

VI. AUTONOMOUS BODIES

VI-A. COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH

S&T CONTRIBUTIONS

1.1 BIOLOGICAL SCIENCES CLUSTER

Role of Leishmania actin in decatenation activity of type II topoisomerase studied

The role of Leishmania actin (LdACT) in this organelle is not known. CSIR-CDRI showed that LdACT is associated with the kDNA disc in Leishmania kinetoplast, and under in vitro conditions, it specifically binds DNA involving its unique DNase-I-binding region and the DNA major groove. This protein also exhibits DNA-nicking activity as well as ATP hydrolysis and through this activity it converts catenated kDNA minicircles into open form. In addition, LdACT specifically binds bacterial type II topoisomerase and inhibits its decatenation activity. These results strongly indicate that LdACT could play a critical role in kDNA remodelling.

Novel bone anabolic agent for the treatment of post-menopausal osteoporosis

A novel compound, ulmoside-A has been isolated by CSIR-CDRI from the stem-bark of *Ulmus wallichiana* that promoted the peak bone mass achievement in growing rats, and preserved trabecular bone mass and cortical bone strength in ovariectomized (OVx) rats. Ulmoside-A stimulated osteoblast proliferation, survival and differentiation, but had no effect on osteoclastic or adipocytic differentiation, suggesting a pure osteogenic action. In cultured osteoblasts, ulmoside-A transactivated aryl hydrocarbon receptor (AhR) which mediated the stimulatory

effect on osteoblast proliferation and differentiation. Furthermore, ulmoside-A stimulated cAMP production, which mediated osteogenic gene expression. In rats, Ulmoside-A treatments increased the mRNA levels of AhR target genes in calvaria or bone marrow stromal cells, and promoted parameters of peak bone accrual in the appendicular skeleton including

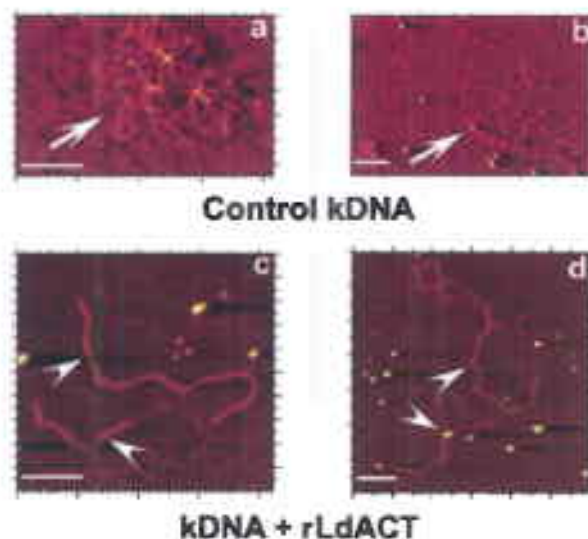


Fig. 1.1. Picture: AFM of kDNA carried out separately in the absence (control) or presence of rLdACT, showing the decatenation of kDNA with rLdACT. Panel a and b, control kDNA, arrows indicate catenated kDNA. Panel c and d, kDNA with rLdACT, arrowheads indicate decatenated nicked kDNA. (Scale bar: 500 nm).

increased longitudinal growth, bone mineral density, bone formation rate (BFR), cortical deposition and bone strength. Ulmoside-A also promoted the process of filling up the newly generating bone into a drill-hole of the femur in both estrogen sufficient- and deficient rats. In

osteopenic OVx rats, ulmoside-A increased BFR and significantly restored trabecular bone compared to the ovary intact group.

Translation factors in the Plasmodium apicoplast and the organellar SUF pathway of [Fe-S] complexation

The plastid of *Plasmodium falciparum*, the apicoplast, performs metabolic functions essential to the parasite. Protein translation in the apicoplast is inhibited by antibiotics that target prokaryotic translation factors, some of whose homologs are predicted to be localized to the parasite organelle. Interaction between apicoplast-encoded EF-Tu and apicoplast-targeted EF-Ts was investigated in order to understand differences with bacterial factors and consequent inhibition with selected antibiotics. The process of ribosomal recycling in the organelle was revealed by localization of a ribosome recycling factor (RRF) to the apicoplast and characterization of its recycling function in conjunction with apicoplast EF-G.

Various reactions in the apicoplast require the assembly of [Fe-S] prosthetic groups on participating proteins. The [Fe-S] assembly pathway involving SUF proteins has been predicted by CSIR-CDRI to function in the apicoplast with one component (PfSufB) encoded by the plastid genome itself. Study demonstrated the ATPase activity of recombinant *P. falciparum* nuclear-encoded SufC and its localization in the apicoplast. Further, an internal region of apicoplast SufB was used to detect PfSufB-PfSufC interaction *in vitro*, and *in vivo* interaction of the two proteins was confirmed by co-elution. As a departure from bacterial SufB and similar to reported plant plastid SufB, apicoplast SufB exhibited ATPase activity suggesting the evolution of specialized functions in the plastid counterparts. These results provide experimental evidence for an active SUF pathway in the *Plasmodium* apicoplast.

