance the useful life of these instruments by coating them with titanium and its alloys. The deposition process was standardized in terms of coating thickness, film stoichiometry, hardness and adhesion.

Titanium Nitride (TiN) was selected for coating on SS ophthalmic surgical instruments using the physical vapour deposition technique. Film

adhesion, micro hardness, stoichiometry and thickness were measured. The coated instruments underwent large number of autoclaving cycles during users' trials at reputed medical institutes including PGI, Chandigarh; AIIMS, New Delhi and GMCH, Chandigarh and were found satisfactory. Adhesion tests and hardness measurement have been done to validate the integrity of coating and examine the absence of the vulnerability to stress failures.

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:

Development of a process for oxidative desulphurization of diesel

Oxidation of dibenzothiophene (DBT), 4-methylthiophene (4-MDBT) and 4,6-dimethylthiophene (4,6-DMDBT) was studied at IIP using the isobutyraldehyde/molecular oxygen oxidation system in the absence of metal catalyst as the sulphur present in hydrodesulphurized (HDS) diesel is mostly in the form of substituted dibenzothiophenes. This oxidation system was found to oxidize these sulphur compounds to their respective sulfones; the oxidation reactivity was found to decrease in the order: 4,6-DMDBT > 4-MDBT > DBT. Further, the study was extended to oxidation of sulphur compounds present in HDS diesel in a two-phase system using the aldehyde/molecular oxygen oxidation system. The oxidized HDS diesel on extraction with polar solvents showed remarkable reduction in total sulphur. Acetonitrile was found to be the most effective among solvents studied, and isobutyraldehyde was observed to be the best among aldehydes studied. In HDS diesel, total sulphur could be reduced from 448 to 77 ppm by oxidation followed by solvent extraction, and it could be further reduced to 31 ppm by passing through a silica gel column.

Corrosion behavior of biodiesel from seed oils of Indian origin

Environmental factors and depleting reserves of crude oil are becoming the main driving force in the quest for cleaner and alternative fuels. In India, adoption of Euro III and Euro IV equivalent emission norms is under consideration. The Euro III emission norms have already been implemented in 7 mega cities and would be implemented in the rest of the country by the year 2010. This will lead to drastic reduction in sulphur content and increase in cetane number, which in turn will adversely affect the lubricity characteristics of the diesel fuel. However, the use of biodiesel will improve the lubricity and cetane number requirements, particularly for ultra low sulphur diesel. Studies for the synthesis and characterization of biodiesel from non-edible oils like *Jatropha curcas*, *Pongamia glabra* (Karanja), *Madhuca Indica* (Mahua) and *Salvadora oleoides* (Pilu) have been carried out at IIP. Corrosion characteristics of biodiesel are important for long term durability of engine parts, and very little information is available on this aspect. The studies were, therefore, taken up to assess the corrosion characteristics of synthesized biodiesel from the above mentioned non-edible oils.

Development of zeolite-based reforming catalyst for aromatics production

Environmental concerns and emerging norms on fuel quality demand production of neat and quality fuel. Lead phase out, aromatics restriction and olefins limitation drive the gasoline blending stocks to specified narrow range products, where the branched paraffins gain much importance. The low octane, high Reid Vapour Pressure (RVP) and light alkane feed stocks in the form of natural gas liquids (NGL) are a suitable source for the production of branched paraffins by several reaction routes such as isomerization and alkylation. Zeolites have been emerging as highly efficient, solid acid catalysts to operate in the refinery reactor. IIP has been working in the area of zeolite-based light alkane conversion for the production of green gasoline and LPG, where a process NTGG (NGL to gas

and gasoline) is presently under demonstration at GAIL site at Vaghodia with a plant capacity of 8000 TPA.

New indigenous catalyst for sweetening of lighter petroleum fractions

The presence of mercaptans in petroleum products like LPG, naphtha, gasoline, ATF and kerosene is undesirable due to their foul odour and highly corrosive nature. In commercial practice, the low molecular weight mercaptans present in LPG and light straight run naphtha (LSRN) are first extracted with alkali and subsequently catalytically oxidized to disulfides with air.

All the Indian refineries are using imported catalysts for these sweetening processes. IIP in collaboration with BPCL has developed an indigenous sweetening catalyst Thoxcat ES, which is applicable to extractive sweetening of LPG and also liquid-liquid sweetening of lighter petroleum fractions like light naphtha and light cracked gasoline.

As the catalyst plays a role in enhancing mercaptide oxidation rate in the oxidizer, activity of this catalyst has been evaluated in the laboratory by studying mercaptide oxidation reaction (caustic regeneration) using ethyl mercaptan as a model compound in a glass column. The results have shown that mercaptan conversion time is less in case of IIP catalyst compared to that for the commercial one. This has confirmed that the activity of IIP catalyst is better than that of commercial catalyst being used.

Commercial trial run of the IIP catalyst was successfully undertaken in one of the FCC LPG Merox units of BPCL, Mumbai for four months. It showed better performance than that of the commercial catalyst being used. Throughput of LPG during this trial was 275-330 MT/day and mercaptan content in feed was 150-200 ppmw. This was followed by another trial run in one of the LPG Merox units of RIL refinery, Jamnagar for eight months. The unit had throughput of 4800-5300 MT/day LPG, which is a mixture of approximately 80-85 % FCC LPG and 15-20 %

coker LPG. Although feed mercaptan varied from 400 to 750 ppmw, total sulphur in treated LPG was being maintained within the range 10-12 ppmw, as this went to the propylene recovery unit. The consumption rate of this catalyst was found to be less than that of the commercial catalyst. The IIP catalyst has shown excellent performance under very rugged conditions.

The process knowhow for manufacturing this catalyst has been licensed and commercial use of this catalyst has been started at BPCL, Mumbai. Other refineries, including RIL Jamnagar, will also start its commercial use in near future. It has been planned to replace imported catalyst by this catalyst in all the Indian refineries and also to penetrate global market.

PEM-based hydrogen generator

CECRI has pioneering work on Polymer Electrolyte Membrane (PEM) based hydrogen generation to generate pure hydrogen and oxygen from water suitable for Proton Exchange membrane Fuel Cell as reactants. CECRI developed a 100, 200, 400W and 5kW capacity PEM water electrolyser. The units are conveniently designed to be portable and to deliver the hydrogen up to a pressure of 50psi.

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:

Preparation of bio-oleoresins from garlic

A premier laboratory of CSIR, CFTRI has prepared garlic bio-oleoresin from blending of volatile oil and resin obtained from enzyme pretreated garlic. The bio-oleoresin finds application as a flavourant in food and as a nutraceutical in pharmaceutical applications. The advantage of bio-oleoresin is that it is free from toxic solvent residues and enzyme-assisted extraction of garlic oil results in significant increase in the yield of oil.

An enzymatic approach as well as the use of ethanol as solvent for resin extraction in place of conventionally used chlorinated solvents for the extraction of volatile oil from garlic was explored. Enzyme treatment of garlic prior to steam distillation/hydro-distillation has resulted in two-fold increase in the yield of oil and a marginal increase in yield of resin, without affecting the physico-chemical quality of the oil. Cellulolytic enzymes applied individually or as commercial mixture of enzymes and also application of enzymes sequentially were found to be effective in increasing the yield of oil. Profiling of the garlic oil by GC-MS has shown that di-2-propenyl trisulfide along with corresponding di- and tetrasulfides constituted the major portion of the oil. The other major flavour compounds identified are methyl 2-propenyl mono-di sulfides, vinyl dithiols and dithianes.