3Cdk2 nitrosylation and loss of mitochondrial potential mediate NO-dependent biphasic effect on HL-60 cell cycle

Nitric oxide (NO), a multifaceted signaling molecule, regulates a wide array of cell functions,

including proliferation, differentiation, cytostasis, and apoptosis, which depend on the cell type and redox status. Study, carried out by CSIR-CDRI, systematically explores the effects of NO donors on promyelocytic HL-60 cell proliferation and apoptosis. The NO donor DETA-NO modulated the HL-60 cell cycle in a biphasic manner. DETA-NO in lower concentrations had a proliferative effect whereas cells treated with higher concentrations showed cytostasis, apoptosis, mitochondrial membrane potential loss, caspase-3 activity, and dUTP nick-end labeling. The proliferative effect of DETA-NO was NO dependent and redox sensitive. Expression of various cell cycle regulators such as Cdk2, cyclin

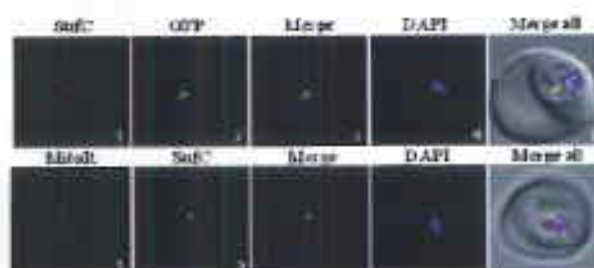


Fig. 1.2. Nuclear-encoded SufC localizes to the Plasmodium apicoplast

B, and cyclin E was significantly augmented in cells treated with 10–50 μ M DETA-NO. The proliferative effect of NO was blocked by roscovitine, a Cdk2 inhibitor. S-nitrosylation of Cdk2 and an increase in the Cdk2-associated kinase activity was observed for the first time in DETA-NO-treated cells. The study demonstrates that the DETA-NO-mediated biphasic effect was dependent on Cdk2 nitrosylation/activation and the loss of mitochondrial potential at low and high concentrations, respectively.

The human APOBEC3B deletion and susceptibility to falciparum malaria in India

APOBEC3B, a gene involved in innate response, exhibits insertion-deletion polymorphism across world populations and its insertion allele was observed to be nearly fixed in malaria endemic regions of Sub-Saharan Africa as well as populations with high malaria incidence in the past. The distribution of the APOBEC3B deletion was studied by CSIR-CDRI in 25 diverse Indian

populations comprising severe or non-severe *Plasmodium falciparum* patients and ethnically-matched uninfected individuals from a *P. falciparum* endemic and a non-endemic region of India. APOBEC3B deletion frequencies ranged from 0 to 43% in the Indian populations and the frequency of the insertion allele strikingly correlated with the endemicity map of *P. falciparum* malaria in India. A strong association of the deletion allele with susceptibility to *falciparum* malaria in the endemic region (non-

severe vs. control, Odds Ratio= 4.96, p value = 9.5E-06; severe vs. control, OR= 4.36, p value = 5.76E-05) was observed. Although the frequency of deletion allele was higher in the non-endemic region, there was a significant association of the homozygous deletion genotype with malaria (OR=3.17, 95% CI=1.10 to 10.32, p value =0.0177). This presents a case for malaria as a positive selection force for the APOBEC3B insertion and suggests a major role for this gene in innate immunity against malaria

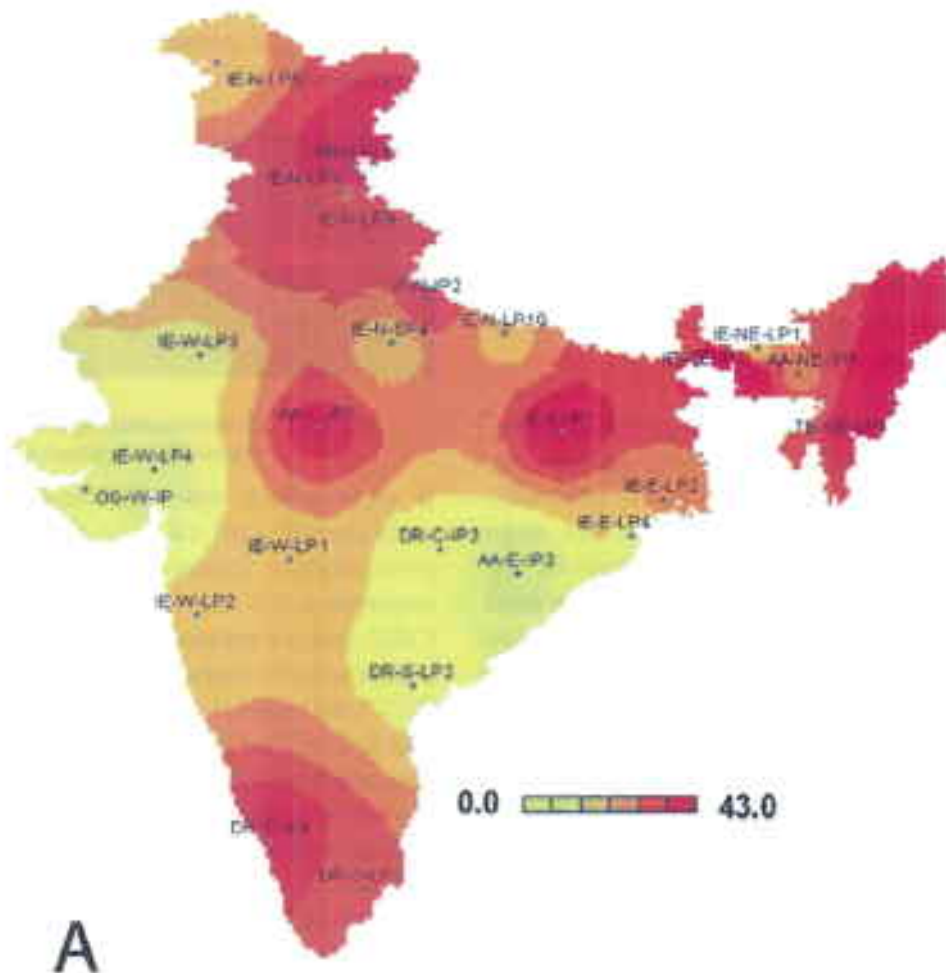


Fig. 1.3. Spatial distribution of the APOBEC3B deletion in Indian populations

Th1 stimulatory proteins identified through proteomics assessed for their immuno prophylactic potential

In visceral leishmaniasis, Th1 types of immune responses correlate with recovery from and resistance to disease, and resolution of infection

results in lifelong immunity against the disease. Leishmanial Ags that elicit proliferative and cytokine responses in PBMCs from cured/exposed/Leishmania patients have been characterized through proteomic approaches in both promastigotes and amastigotes.

In context of promastigotes, 18 proteins were identified by CSIR-CDRI as potent immunostimulatory proteins. Of these 15 recombinant proteins viz. elongation factor-2, p45, aldolase, enolase, triosephosphate isomerase, protein disulfide isomerase, calreticulin, Adenosylhomocysteinase, Cofactor-independent phosphoglycerate mutase, Heatshock70-related protein1 precursor, HSP-83, 1, Trypanothione reductase and NAD-dependant SIR2 putative gene (NAD-SIR2) and two Hypothetical proteins were developed and their molecular and immunobiochemical characterization were carried out. When these rproteins were re-assessed for their immunogenicity all except two – (Calreticulin and Trypanothione reductase) exhibited significant cellular response (as compared to SLD) with lymphocytes from cured Leishmania infected hamsters as well as PBMC's from cured patients.

The recombinant Elongation Factor-2 (rLeIF-2) was able to provide considerable prophylactic efficacy ($\approx 65\%$) to hamsters against *L. donovani* challenge. The efficacy was supported by the increased inducible NO synthase mRNA transcript and Th1-type cytokines IFN- γ , IL-12, and TNF- α and downregulation of IL-4, IL-10, and TGF- β . Hence, it is inferred that rLeIF-2 elicits a Th1 type of immune response exclusively and confers considerable protection against experimental visceral leishmaniasis.

Novel mechanisms of IL-1 beta production

IL-1 α is an important pro-inflammatory cytokine that has a role in varied type of diseases including type1 and 2 diabetes, atherosclerosis, metabolic syndrome and autoimmune diseases like rheumatoid arthritis and inflammatory bowel disease. Recent findings demonstrate that interleukin 1 receptor associated kinase (IRAK) regulates IL-1 α production in monocytic cells. A functional interaction between IRAK1 and PKC delta is important for the production of this inflammatory cytokine. CSIR-CDRI identified a novel mechanism of IL-1 β production that involves TLR2, CD11b, PKC β -IRAK1-JNK-AP1 axis. This study proposes new therapeutic targets for the prevention of chronic inflammatory diseases involving IL-1 β production.

Novel trichomonacidal spermicides for prophylactic contraception

Metronidazole, the approved drug against trichomoniasis, is non-spermicidal and hence cannot offer pregnancy protection when used vaginally. Furthermore, increasing resistance of *Trichomonas vaginalis* to 5-nitro imidazoles is a cause of serious concern. The vaginal spermicide nonoxynol-9 (N-9) does not protect against STDs and HIV and also likely to increase their incidence due to its non-specific, surfactant action. CSIR-CDRI designed dually active, non-surfactant molecules that were capable of killing *Trichomonas vaginalis* (metronidazole susceptible and resistant strains) and irreversibly inactivating 100% human sperm, and safer than N-9 in vitro. The most promising compound identified was more effective than N-9 in inactivating human sperm; more efficacious than metronidazole in killing *Trichomonas vaginalis* (including metronidazole-resistant strain); significantly reduced the available free thiols on human sperm and inhibited cyto-adherence of *Trichomonas* on HeLa. In addition, experimentally in vitro, these compounds appeared safer than N-9 for intravaginal topical use.

Gene regulation identified

In an effort to understand the role of repeat sequences in a genome, CSIR-CCMB developed a model that shows repeats to play a regulatory role by contributing to the packaging of the genome during cellular differentiation. Scientists at CSIR-CCMB have also identified a functionally conserved repressive element by testing the non-coding DNA from the HoxD complex of mouse. The study opens 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.

CSIR-CCMB scientists have presented for the first time, evidence for a developmental stage and testis-specific transcription from the male-specific region of the Y (MSY) heterochromatic block. 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. The study also records for the first time Y chromosomal control of an autosomal gene.

At CSIR-IGIB, a set of human miRNAs were predicted to bind to the HIV1 nef gene from computational studies. The miRNA was cloned, expressed and demonstrated to target the nef gene. A novel molecule, designed by incorporating the features of modified backbone nucleic acids and ribozymes for degradation of specific miRNAs was developed and tested. The results show that these molecules called antagomiRzymes maybe used to regulate miRNA levels in cultured cells.

Functional role of nuclear lamin investigated

CSIR-CCMB is investigating muscle-specific functions for lamin A. Using cultured myoblasts, it has been shown that internal lamins are rearranged during the early stages of muscle differentiation to a uniform, diffuse pattern in a process that is unique to muscle cells and is induced by cyclin D3 and pRb, and interestingly cyclin D3 can bind directly to lamin A. In a novel finding, it has been shown that lamin A mutants induce proteasomal degradation of key nuclear proteins such as heterochromatin proteins by activation of a novel F-box protein, FBXW10 that is a substrate adapter of a RING-type E3 ubiquitin ligase, and two other ubiquitin ligases, RNF123 and HECW2. These findings have important implications for understanding the basis of laminopathies.

Nucleic acid delivery evolved

In an effort to understand the molecular basis of peptide-based nucleic acid delivery, CSIR-CCMB adopted a novel design strategy to generate cell-penetrating peptides to overcome various cellular barrier. The strategy enabled efficient introduction of DNA in a cell-specific manner through designed targeting peptide ligands that interact with cell surface receptors overexpressed in certain cancer. These have been validated for its efficacy in vitro

by delivering plasmid DNA and shRNA. With this fundamental work in place, the molecular basis of delivery is now being investigated for siRNA delivery. Formulations for nucleic acid delivery have been evolved through in vivo study.