Detoxification of coffee processing waste by Pleurotus

This technique opens a new vista for the production of mushrooms that are nutritionally better while contributing to the control of environmental pollution from coffee processing wastes.

Coffee processing results in waste, which comprises mainly pulp and hull. This waste is not utilized due to anti-nutritional factors, leading to environmental pollution. Instead, this waste can be channelized to lead to value addition, enhancement of rural economy and pollution control. CFTRI has used coffee processing wastes such as coffee pulp, coffee hull and spent coffee for the production of mushrooms. It has been observed that the mushrooms produced using these substrates have better nutritional value compared to mushrooms produced using rice straw. No accumulation of caffeine in the fruiting bodies is observed indicating that growing *Pleurotus* may decaffeinate the substrates as well.

Pure stevioside from *Stevia rebaudiana* leaves

Stevia compounds are three hundred times sweeter than sucrose and have a lingering taste

in mouth. The heat and pH stability of steviosides enables their use in food preparations, as many conventional sweeteners cannot be used. Due to their physical, chemical and biological properties, these compounds have found use in food and pharmaceutical industry. China meets 80% of the world demand for these compounds.

CFTRI has developed a Stevioside process, which has helped in formulating many efficient methods useful in the biotechnology applications in the institute. Reduction in the levels of polyphenolics and use of reusable adsorbent are the novel steps, and the methodology involved in the process is also unique. The process also involves production of pure stevioside extract, which can also be used as such in liquid dispensers as a non-nutritive sweetener. The crystalline stevioside will be useful in formulations for food and pharma applications due to its high sweetness and almost zero caloric value; moreover, it has storage advantage due to its high stability. This stevioside process knowhow has been useful in formulating various recipes requiring non-nutritive sweetener for food applications.

2.9 HEALTH CARE, DRUGS & 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:

Mechanistic insights from the crystal structure of a feast/famine regulatory protein from *Mycobacterium tuberculosis* H37Rv

Rv3291c gene from *Mycobacterium tuberculosis* codes for a transcriptional regulator belonging to the Lrp/AsnC-family (leucine responsive regulatory protein/regulator of asparagine synthase C gene product). CDRI has identified a novel effector-binding site from crystal structures of the apo protein and its complexes with a variety of amino acid effectors, and X-ray-based ligand screening and qualitative fluorescence spectroscopy experiments. The

new effector site is in addition to the structural characterization of another distinct site in the protein, conserved in the related AsnC-family of regulators. The crystal structures reveal that the ligand-binding loops of two crystallographically independent subunits adopt different conformations to generate two distinct effector-binding sites. A change in the conformation of the binding site loop 100-106 in the B subunit is apparently necessary for octameric association and it also allows the loop to interact with a bound ligand in the newly identified effector-binding site. There are four sites of each kind in the octamer and the protein preferentially binds to aromatic amino acids. While amino acids like Phe, Tyr and Trp exhibit binding to only one site, His exhibits binding to both sites. Binding of Phe is accompanied by a conformational change of 3.7 Å in the 75-83 loop, which is advantageously positioned to control formation of higher oligomers. Taken together, the present studies suggest an elegant control mechanism for global transcription regulation involving binding of ligands to the two sites, individually or collectively

Structural genomics of Mycobacterium tuberculosis proteins using NMR spectroscopy

CDRI has achieved a significant milestone by solving structure of the potential drug target protein peptidyl-tRNA hydrolase from *M. tuberculosis* H37Rv (MtPth) in solution by NMR spectroscopy. CDRI has assigned ~2100 NOEs derived from ¹⁵N-edited NOESY-HSQC and ¹³C-edited NOESY-HSQC experiments and used the distance constraints, dihedral angle constraints and hydrogen bond constraints to generate an ensemble of 40 structures using the software CYANA-1.0.5. This ensemble of 40 structures represents the solution structure of MtPth and has been deposited in PDB under ID 2JRC. Parallely, the amide ¹⁵N T1, T2 and ¹⁵N{¹H} heteronuclear NOE have been measured and these parameters used for detailed dynamic analysis of the protein. Results highlight the dynamic interaction of the protein with its substrate peptidyl-tRNA.

Conversion of antimalarial drug artemisinin to a new series of tricyclic 1,2,4-trioxanes

The discovery of artemisinin as the active principle of the Chinese traditional drug *Artemisia annua* is a major achievement in malaria chemotherapy. Artemisinin and its more potent semisynthetic derivatives, e.g., artemether, arteether and artesunic acid, are active against both chloroquine-sensitive and -resistant malaria. These compounds are fast acting and are currently the drugs of choice for the treatment of cerebral/complicated malaria caused by multidrug-resistant *Plasmodium falciparum*. While these drugs show excellent activity by the parenteral route, they show poor absorption by the oral route. While the 1,2,4-trioxane moiety is believed to be essential for antimalarial activity of these drugs, the extra acetal-lactone and acetal-acetal linkages are linked with their poor hydrolytic stability and, therefore, poor absorption.

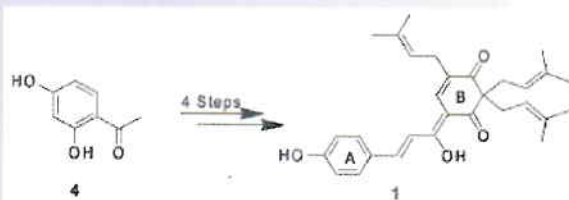
For the first time, CDRI has developed a highly efficient route for the conversion of the antimalarial drug artemisinin to a novel hydroxy-functionalized tricyclic 1,2,4-trioxane. Neither the trioxane nor its derivatives, all of which lack the hydrolytically unstable lactone linkage, show antimalarial activity comparable with that of acetal artemisinin. CDRI has also prepared several seco analogues of artemisinin and evaluated them for their antimalarial activity.

Total synthesis of munchiwarin, a triprenylated chalcone from crotalaria medicagenia

Chalcones are main precursors for the biosynthesis of a large number of ubiquitous flavonoids, which are frequent components of the human diet. In vitro and in vivo antimalarial and antileishmanial activity has been reported for licochalcone A isolated from *Glycyrrhiza inflata* Batalin (licorice). Medicagenin isolated from the roots of *Crotalaria medicagenia* DC, exhibits antimalarial activity. 3-Methoxy-4-hydroxy lonchocarpin isolated from the *Lonchocarpus utilis* A.C. Sm. inhibits NADH: ubiquinone oxidoreductase activity

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An efficient method for the synthesis of the modified triprenylated chalcone, munchiwarin, isolated from the roots of *Crotalaria medicagenia* has been developed by CDRI. The synthesis of 1 utilizes a Claisen-Schmidt condensation between 2,4-dihydroxy-3,5-diprenyl acetophenone and 4-methoxy benzaldehyde in the presence of Ba(OH)₂ to yield the unusual chalcone that contains a nine-membered ether ring. Further prenylation with 1-bromo-3-methylbut-2-ene and its subsequent demethylation with BBr₃ gave munchiwarin (1).