Antimony-resistant Leishmania donovani isolates inhibit sodium antimony gluconate induced dendritic cell activation: Perturbation of antileishmanial immunity

Antimonial drugs like sodium antimony gluconate (SAG) have been the mainstay of therapy for Kala-azar, a life-threatening parasitic disease caused by *Leishmania donovani* (LD). Due to the emergence of antimony-resistance in parasites, SAG often fails to cure kala-azar patients, which presents higher challenges in tackling the disease. Poor information on LD exhibiting antimony-resistant phenotype, and antimony-sensitive phenotype and SAG treatment effects exists. This demands an understanding of the nature of host immune responses against these two distinct categories of parasites. Accordingly, CSIR-IICB compared the impact of infection with LD exhibiting antimony-resistant versus antimony-sensitive phenotype on dendritic cells (DCs). DCs upon activation/maturation initiate anti-leishmanial immunity. It was shown that parasites with antimony-resistant but not antimony-sensitive phenotype prevented SAG-induced DC activation/maturation by blocking activation of NF- κ B. The latter is a key signaling pathway regulating DC activation/maturation. Studies for the first time provide both a cellular and molecular basis for differential response of host cells to parasite isolates with antimony-resistant and antimony-sensitive phenotype, which may influence the outcome of the disease.

Is Phenolic glycolipid-I really a specific antigen for leprosy?

Phenolic glycolipid-I (PGL-I) of *Mycobacterium leprae* is a specific antigen for leprosy, and its terminal residue (ie, 3, 6-di-O-methyl glucose) has not been found in any other natural molecules. Thus, PGL-I is being employed as a diagnostic tool for the detection of early leprosy. The serum samples obtained from patients with active leprosy

cross-reacted with the antigens derived from *Leishmania donovani*. In an experiment using an enzyme-linked immunosorbent assay, scientists of CSIR-IICB found that 50% of the visceral leishmaniasis (Kala azar) serum samples showed positive response with PGL-I. Serum samples obtained from patients with active leprosy also demonstrated a cross-reaction with leishmanial antigens. They observed three distinct polypeptides (bands of 72, 63 and 55 kDa) being recognized by the monoclonal antibody specific for PGL-I. These polypeptides were abundantly recognized by serum samples of patients with Kala azar as well. This interesting finding reveals that PGL-I is not a specific antigen for *M. leprae*, at least in the Indian scenario, because it cross-reacts with leishmanial antigens. This finding holds high significance as many laboratories have been trying to establish a diagnostic test using this antigen for early detection of leprosy.

Comprehensive analysis of the molecular bases of oculocutaneous albinism (OCA) in Indians

OCA is a group of autosomal recessive disorders characterized by hypopigmentation and abnormalities related to ocular development, and is one of the four major causes of childhood blindness in India. Mutations in genes regulating melanin-biosynthesis cause four classical types of OCA (OCA 1-4). The clinical spectrum of OCA often depends on the pigmentation threshold of a patient, highlighting the importance of ethnic-specific SNPs. CSIR-IICB aimed to understand the molecular bases of OCA. Blood samples were

collected from OCA patients and family members, mostly from eastern and southern India. Seven pigmentation related genes were screened for variations. Relevant non-synonymous changes in tyrosinase (TYR) were functionally validated. Eighteen SNPs from three OCA genes were genotyped in 552 normal individuals covering various ethnic groups of India. Data suggest that defects in TYR cause albinism in 58% (36/62) of the cases. Screening of the remaining cases (43%) revealed OCA2 to be the second (11%) common locus followed by SLC45A2 (7%). Evaluation of SNPs in TYR, OCA2 and SLC45A2 in normal population suggested definitive bias for some of the SNPs towards specific populations. The investigation also suggests that ~58% of OCA in India belong to OCA1 category and endoplasmic reticulum retention is the major cause of lack of TYR activity in these patients. Information on allelic distribution of SNPs is important for co-segregation analysis of candidate genes in affected families.

Synthetic phosphodiesterase 4 (PDE-4) inhibitor with antiasthmatic activity

Four CSIR laboratories, CSIR-IICB, CSIR-IIIM, CSIR-IGIB and CSIR-IITR jointly achieved the synthesis of novel PDE-4 inhibitor therapeutically effective for the treatment of asthma and asthma related respiratory diseases. The study aims at treating bronchial asthma by inhibiting phosphodiesterase activity with one or more 'triazine-aryl-bis-indole' class of compounds represented by Formula 1.

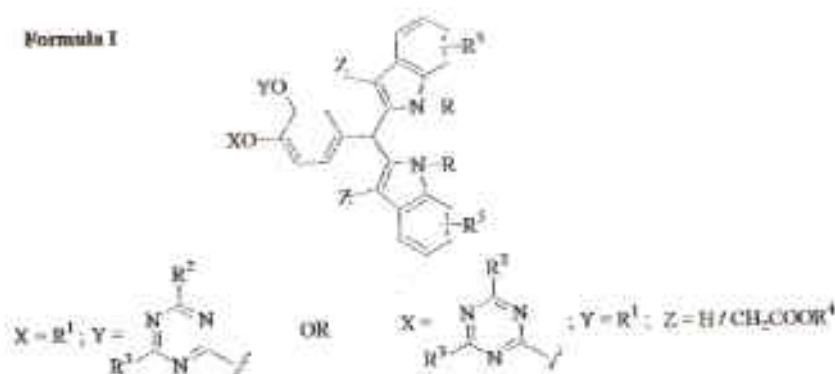


Fig. 1.4 Schematic of triazine-aryl-bis-indole

In addition to the inhibition of PDE-4 activity, there is down regulation of ICAM and VCAM expression which are crucial in asthma pathogenesis.

Tryptamine derivatives, their preparation and their use in gastropathy

CSIR-IICB scientists synthesized the compound SEGA showing excellent antioxidant property by the combination of serotonin with gallic acid. SEGA shows gastroprotective effect against NSAIDs (indomethacin or diclofenac)-induced gastropathy in dose dependent manner and also accelerates the healing from injury. It prevents the NSAIDs-induced mitochondrial oxidative stress in vivo. This derivative prevents NSAID-induced mitochondrial oxidative stress-mediated apoptosis in vivo by preventing the activation of caspase-9 and caspase-3 and restores NSAIDs-mediated collapse of mitochondrial transmembrane potential and dehydrogenase activity. SEGA plays an important role as an iron chelator as well as intra mitochondrial ROS scavenger. Thus, SEGA is a

characterization of valvular heart disease through a protein marker. The mechanism of upregulation of the protein in human plasma in the patients suffering from the disease is established. The increased level of the protein in the urine samples of the valvular disease patients was also verified. Estimation of this marker protein may be useful for diagnostic purpose for the patients with no clinical evidence for valvular disease. This protein can also be used for prognostic purpose after surgical intervention and for screening antifibrotic drug for the treatment of valvular heart disease. The identification of a protein marker facilitates an easy and fast biochemical method for diagnosis, detection and characterization of valvular heart disease using blood or urine sample of the subject and therefore accessible to mass population. .

A synthetic peptide formulation against melanoma and other cancers over-expressing S100B

CSIR-IICB developed a therapeutic peptide against melanoma, glioma and other types of cancers that over-express S100B, a calcium regulated cell

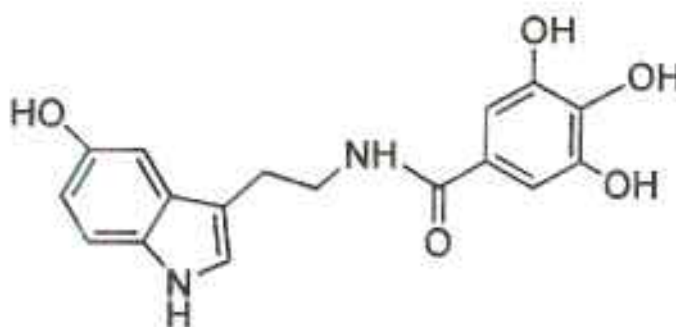


Fig. 1.5. Schematic of SEGA

potent antioxidant antiapoptotic molecule, which efficiently prevents NSAID-induced gastropathy and stress or alcohol-mediated gastric damage.

Biomarker for valvular heart disease

The current and only available method of diagnosing valvular heart disease is the imaging of defective heart valve by echocardiography which requires sophisticated instrument and specially trained technician. CSIR-IICB developed composition and methods for diagnosis and

progression and differentiation protein. Increased levels of S100B in several tumors contribute to tumor progression by interacting and down regulating p53 and inhibiting its function as a tumor suppressor. Development of high affinity bivalent peptidomimetics is achieved through progressive modifications of p53 target sequence using S100B peptide as a guide. This high affinity bivalent helically constrained peptide against S100B has got the ability to kill cancer cells rapidly with high specificity by exerting anti-proliferative action through simultaneous inhibition of key

growth pathways including activation of p53. At moderate intravenous dose, the peptide completely inhibits melanoma growth in a mouse model without any significant observable toxicity. The identified peptide provides an effective therapeutic intervention and treatment of several types of tumor in which S100B a calcium binding protein is over-expressed. These proliferative disorders include melanoma, glioma and other types of cancers in which the wild-type p53 level is lowered.

Ayurgenomics- efforts underway to develop predictive and personalized medicine

In a landmark study, the first of its kind in the world, it has been demonstrated by CSIR-IGIB that normal individuals within the same ethnic population, clustered on the basis of clinical criteria described in Ayurveda, show variations in the basal levels of blood parameters used in routine diagnostic purposes, as well as in basal levels of expression of genes. Links have been found between Prakriti, a fundamental principle of personalized medicine of Ayurveda, and modern genomics for development of predictive and personalized medicine. The study reveals that it is possible to identify groups within normal individuals of the population, who could be predisposed to certain kind of diseases, and which also might respond differently to drugs. Ayurgenomics holds great potential and promise for future predictive and personalized medicine at an affordable cost.

New generation thrombolytic molecules

Nostrum Pharmaceuticals Inc., USA, a privately-held company based in Edison, New Jersey, obtained the worldwide license to develop and commercialize new (Third and Fourth) generation thrombolytic molecules. The license was obtained from CSIR-IMTECH on November 24, 2010. The quantum of financial deal through agreement is close to USD 150 million in milestone payments plus royalties. Nostrum's collaboration with CSIR is an example of successful public-private partnership. Effective but affordable treatments for circulatory disorders such as heart attacks and stroke are a dire need, especially in countries where the more expensive option of surgical

intervention via Cath Labs is not an easy option. Designing of these new generation thrombolytic molecules was based on long-term basic research which has led to the production of vitally needed streptokinase at affordable costs in India. At present, products such as 'STPase' (Cadila Pharm. Ltd., Ahmedabad), and 'Klotbuster' (Alembic) and 'Lupiflo' (Lupin) have successfully been launched in the market.

These novel next generation thrombolytics are clot specific plasminogen activator proteins, with unique value-added properties such as longer half-life in blood circulation and re-occlusion prevention during and after heart attacks. Moreover, these fourth-generation clot-buster molecules will help to effectively mitigate a number of systemic side effects, such as bleeding, usually associated with the prevalent thrombolytic protein molecules in the market today.