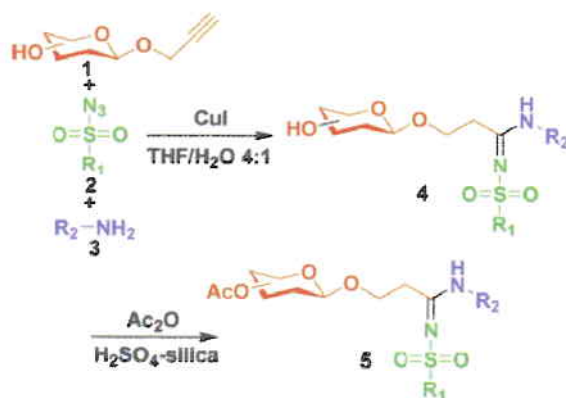
Synthesis of munchiwarin

Inhalable drug delivery systems targeting macrophage-resident TB bacteria

As a part of efforts in the area of drug delivery, CDRI in collaboration with M/s. Lupin Laboratories Ltd., has developed a novel formulation for delivering controlled-release microparticles to lung macrophages. This formulation shows unexpectedly high efficacy against experimental animal tuberculosis (Sen et al. US Patent Application 20070154408, 5 July 2007). These microparticles also have the ability to enlist the aid of the innate immune response of the host in clearing bacteria.

Glycosylated N-sulfonylamidines: highly efficient copper-catalyzed multicomponent reaction with sugar alkynes, sulfonyl azides, and amines

Multicomponent reaction (MCR) is a powerful tool for generating highly functionalized molecules with complexity and diversity in a straightforward single-pot reaction. Therefore, MCR is growing in popularity for its application in combinatorial chemistry and drug discovery. Amidines are useful targets for drug discovery and development with respect to their profound application as important pharmacophores, synthetic intermediates and efficient coordinating



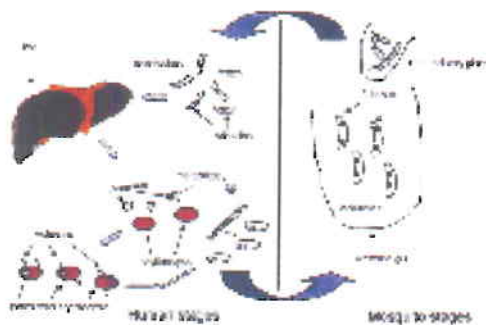
Scheme for synthesis of glycosylated N-sulfonylamidines via Cu-catalyzed MCR

ligands. Moreover, they are abundant in various medicinally active natural products. However, the chemical synthesis of amidine is not an easy task. Generally, they are prepared from synthetic intermediates such as aldoximes, thioamides, or isonitriles, relying on simple functional group transformations. The MCR approach for the synthesis of amidines is still rare in the literature.

CDRI has developed an efficient synthetic route for the preparation of glycosylated N-sulfonylamidines through the Cu-catalyzed MCR approach with sugar alkynes, sulfonyl azides and amines. The method is simple and affords the target compounds in high yield and purity. These highly functionalized molecules are under evaluation for their bioactivity.

Malarial adhesins and adhesin-like proteins predictor (MAPP)

A web server has been developed by IGIB scientists to identify adhesin or adhesin like virulence factor proteins in Plasmodium species.



Adhesin surface proteins are required at various stages of the malaria parasite. The case for *P. falciparum* is shown.

The MAAP Web server has been built with a trained Support Vector Machine (Machine Learning) as its engine. It is likely to aid not only in deciphering the molecular mechanisms of host pathogen interaction but also in developing new vaccine formulations, which can be tested in suitable experimental model systems.

M. tuberculosis SysBorg: A systems biology platform for the whole organism (M. tuberculosis)

Through a CSIR-networked effort, a systems biology platform for tuberculosis research has been developed in the first phase. The platform offers a comprehensive resource of annotations, drug information, host pathogen interaction, polymorphism, gene expression and pathways. This platform would be useful for researchers in identifying and assessing drug targets and vaccine candidates. The platform was launched and demonstrated at IGIB on Aug 10th, 2007.

Targeting promiscuous peptides to dendritic cells for elicitation of protective immunity against M. tuberculosis

Identification of promiscuous peptides, which bind to human leukocyte antigen, is indispensable for global vaccination. However, the development of such vaccines is impaired due to the exhaustive polymorphism in human leukocyte antigens. The use of in silico tools for mining such peptides circumvents the expensive and laborious experimental screening methods. Nevertheless, an intrepid use of such tools warrants a rational assessment with respect to experimental findings. Using 179 peptides from diverse antigens, IMTECH scientists have validated six commonly used in silico methods, namely, ProPred, MHC2PRED, RANKPEP, SVMHC, MHCpred and MHC-BPS. It has been observed that the prediction efficiency of the programs is not balanced for all the HLA-DR alleles and there is extremely high level of discrepancy in the prediction efficiency depending upon the nature of the antigen. It is known that the in silico methods studied are not very proficient in identifying promiscuous peptides. This puts much constraint on the

intrepid use of such programs for human leukocyte antigen class II binding peptides. This study concludes that the in silico methods cannot be wholly relied upon for selecting crucial peptides for development of vaccines.

Studies on structure-function and molecular mechanism of functions of novel microbial hemoglobins

Fundamental studies on novel hemoglobins of Mycobacterium tuberculosis have been undertaken and several novel aspects of their functionalities have been unraveled. These studies indicated that M. tuberculosis hemoglobins, HbN and HbO, may be playing vital roles in cellular metabolism and pathogenicity of mycobacteria. The research carried on these oxygen-binding proteins at IMTECH has been published in various international journals of high repute and has received wide citations. It establishes the importance of these oxygen-binding proteins for the pathogenicity and intracellular survival of M. tuberculosis. Fundamental studies on their molecular mechanism of function and protein-protein interactions provide novel drug targets for the development of antimycobacterials.

Identification of a novel cysteine-specific transporter in Saccharomyces cerevisiae

Cysteine, with its free sulphhydryl group, is an important amino acid residue affecting the structural and functional properties of proteins. In addition to the de novo synthesis of cysteine from inorganic sulphur in S. cerevisiae, the transport of cysteine from the extracellular medium also contributes to the cellular cysteine homeostasis.

Several studies have been carried out to characterize cysteine transport biochemically and identify the transporter proteins responsible for uptake of cysteine in S. cerevisiae. However, these studies have been complicated by the different strain backgrounds and growth conditions employed and have led to quite contradictory conclusions. Several transporter proteins have been identified that can mediate the transport of cysteine in S. cerevisiae. On the

basis of studies by earlier groups, it appears that cysteine is not taken up by a specific permease, but rather by multiple permeases with broad specificity, each active under different sets of growth conditions. However, no specific high affinity transporter for cysteine uptake has so far been proposed or characterized in the yeast *S. cerevisiae*.

The absence of a specific transporter for this important amino acid, being puzzling, has led IMTECH scientists to re-examine the yeast genome for the existence of a cysteine-specific transporter. Starting with an analysis that mined existing genome-wide data, they sought out membrane transporters that were being de-repressed under conditions of increased cysteine requirements in the cell. This analysis identified a candidate transporter, Yll055wp of unassigned function, belonging to the Dal5p transporter family. Although all the amino acid transporters described so far in *S. cerevisiae* fall into the amino acid permease family, IMTECH scientists nevertheless investigated the possibility that YLL055w might encode a cysteine transporter. Detailed genetic, molecular and biochemical analyses of this protein along with studies on its regulation, reveal that the YLL055w ORF encodes a high-affinity, cysteine-specific transporter.

Important fresh insights into the mechanism of RNA interference and heterochromatic silencing

IMTECH has demonstrated a surprising role of Anaphase Promoting Complex (APC) in silencing at mating type, centromere and rDNA loci in *S. pombe*. This function is ascribed to the interaction of APC subunits Cut4p and Cut9p with the heterochromatin proteins Swi6 and Clr4. Genetic and molecular studies indicate that Swi6 acts downstream of APC in assembly of heterochromatin. Preliminary experiments indicate that Swi6 also interacts with the securin Cut2.

It has also been found that APC participates in the RNA interference pathway. The results indicate the occurrence of bi-directional transcription from the dh repeats, which are

considered to be the sites of nucleation of RNAi-mediated establishment of heterochromatin. This accumulation occurs owing to lack of degradation of the reverse transcripts from the dh repeats in the RNAi mutants.

Understanding the precise role of nuclear transcription factor kappa B (NF- κ B) in mycobacterial infection

As NF- κ B activation is antiapoptotic, the present study was conducted to see the role of NF- κ B in virulent (*Mycobacterium tuberculosis* H37Rv; H37Rv) and avirulent (*M. tuberculosis* H37Ra; H37Ra) mycobacteria infection in THP-1 cells. For this study, to inactivate NF- κ B, pCMV-IkBaM dn, containing THP-1 cell line was generated by IMTECH scientists, which showed a marked increase in apoptosis with H37Rv and H37Ra. Infected THP-1-IkBaM dn cell line showed decrease in mitochondrial membrane potential, cytochrome c release, activation of caspase-3 and enhanced TNF- α production. Increase in apoptosis of infected THP-1-IkBaM dn cells resulted in inhibition of intracellular mycobacterial growth. Differential NF- κ B activation potential was observed with H37Rv and H37Ra. Both activated NF- κ B after 4 h in THP-1 cells, but after 48 h only H37Rv activated NF- κ B and caused upregulation of bcl-2 family anti-apoptotic member bfl-1/A1. Overall, the results demonstrated that H37Rv activated NF- κ B and bfl-1/A1, a survival strategy adopted by this pathogen for its antiapoptotic effect.

Characterization of a membrane expressed multifunctional glycolytic enzyme and its role in macrophage function

GAPDH is known primarily as a cytosolic protein. IMTECH has demonstrated for the first time that GAPDH has a novel cell surface localization in mammalian cells.

It was of interest to understand how an essentially cytosolic protein is localized on the cell membrane surface and elaborate its novel functions. In order to answer this question, complete characterization of the membrane expressed GAPDH was undertaken wherein it was established that this molecule functions as a

novel receptor for the important iron transport protein transferrin. Iron is a crucial element for the survival of both eukaryotic and prokaryotic cells. Previously, two transferrin receptors (TfR1 and TfR2) have been identified in mammalian cells. The present findings describe the presence of an entirely new uptake mechanism for the iron transport protein transferrin into mammalian macrophages, wherein these cells utilize the ubiquitous moonlighting protein GAPDH as a receptor. This mechanism provides an elegant method by which this abundant cellular protein is relocated to the membrane for this additional role. It is thus proposed that mammalian cell surface GAPDH represents a primitive mechanism for the uptake of iron transport proteins that has been conserved in cells. Because GAPDH is a ubiquitous protein, the broader implications of this finding are that in addition to macrophages, this may be an alternative mechanism for iron acquisition in other mammalian cells and tissues.

The current findings are central to understanding iron metabolism in mammalian cell systems. The importance of these findings can be gauged from the fact that the first ubiquitous transferrin receptor (TfR-1) was identified in the 1950's. The second transferrin receptor (TfR-2) was identified in the 1990's, which, however, is expressed only on certain cell types. This present discovery identifies a new type of ubiquitously expressed transferrin receptor that bears no homology to the two previously known receptors. The study has also established that this receptor is regulated by the levels of extracellular iron.

Curcumin glucoside as an anti-aggregating agent of α -synuclein: therapeutic relevance to Parkinson's disease

A process for the preparation of curcumin glucosides in improved yields was developed by CFTRI and their implication in alleviating Parkinson's Disease (PD) symptoms was studied. Curcumin glucoside behaves as an anti-aggregating agent, prevents toxic oligomer formation and delays the process of aggregation. This new findings might possibly help to prevent the progression of PD, as α -synuclein

aggregation is the hallmark for PD progression. This data has immense therapeutic application in relation to PD.

Antilithogenic influence of dietary garlic, onion and fenugreek

CFTRI has evaluated the beneficial influence of dietary garlic and onion in cholesterol gallstone disease, in experimental mice. Cholesterol gallstones (CGS) were induced by maintaining the animals on a lithogenic diet (0.5% cholesterol) for 10 weeks. Inclusion of garlic and onion (either raw or heat processed) powders (0.6 and 2.0% respectively in the lithogenic diet) significantly reduced the incidence of CGS. The reduction in the incidence of CGS was 40% in the case of raw garlic and 50% in the case of heat processed onion. The antilithogenic potential was also evidenced with respect to severity of CGS. The increase in gallbladder weight in lithogenic diet-fed group was significantly countered by dietary garlic and onion. The cholesterol saturation index was significantly lowered in all the spices-fed groups compared to the lithogenic group. Biliary lipid profile showed significant alterations in the proportion of bile acids, phospholipids and cholesterol, which is important in determining the solubility of cholesterol in bile. The cholesterol: phospholipid ratio was significantly decreased in bile by feeding raw and heat processed spices. Total bile acid content was also increased by dietary spices. The hydrophobicity index was significantly lowered by dietary *Allium* spices. The antilithogenic effect of garlic and onion was accompanied by a beneficial hypocholesterolemic influence in these animals.

Similarly, fenugreek seed powder, when included as 5, 10 and 15% of this atherogenic diet, significantly lowered the incidence of cholesterol gallstone in mice. The gallstone incidence was 66% in 5% fenugreek group, 36% in 10% fenugreek group and 8% in 15% fenugreek group. The beneficial antilithogenic influence of dietary fenugreek is attributable to its hypocholesterolemic effect. Biliary cholesterol was 297-422 mg/dl as a result of dietary fenugreek, as compared to 1.33g/dl in high cholesterol feeding without fenugreek.

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Product Launched

- The antimalarial drug α - β Arteether (brand name: E-mal), developed by CDRI and marketed by Themis Medicare, was launched in Ghana on 29th November, 2007.
- Mycobacterium tuberculosis diagnostic kit, developed by CDRI and licensed to Biotron Health care Ltd., Mumbai, was launched during the Annual Day of CDRI on 17th February, 2008.