Open source drug discovery (OSDD)

OSDD seeks to develop molecules for treatment of tuberculosis in open source mode. It has received overwhelming response in terms of active participation from various institutions and scientific groups of India as well as from abroad. Presently there are more than 2000 contributors in the OSDD web portal which also include contributors from Berkeley, Harvard, IISc, AIIMS, IITs etc. The OSDD distributed virtual library has over 50 institutions and more than 2000 researchers as a part of this initiative.

A systems biology platform, 'Sysborg' 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 CSIR-IGIB.

INDICO (Indian Diabetes Consortium)

A network of clinicians and researchers from major research laboratories from all over India has been established and named as INDICO (Indian Diabetes Consortium). An in silico disease gene

prediction method for type 2 diabetes has been developed. At CSIR-IGIB Genome-wide association study (GWAS) involving 2500 participants from North India belonging to Indo-European ethnicity has indicated that new genes and pathways are involved in the patho-physiology of type 2 diabetes in Indians. Genetic methylation studies have suggested that at least twelve genes have six fold differences in methylation levels and these differentially methylated genes belong to important pathways related to type 2 diabetes.

New drug targets & therapeutics

- **Schizophrenia:** CSIR-IGIB examined 108 (730 SNPs) novel positional candidate genes for association in schizophrenia and bipolar disorder samples from southern India. This has finally led to the identification of one gene that shows association with bipolar disorder. Additionally, in a replication study, evidence for interaction between two dopaminergic pathway genes was obtained in schizophrenia.
- **Asthma:** CSIR-IGIB scientists demonstrated that Ovalbumin induced experimental allergic asthma in BALB/c mice is associated with mitochondrial dysfunction. It also reported the association of mitochondrial structural changes and dysfunction with experimental allergic asthma. These findings may help in the development of novel drug molecules targeting mitochondria for the treatment of asthma.
- **Pancreatitis:** CSIR-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. 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.

- **Coronary artery disease (CAD):** Several recent genome-wide association studies (GWAS) have reported the association of multiple single nucleotide polymorphisms (SNPs) mainly in the 9p21 region with Coronary artery disease (CAD). However, the association of these SNPs with CAD has not been rigorously tested in Indian population, which accounts for the largest incidences of CAD in the world. Genotyping of six such SNPs identified through GWAS, in 754 individuals (311 angiography-confirmed CAD patients and 443 treadmill test controls) showed that three of these SNPs were significantly associated with CAD even after controlling for the confounding factors such as age, sex, body mass index, homocysteine, hypertension, diabetes, smoking, diet, etc.
- **Diabetes mellitus:** CSIR-IICB synthesized nearly 400 new molecules based on the selected anti-diabetic drug targets i.e. DPP-IV, PTP1b and GLP-1, alpha-glucosidase, glucose-6-phosphatase, glycogen phosphorylase, and aldose reductase and evaluated against their putative targets. Three new molecules showed inhibition against PTP1b, where as nine new molecules showed inhibition against DPP-IV. One of glucose-6-phosphatase and two alpha-glucosidase inhibitors showed antihyperglycaemic activity on streptozotocin-induced diabetic rats. In addition, at CSIR-CDRI eight promising antidiabetic molecules were further explored for their in vivo efficacy. Transcriptomic analysis has revealed a novel mechanism of action of compound S-001-469 for which US patent has been granted. Pharmacokinetic and stability studies have been completed in two new NCEs.

New drug targets & therapeutics for parasitic and microbial diseases:

- ◆ Leishmaniasis: CSIR-IICB discovered a non-recombinant membrane antigen and developed diagnostic kit for detection of visceral Leishmaniasis. The kit provides a non-recombinant membrane antigen (LAg) obtained directly from promastigotes of *Leishmania donovani* strain AG83, wherein the said membrane antigen (LAg) being characterized by a complex of 25-35 polypeptides having molecular mass in the range of 18 - 155KDa and having sensitivity and specificity in the range of 95 - 100% to anti-Leishmanial IgG antibodies is present in the serum of patient suffering from Visceral Leishmaniasis (VL) or post kala-azar dermal leishmaniasis (PKDL).
- Two new chemical prototypes (Azole and Chalcone derivatives) were identified as novel antileishmania compounds at CSIR-CDRI. Two novel drug targets, Pteridine reductase I (PTR1) and Trypanothione reductase (TR) were validated as novel leishmaniacidal inhibitor. Further, in vitro screening models based on reporter genes GFP/luciferase tagged *L. donovani* were established for identification of new hit molecules. A recombinant PPG (proteophosphoglycan) molecule was purified and characterized for elucidation of its immunobiological function so as to undertake its preclinical development as a vaccine.

Monocrotophos activates drug metabolizing enzymes (P450) in neuronal cells and causes cell death

CSIR-IITR attempted to understand the adverse effect of a commonly used organophosphorus pesticide, Monocrotophos which may provide vital information in the context of neurotoxicity. The pesticide was found to activate the major drug metabolizing isozymes viz., CYP1A1/1A2, 2B1/

2B2, 2E1 and oxidative stress markers in neuronal cells, PC12. The damage inflicted by the pesticide was evident by increased neuronal cell death which was found to be mediated by mitochondria related enzymes and other associated proteins. The study suggests the possible correlation of P450s and neuronal cell death leading to Monocrotophos induced neurotoxicity.