2.10 HOUSING & 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.

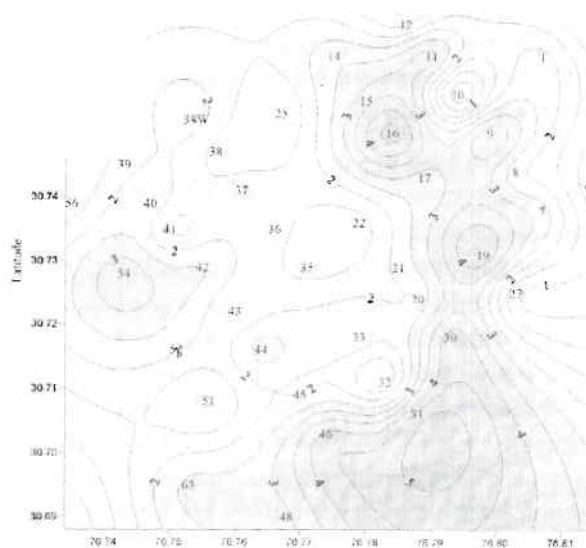
Liquefaction hazard mapping of Chandigarh region based on site characterization

Soil liquefaction during an earthquake has been one of the major concerns for geotechnical engineers. Liquefaction is a phenomenon by which the soil loses all its shear strength due to increase in pore pressure caused by ground shaking during an earthquake. This results in disastrous effects such as land sliding, sand boiling and, particularly, tilted buildings and foundation failures. For new construction activity in any city, it is important that engineers have adequate information regarding liquefaction potential level of soil and the related methods for its mitigation.

Chandigarh, a newly laid out city in northern India, is occupied by semi-consolidated formations of upper Shivalik system of middle Miocene age and is exposed in north-eastern fringe. Indo-Gangetic plain in the rest of the territory is occupied by the alluvium of Pleistocene age. The city lies in a highly

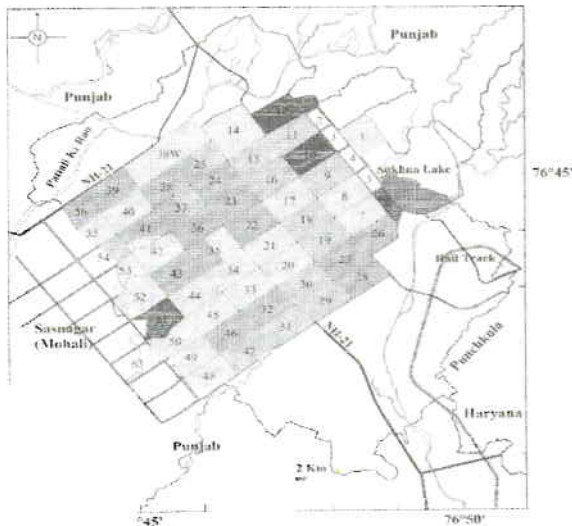
earthquake prone Himalayan seismic belt (zone IV, IS 1893 - 2002).

CBRI has carried out a series of liquefaction analyses to evaluate the factor of safety based on the local soil conditions at different depths in various sectors. Accordingly, the factor of safety against liquefaction has been assessed with respect to different peak ground accelerations (PGA) and the range of minimum values compiled. For better understanding of the influence of PGA, the factor of safety distribution contours with respect to different PGA values have been drawn. Figure below shows a typical factor of safety contour for a peak ground acceleration of 0.08g.



Factor of Safety Contours

It is observed from the figure that the factor of safety ranges from 1 to 5 in most parts of the city. Further, based on the range of factor of safety values, city areas have been classified into different zones of liquefaction susceptibility level, such as high, moderate, low and nil. Finally, an attempt has been made to prepare the liquefaction susceptibility map of Chandigarh city as per the classified susceptibility level of each sector. The liquefaction susceptibility map of the area prepared for the PGA of 0.08g is shown in Figure.



Liquefaction Susceptibility Map

It indicates that for a major part of the city, liquefaction susceptibility level ranges from nil to moderate. However, a few sectors in the city show high vulnerability against liquefaction; it is mainly attributed to the presence of non-plastic silts with low SPT eN' values and subsurface water table level at shallow depth. The study would be useful for planners/engineers to know the liquefaction susceptibility of Chandigarh city for better earthquake disaster management.

Alpha plaster & cementitious binders from non-traditional materials

For ceramic industry, dentistry and structural boards, there is a need of high strength plaster. Normal β -plaster, popularly called plaster of Paris, has low strength and medium density. The α -plaster variety of plaster gives high strength and longer life of use. Thus, CBRI has developed α -plaster by autoclaving selenite gypsum powder (passing 150 micron) in presence of several admixtures. The calcined gypsum slurry was immediately filtered and dried at 130°C. It was found that on using sodium succinate (0.25%) at 35 psi steam pressure for a period of 2 hr, the α -plaster obtained had a compressive strength of 25-30 MPa, setting time of 8-10 minutes and bulk density of 1.40-1.50 g/cc. SEM studies showed formation of needles, and columnar and prismatic crystals of broadened surface.

Three series of cementitious binders were produced. The first series was prepared by

blending fly ash, α -plaster and hydrated lime, whereas in second series fly ash, granulated blast furnace slag, fluorogypsum, hydrated lime and a chemical activator in different proportions were used. The 25mm cubes of cementitious binders cast at normal consistency and cured at 27°, 40° and 50°C under humidity showed an increase in compressive strength and bulk density with increase in curing period and temperatures in all binder compositions. Data showed that a binder having the composition fly ash: α -plaster: hydrated lime as 40: 30: 30 exhibited enhancement in strength at all temperatures.

The maximum strength was achieved at 50°C (26.4 MPa), whereas at 40°C and at 27°C the strength at 28 days was 22.8 and 12.6 MPa, respectively. The study shows that water absorption and porosity decreased with increase in temperature (water absorption: 25.7%, 22.4%, 19.3 and porosity 34.4, 31.7 and 27.6 at 27°, 40° and 50°, respectively). Studies on binders made under the third series containing alpha plaster, marble dust, hydrated lime and additives are in progress.

Instant house made of natural fiber composite

A foldable and transportable twin house unit having foldable side walls, foldable end walls and foldable roof panels, which, in their unfolded condition, form a rectangular configuration, has been developed. It also includes a frame structure erected using three numbers gable frame and twelve numbers horizontal member by a hinged joint. This expandable, portable twin house unit can be transported in the load bed of a truck. When the house is collapsed for transport the sheet panels can be folded. The shelter can be removed from the truck's load bed component-wise and can be assembled on site. There is a provision for foundation of instant house. For this purpose, holes can be drilled at site and base frame can be grounded. This foldable house has four wall panels and two roof panels hinged together edge-to-edge, such that these panels can be folded in a side-by-side layered fashion. When the sheet panels are unfolded and are disposed in an upright position, various forms of covers may be mounted on the edges of the frame panels using nut and bolts to form a shelter. There is provision of leveling of

house using leveling screws mounted on the frame itself. This will help in maintaining an even level in case the house is required to be erected on rough ground. A floor can be added as an additional part of the structure, which is at full strength when set up flat on the ground.

2.11 INFORMATION DISSEMINATION & PRODUCTS

CSIR has made for itself a name in information dissemination and science policy related studies. Two of its institutions, NISCAIR and NISTADS, have continued to contribute in the area as described below.