Metal mixture (MM) causes developmental neurotoxicity in rat brain cells

CSIR-IITR undertook the studies on the combinatorial effect of arsenic (As), cadmium (Cd) and lead (Pb) on rat brain development. The observations revealed that disruption of blood brain barrier (BBB) is associated with increased metal deposition in the developing rat brain along with synergistic reduction in glial fibrillary acidic protein (GFAP) expression during brain development. However, post-weaning withdrawal of MM partially restored the levels of GFAP in adults. GFAP exists as five splice variants, such as, GFAP α , GFAP, GFAP β , GFAP δ and GFAP γ . Of these, GFAP α appeared to be the predominant one in developing rat brain that undergoes consistent suppression following MM-treatment concomitant with behavioral dysfunction in adults. The study suggests that MM has the capacity to induce synergistic toxicity in astrocytes (probably through suppression in GFAP α) that may compromise the BBB leading to developmental neurotoxicity.

Elucidation of the mechanism(s) involved in Argemone oil mediated epidemic Dropsy

Consumption of adulterated mustard oil with Argemone oil (AO) leads to a clinical condition known as epidemic dropsy. CSIR-IITR carried out the studies to understand the molecular insights of AO caused dropsy in human population. The findings suggest that AO exposure induces generation of reactive oxygen species and reactive nitrogen species leading to oxidative stress. These free radicals trigger the immunological cascade and DNA damage which subsequently leads to the damage in the target organs viz. liver, lungs, kidney and heart of dropsy patients.

Mutagenic potential of metal oxide nanoparticles in bacterial cells evaluated

CSIR-IITR explored the effect of ZnO and TiO₂ NPs in a model bacterium, *Salmonella typhimurium*. TEM and flow cytometric analysis demonstrated the internalization and uniform distribution of NPs inside the cells. These NPs exhibited weak mutagenic potential in *S. typhimurium* strains TA98, TA1537 and *Escherichia coli* (WP2uvrA) of Ames test underscoring the possible carcinogenic potential similar to certain mutagenic chemicals. The study reiterates the need for re-evaluating environmental toxicity of ZnO and TiO₂ NPs presumably considered safe in environment.

Combination of resveratrol and black tea polyphenol (BTP) synergistically suppress mouse skin tumors

Combinatorial chemopreventive property of phytochemicals is a novel approach in cancer management. Polyphenolic constituents from black tea and resveratrol, a phytochemical present in grape and red wine, exhibited synergistic inhibition of chemically induced mouse skin tumor. The CSIR-IITR studies revealed that combination of these two phytochemicals leads to decreased expression of MAP kinases, ½ C-Jun, N-terminal kinase, p38 and induces p53 in skin tumors along with significant decrease in proliferating cell nuclear antigen. Therefore, combination of these two phytochemicals show promise towards therapeutic strategies in cancer management.

Increased chemosensitivity of cisplatin by knocking down polo-like kinase-1 (PLK1) in human cancer cells

PLK1 is a key regulator of mitotic entry, progression of cancer cells. CSIR-IITR studies showed that knocking down of plk1 gene in human epidermoid squamous carcinoma (A431) cells affect the cell cycle progression, proliferation and chemosensitivity of tumor suppressor gene p53 towards a widely used anticancer drug cisplatin (CDDP). Conclusively, plk1 silencing can enhance the sensitivity of CDDP in A431 cells by upregulating p73 α expression.

Gellan gum blended PEI nanocomposites as efficient gene delivery agents

In a collaborative study by CSIR-IGIB and CSIR-IITR, branched Polyethylenimine, 25 kDa (PEI), was blended with gellan gum anionic heteropolysaccharide, for partial neutralization of its excess positive charge to form a series of gellan gum-polyethylenimine (GP) nanocomposites (NCs). Among all the NCs, one member, named GP3, showed the best transfection efficiency in tested cell lines in comparison with the rest of the series, PEI, Lipofectamine and other commercial transfection agents and also exhibited minimum cytotoxicity. It was found to transfect primary cells of mouse skin with better efficiency than PEI and Lipofectamine and was able to protect the plasmid DNA from nucleases and serum proteins present in the blood. GP3 exhibited efficient intracellular delivery of plasmid as revealed by confocal studies while its intracellular presence was also confirmed by the knockdown of GFP expression and JNKII by quantifying proteins in cell lysates. In vivo cytotoxicity studies in *Drosophila* showed lack of induction of stress response in the exposed organisms. Further, exposed organisms did not show any developmental delay or mortality and no morphological defects were observed in the emerged flies. In vivo gene expression studies in Balb/c mice revealed maximum expression of luciferase enzyme in spleen. The study suggests that GP3 may act as an efficient non-viral gene carrier with diverse biomedical applications.

Computational approaches to induce resistance against blackleg disease in *Brassica oleracea* var. botrytis CSIR-IITR developed a methodology to induce resistance against Blackleg disease caused by *Leptosphaeria maculans*, a fungal pathogen, in major vegetable crops of Brassicaceae family. The glyoxylate cycle, essential for the pathogen was studied in detail and an enzyme isocitrate lyase (ICL) was identified at the crucial stage of the pathway. Series of molecular modeling approaches, combining in silico docking, energy minimization calculations were used to develop a synthetic peptide that interacts with ICL, hence inhibits its interaction with isocitrate in the pathogen. The study demonstrates that a nine

amino acid long synthetic peptide is capable of developing resistance against the Blackleg disease after integration with the plant genome.

*Successful induction of nodulation in *Cymbopogon winterianus**

Crops like Java Citronella (*Cymbopogon winterianus*), important for essential oil, require application of Nitrogen in sufficient quantity for achieving adequate vegetative growth and synthetic fertilizers are to be applied for the purpose. In this respect, a novel approach was made for inoculations of Nodules for fixing atmospheric in Cereals and Grass family, an emerging area. Successful induction of nodulation has resulted in reducing the use of synthetic nitrogen and achieving adequate vegetative growth. The achievement supported by anatomical studies and field evaluation, is likely to lead to development of an improved strain of Citronella offering considerable contribution to Agrotechnological Entrepreneurship.