Dissemination of information to S&T community

NISCAIR provides communication links to scientific community through the publication of 19 scholarly journals of international repute, covering all major disciplines of science and technology. These 19 journals include 17 research and two abstracting journals. The research journals are (volumes corresponding to years 2007-2008): *Journal of Scientific and Industrial Research* (JSIR, monthly, Vol. 66-67), *Indian Journal of Experimental Biology* (IJEb, monthly, Vol. 45-46), *Indian Journal of Biochemistry and Biophysics* (IJBB, bimonthly, Vol. 44-45), *Journal of Intellectual Property Rights* (JIPR, bimonthly, Vol. 12-13), *Natural Products Radiance* (NPR, bimonthly, Vol. 6-7), *Indian Journal of Marine Sciences* (IJMS, quarterly, Vol. 36-37), *Indian Journal of Traditional Knowledge* (IJTK, quarterly, Vol. 6-7), *Indian Journal of I Biotechnology* (IJBT, quarterly, Vol. 6-7), *Bharatiya Vaigyanik evam Audyogik Anusandhan . Patrika* (BVAAP, Hindi, half-yearly, Vol. 15-16), *Indian Journal of Chemistry - Section A* (IJC-A, 1 monthly, Vol. 46-47), *Indian Journal of Chemistry - Section B* (IJC-B, monthly, Vol. 46-47), *Indian Journal of Pure and Applied Physics* (IJPAP, monthly, Vol. 45-46), *Indian Journal of I Radio and Space Physics* (IJRSP, bimonthly, Vol. 36-37), *Indian Journal of Chemical \ Technology* (IJCT, bimonthly, Vol. 14-15), *Indian Journal of Engineering and Materials Sciences* (IJEMS,

bimonthly, Vol. 14-15), *Indian Journal of Fibre and Textile Research* (IJFTR, quarterly, Vol. 32-33), *Annals of Library and Information Sciences* (ALIS, quarterly, Vol. 54-55). The abstracting journals are: *Medicinal and Aromatic Plants Abstracts* (MAPA, bimonthly, Vol. 29-30), and *Indian Science Abstracts* (ISA, fortnightly, Vol. 43-44). Two of these, viz., IJTK and MAPA are included in the list of 'Prior Art Journals' used by the International Search Authorities for prior art search while granting patent(s).

All the NISCAIR journals follow international practices for scholarly communication, e.g., having editorial boards, peer reviewing in case of research journals, and timeliness, and are covered by the major abstracting, indexing and current awareness services in their respective fields. Many are also covered by SCI, e.g., IJC-A (2006 IF 0.631), IJC-B (2006 IF 0.491) and IJPAP 2006 IF 0.380). All the journals enjoy good subscriber base (16815 as of Dec 2007).

Special issues of the journals were brought out from time to time on important themes. The themes of special issues of the various journals brought out during 2007-08 are: Fractals in Marine Sciences (IJMS, Vol. 36 No.2, June 2007), Marine Micropaleontological Studies from the Northern Indian Ocean (IJMS, Vol. 36 No.4, December 2007); Management with Emphasis on Mobile and Tele-communications Industry (JSIR, Vol. 66 No.4, April 2007), Advances in Industrial Biotechnology'- Indian Scenario (JSIR, Vol. 66 No.8, August 2007); Molecular and Clinical Immunology in Health and Disease (IJBB, Vol. 44 No.5, October 2007); Micro Electro Mechanical Systems (IJPAP, Vol. 45 No.4, April 2007), Applications of Mossbauer Spectroscopy (IJPAP, Vol. 45 No. 10, October 2007); Rural Wireless Communication (IJRSP, Vol. 36 No.3, June 2007), GPS and Its Applications (IJRSP, Vol. 36 No.4, August 2007), Select Papers from CODEC-06, Kolkata (IJRSP, Vol. 36 No.5, October 2007), A. P. Mitra Commemorative Issue on Ionosphere, Atmosphere & Global Change (IJRSP Vol. 36 No.6, December 2007); and Indian Science,

Engineering and Technology (BVAAP, Vol. 15 No. 1-2, December 2007).

NISCAIR's contribution to the economy/ society has been through the following major activities:

- (i) Popularization of Science
- (ii) CSIR e-Journals Consortium
- (iii) National Science Digital Library
- (iv) Graphic Art, Production and Printing

Science popularization

NISCAIR endeavours to take science to the people, mainly students, through its well-circulated three popular science magazines: *Science Reporter* (English, monthly), *Vigyan Pragati* (Hindi, monthly) and *Science Ki Duniya* (Urdu, quarterly).

During 2007-08, *Science Reporter* (Vol 44-45) continued with its objective of providing to its readers topical coverage of issues in various fields such as information technology, wildlife, environment, space, nuclear technology, health and biotechnology as well as light reading material such as humour, amazing scientific facts, profiles of scientists, science projects, inventions and discoveries and much more. Five of the 12 issues brought out during the year were special numbers on: Nanotechnology (April 2007); Environment (June 2007); 60 Years of Indian Science (August 2007); Wildlife (October 2007) and Space (March 2008). Also, four new columns were introduced from January 2008: 'CSIR in the Service of Nation'; 'What's New'; 'Strange Plants' and 'In the Picture'.

Likewise, *Vigyan Pragati* (Vol. 56-57) continued to provide information in an easy to understand mode on important current events/issues. Five special issues were brought out on: World Health Day (April 2007), World Environment Day (June 2007), Children's Day (November 2007), and National Science Day (February 2008). Some new columns were also introduced such as 'Yugpravartak Mahavibhuti', 'Naveen Jankari', 'Rochak Jankari' and 'Ek; Report'.

Similarly, *Science Ki Duniya* (Vol 33-34) continued to provide a package of interesting

columns such as Science Quiz, Science Models, Science News, Science for Children and Science for Women apart from major articles covering a wide range of fields including agriculture, energy, environment, food, health care, oceanography, space and wildlife.

NISCAIR also brings out the Council's newsletter *CSIR News* (fortnightly, Vol 57-58, during the reporting period) that serves as a useful link among the various CSIR establishments and also communicates activities/ accomplishments of the Council, particularly those pertaining to research and developments, to other R&D organizations, universities, S & T agencies/ departments, industry and other users, mass media, etc. It also disseminates information regarding CSIR to other countries through Indian/foreign missions. Its Hindi version, *CSIR Samachar* (monthly, 24-25), is also brought out.

Spatial database on natural resources and socio-economic parameters

NISTADS has developed an integrated spatial database on natural resources and socio-economic parameters using GIS/GPS/RS technologies to help in local area development planning. The study area was Chharora (Tauru) Mewat, Haryana. The village Sizra revenue map (indicating all land parcels) was procured with the help of Mewat Development Society (MDS) volunteers. In Lal Dora, each and every household/structure was surveyed and plotted on paper to prepare Naksha Najri (village Lal Dora map indicating all households) and was geo referenced. Accordingly, a database for the study area has been created and various thematic maps prepared. Video coverage of the Chharora village was undertaken. Each and every household listed in the voter list was checked. A glossary of local terms is being prepared. Notable results are as under:

- Linkages were established with village development functionaries, mainly, planners, decision makers and implementing agencies working in the field including government, non-government and private bodies.
- More than one dozen original maps were generated including map composition

format, vectorised digital map/sizra, regional setting and geographical position with respect to administrative units. GIS databases were also created using Geo Concept 5.6.GIS software and JT Maps1.2 GIS S/w.

- The study demonstrated the methodology for village development planning through appropriate use of S&T inputs for integrated resource management and development. The results of GIS study are useful for village level functionaries like Gram Sabha/Panchayat, District Rural Development Agency, officials in revenue department, particularly Patwari/Girdawar/ Tehsildar; public delivery system; Election In-charge; Block Development Officer; Block Education Officer and Chief Medical Officer. It would also help in technical capacity building at various levels of administration for enabling the adoption of the technologies developed in integrated development planning.

Promotion of science & technology and innovation systems in NE states of India

NISTADS has carried out some preliminary work for the northeastern states of India with respect to two dimensions - S & T manpower and development of systems of innovations. An analysis of data from IAMR, UGC and IASST on S & T manpower in northeastern states exhibits serious deficits and mismatches. There is still acute lack of technical and higher institutions of learning, and new and emerging disciplines of study are unavailable. The problem is compounded by acute shortage of teachers. S & T manpower absorption pattern shows that the Central and State Governments continue to be the major employers. There is a need for the private industry to create market for the manpower. There is also a mismatch in the functions performed by the S & T manpower with a significant proportion of them performing administrative and non R & D functions. The deficits and mismatches in S & T manpower development and employment reflect acute underdevelopment of the region in respect of

S & T capacity. Work was also undertaken to understand the regional processes of the formation of S & T capabilities with a view to improving the prospects of regional innovation policies in India in the face of challenges thrown by economic liberalization, in particular with regard to programmes and S & T manpower supply. There is a need for development of special S & T plans for the region, given the nature of its special problems of underdevelopment.

Women and science in India

It is generally said that the feudal authoritarian values and hierarchy have characterized the Indian society. Are these reflected in Indian science as well? A study was undertaken by NISTADS to investigate the role and position of women in science in India. Using the available data, the study aimed to examine the issues and importance of gender vis-a-vis other characteristics in determining scientists' research related values, research performance, academic rank and professional recognition in the Indian context. An analysis of the data by NISTADS on around 500 physical science research scientists reveals the following trends:

- The number of women scientists is marginal (women constitute only 18% of the total number of scientists).
- 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 higher proportion of women at lower ranks is not a simple function of low research productivity. The female scientists do not differ significantly from male scientists in terms of research contributions. Study is still in progress.

Measures of progress of science in India

Publications data from SCIE edition of Web of Science during 1985-2005 reveal that India's

annualized publications growth is accelerating from 2.51% during 1985-2002, to 5.96% during 1996-2005, and to 10.5% during the recent five years, 2000-05. In absolute numbers, its output rose from 13634 to 28603 publications during 1985-2005. The statistics on India's growth rates (computed for the periods 1996-2000 and 2001-05) do not differ significantly in databases such as SCI (32.40%), SCIE (33.17%) and SCOPUS (32.85%). However, they do differ significantly regarding publications count. India's quinquennial output (2001-05) in SCIE was 46% greater than that in SCI, and 17.9% lesser than that in SCOPUS. As per SCIE, India published 23153 publications (coming from 1734 institutions) in 1985-86, 27088 publications (coming from 2223 institutions) in 1993-94 and 35142 publications (coming from 3443 institutions) in 2001-02. Only 10% institutions (181 institutions in 85-86, 215 in 93-94, and 310 in 01-02), account for 80% output by the country. It shows that excellence in S & T is confined to a select few institutions only. A significant number of institutions are low in publications productivity.

2.12 LEATHER

It is an area in which CSIR through its Central Leather Research Institute has continued to make wide ranging research, societal, industrial and HRD contributions. It is an institution which is globally known for reviving India's leather industry by developing several efficient and environment-friendly processes. Some of its general contributions are described below.

- **Vocational training:** 58 candidates have completed the vocational training programmes. 261 candidates from the leather industry and various organizations have undergone training in various fields of leather and leather products technology.
- **International training programmes:** 11 international candidates from Sudan, Ethiopia, Kenya and Iran received training in leather and leather products technology.
- **HRD mission:** This national level mission mode programme aims at addressing the training needs of both the decentralized

production base and the organized sector in the country. About 1.6 lakh people have been connected through a unique HRD initiatives for skill mapping and upgradation, training of trainers, on-site training for shop floor personnel, designer and supervisory level training activities, cluster development programmes for artisanal skill upgradation and management training programmes. A major intervention in Agra footwear cluster has been implemented targeting 60,000 shoemakers in the region.

- **Global benchmarking scheme:** The scheme aims to enable a total of 75 units in leather sector to benchmark against best global practices in terms of productivity and quality. 65 units have been enrolled. Productivity increase of >10% on account of interventions made has been reported.
- **Non-leather footwear sector:** Recognizing the need for strengthening the non-leather footwear production in the country, efforts have been made with support from the Ministry of Industry, Government of India to establish training-cum-production centres in Kerala and northeast. A proposal for establishment of non-leather footwear training-cum-production centre at Jalandhar is under consideration.

2.13 MATERIALS, MINERALS, METALS & MANUFACTURING

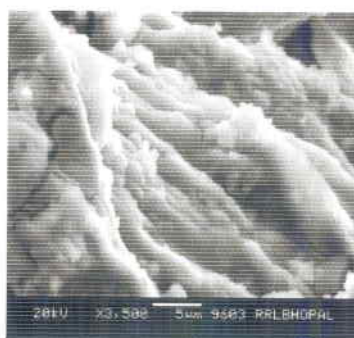
Being an area of immense significance for the country, CSIR has set up many domain-specific laboratories, which continue to contribute by way of high science and industrial processes/products as described below.

Aluminium foam for engineering applications - rural climatizer

Open cell aluminium foam has emerged as a potential material for thermal management applications. Aluminium foam has porosity in the range of 60-90% and the pore size varies in the range of 1-2 mm. The density of Al foam varies in the range of 0.2-0.6 g/cc. Because of its large surface area, open cell Al foam can be used as a heat sink, heat exchanger and as evaporator.



Microstructure of open cell



Microstructure of open cell Al foam showing fibrous channels



Climatizer

Usually, open cell Al foam is produced by infiltration of polyurethane foam with the heat resistant material. The polyurethane foam is removed by heating and liquid metal is infiltrated through the fine pores. AMPRI has developed a novel technique to produce open cell Al foam using melt route. The process essentially consists of thickening the melt by externally adding ceramic particulates, followed by dispersing of a suitable foaming agent.

Based on the above-mentioned technique a climatizer of size 300 mm x 300 mm x 300 mm has been designed and fabricated using open cell Al foam. It is designed in such a way that the efficient cooling of the chamber is attained without using electricity so that it can be used in the rural sector most effectively. It works on the principle that the heat is taken away as the latent heat of evaporation by water through the open cell Al foam from the chamber. Water is fed from the top surface of the foam panel. The temperature of the chamber, atmosphere and the circulating water are monitored and recorded at different times during day time. It is noted that the inside temperature is reduced by 7-9°C with respect to the atmospheric temperature.

Process for making PTFE-lined thrust bearing pad material on laboratory scale for hydrogenerators

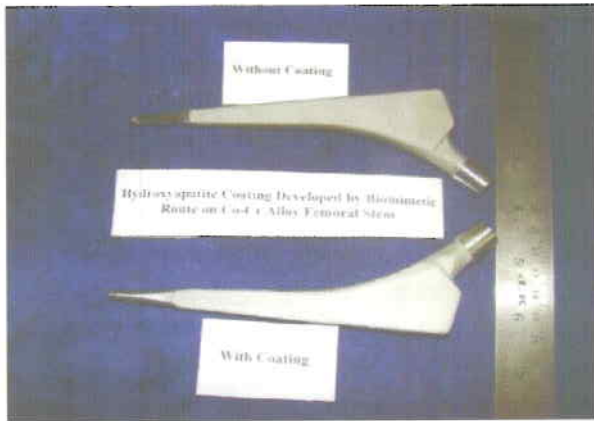
AMPRI has developed a process for making PTFE-lined thrust bearing pad material for hydrogenerators at laboratory scale. Currently, conventional Babbitt-lined thrust bearing pads are used in hydrogenerators, which suffer from problems like thermal deformation, low scratch

resistance, short life, low load bearing capacity, frequent break down of pad, etc.

Further, the coefficient of friction of such a lining is high leading to additional power losses. These problems may be overcome by using PTFE-lined bearing pads in place of Babbitt-lined ones. There are many advantages of using PTFE-lined pads, such as antifriction, scratch resistant, higher load carrying capacity, extended thermal limit, possibility of having operation with a hydrostatic jacking system during a startup and shut down, and insulating characteristics as compared to traditional Babbitt-lined bearing pads.

Remodeling of bone-ceramic interface

Musculoskeletal conditions are among the most frequent occurrences and they have a substantial impact on the quality of life of people. Usually Ti-6Al-4V/SS 316 L/Co-Cr alloy prostheses coated with plasma-sprayed hydroxyapatite (HAp, $[\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2]$) layers are used in joint reconstruction. This makes it possible to have cementless fixation of the implant at the damaged tissue site without an intervening fibrous layer. CGCRI scientists used biomimetic technique for fabrication of a dense, uniform and homo-geneous coating at room temperature (37°C). The proteinaceous content of mineral coatings plays a major role in determining its biocompatibility and bioresorption. Some non-collagenous proteins and bone-derived growth factors also have great importance in the regulation of bone formation, absorption and fracture healing. CGCRI has used an innovative process by using nano spaces/nanoreactors of



Some of the products developed through biomimetic route

the functionalized biomolecular templates for mineralization of HAp coating on metallic/ceramic substrate. This is analogous to the formation of the apatite crystals in a controlled reaction environment of the oriented collagen fibres in natural bone tissue. It is designed to mimic the structural and characteristic properties of the biological apatite to expedite osseointegration kinetics and to further enhance biocompatibility of the implant materials in vivo.

Noninvasive diabetes detection from breath using inexpensive semiconductor sensors - demonstration of proof-of-concept

It has been known for quite sometime that the concentration of acetone in a diabetic patient is higher (>0.9 ppm) than that of a healthy person. However, monitoring that low concentration of

acetone in a diabetic patient can only be done through highly expensive sophisticated instruments and is of academic interest only. CGCRI scientists have found that nanosized semiconducting $\gamma\text{-Fe}_2\text{O}_3$ prepared by a specialized technique (sono-chemical method) can be used as a semiconductor sensor in the form of thick film coating, which is able to detect a very low concentration of acetone in breath. The photograph of a sensor head is given below.

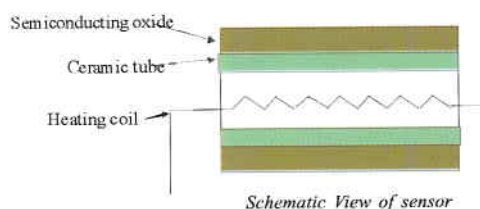
Fabrication of porous silicon nitride diaphragm tubes for fast breeder reactor

CGCRI developed porous silicon nitride tube from powder silicon metal of suitable particle size mixed with carbon. The mixture was slip cast in plaster mould to fabricate the green tube. They were dried carefully under controlled temperature and humidity in a humidity drier and carbon was removed in a furnace at 60°C. The tubes were finally sintered in a large furnace in nitrogen at temperature between 1150°C to 1400°C for 3 days. The sintered tubes were tested to estimate the density, porosity, pore size distribution, microstructure, etc. It is expected to replace alumina in critical nuclear fuel reprocessing.



Top View

1mm de View



Schematic View of sensor

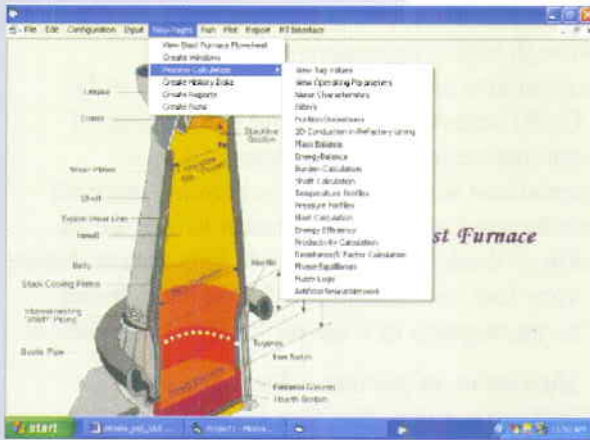
A sensor head for Diabetes affliction



Slip cast silicon green tube of required dimensions

Real time process simulator

NML has developed several comprehensive process models for the blast furnace iron-making phenomena with expert help from academia, and, for the first time in India, a "Real Time Process Simulator" has been developed for on-line monitoring and prediction of the internal



View of web-page of Real Time process

dynamics of the blast furnace. Both the real time process simulator and the process models have been successfully installed at a blast furnace in the Bokaro Steel Ltd., Bokaro. With the help of this technology, the end-user has reported a reduction in coke consumption rate by 21 kg/ton and 18% improvement in the productivity of the furnace.

Biomimetic payload completes its journey in space

India got one step closer to manned space mission, when ISRO's scientists brought

SRE-I back to earth on January 22, 2007, using a complex technology, mastered only by America, China and Russia before India. It was a feather in NML's cap too, as one of the two microgravity payloads on board SRE-I belonged to it. The aim of the experiment was to study the effect of microgravity on the polymer matrix mediated synthesis of hydroxyapatite nanoparticles, a base material for bone tissue engineering. NML scientists not only designed the experiment, but also successfully took up the challenge of designing and fabricating a biomimetic reactor for an unmanned space capsule.

It could be completed through a very close and active participation of ISRO Satellite Application Centre (ISAC), Bangalore.

As postulated by NML team, the nanoparticles synthesized under microgravity exhibited a great degree of morphological sophistication in terms of nanoparticle size, shape and their ordered assembly leading to the formation of higher order nanostructures akin to biological structures like tooth enamel.

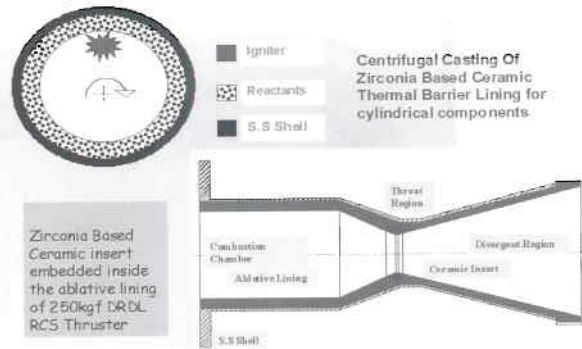


View of Biomimetic payload

Zirconia based cermet convergent and divergent nozzle

Technology for near net shaped convergent & divergent nozzles embedded inside graphite holders was developed by NAL. In this, the inserts were fabricated using centrifugal forces assisted combustion synthesis. The insert was made of an ultra high temperature cermet material. This was tested at 3000 K with high heat flux of 18 mega watts per meter square in an oxygen rich corrosion environment. The material withstood these aggressive conditions for about 20 seconds at a gas velocity of 5 Mach. This successful development is expected to lead to its applications on rocket thrusters in the near future.

Indigenous Process Technology for Casting of Metals and Ceramics using Themit type Reactions Under the Effect of Centrifugal Force



Zirconia based cermet convergent-divergent nozzle being tested