*Fig. 1.6. Nodulation in *C. winterianus**

L-Asparaginase-gene isolation and over expression

An important industrial enzyme L-asparaginase is an anticancer agent that selectively decreases the level of L-asparagine in blood and diminishes the proliferation of the cancerous cells. L-asparaginases from *E. coli* are widely used for clinical application because of their high substrate specificity and limited glutaminase activity. An enzyme with increased half life will be stable in

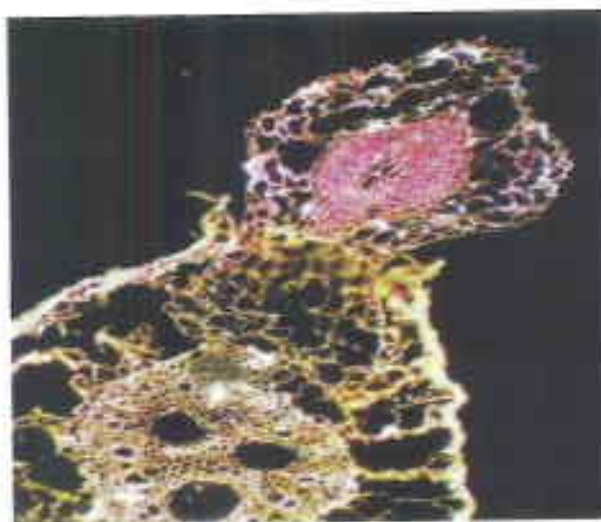


Fig. 1.7. Cross section of Nodule

blood and thus frequent administration of the drug can be avoided. Hence, an ideal asparaginase for therapeutic use should possess characteristics such as high activity, a low K_m , and a strong preference for asparagines over glutamine. The L-asparaginase II gene of a lab isolate from cow dung was cloned in pET20b vector and over-expressed in *E. coli* (Fig 1.9) BL21DE3 by CSIR-NIIST. The cloned gene showed 98% sequence similarity towards the L-asparaginase II of *E. coli*. Studies were initiated to introduce mutation in to the cloned gene in order to improve the stability of L-asparaginase.

Microbial-cum-phytoremediation of oily sludge and hydrocarbon contaminated sites

CSIR-NEERI developed a bacterial consortium to enhance biodegradation of oily sludge using rhizoremediation approach in presence of selected plant species and demonstrated a microbial plant-based clean-up process for hydrocarbons and oily sludge contaminated sites at pilot scale. Pot culture studies were conducted with ONGC oily sludge (Jorhat). Organic amendment resulted into maximum degradation of total petroleum hydrocarbon (TPH) in the range of 70-75% in treatments (soil + oily sludge + microbial consortium + cow dung and soil + oily sludge + microbial consortium + cow dung + *Vetiveria zizanioides*) as compared to other treatments. Thus, organic amendment with consortium and plant can

be used as a potential treatment for effective degradation of oily sludge. Root exudates of *Vetiveria zizanioides* were tested for presence of sugars, amino acids, organic acids and phenolic compounds and found to enhance antioxidant activity in presence of toxic oily sludge.

Novel therapy for management of sepsis; Phase II clinical trials completed

Sepsis is the culmination of complex interactions between the infecting microorganism and the host immune system. Normally the host response prevails in containing and eliminating the pathogenic threat. The excessive and/or sustained response leads to sepsis (systemic inflammatory response). Current management of sepsis includes broad spectrum antibiotics and supportive care to maintain oxygenation, systolic blood pressure (more than 65 mm of Hg), central venous pressure (8-12 mm of Hg), hematocrit (more than 30%).



Fig. 1.8. Packing of Immuvac

CSIR in association with Cadila Pharmaceuticals, NII, IISc and PGI Chandigarh has developed Mw as novel therapy for management of sepsis. The human studies (Phase IIa, safety using 3 doses) conducted at PGI, Chandigarh showed encouraging results with improvement in different

organ functions mainly lungs, liver, kidney and fever.

Anti-oxidant extracted

The major colouring principles beta cyanin and beta xanthin present in beet root have been fractionated by CSIR-CFTRI to homogeneity by aqueous two phase extraction. Water soluble amino acid derivatives of curcumin have also been developed. These amino acid derivatives, with high anti-oxidant and anti-mutagenic activities, could find potential applications in food and pharma industries.

Processed food technologies developed

In CSIR-CFTRI led development, technology has been developed and transferred to industry for process line for poory, lemon cutting machine – manual, domestic chapatti machine, dough sheet extruder. Technology is ready for commercialization for process line for murukku and sev, process line for boondi, continuous roasting/drying unit, process line for food bars, process line for laddu machine, wet/dry grinder, mini chakki mill, lab lyophilizer, cereal cake machine, coconut grating machine and ready for large scale performance for garlic peeling machine, jilebi forming unit, pressure fryer, pulsed electric field system.

Bioactives from pineapple residue

Pineapple (*Ananas comosus*) is a tropical fruit with potential health benefits. CSIR-NIIST evaluated the therapeutic properties of the pineapple residue, a byproduct of the pineapple processing industry. The antioxidant potential of the fractions obtained by extraction was evaluated by CSIR-NIIST. The in vitro antioxidant activity was assessed by ABTS radical scavenging assay and total antioxidant activity. The control of postprandial blood glucose concentration is one of the therapeutic interventions for the treatment of diabetes. α -Glucosidase plays a very important role in the digestion of carbohydrates to produce glucose. So

the inhibitory potential of the fraction against this enzyme was assessed and found significant inhibition against the same. The antiglycation effect of the two fractions (methanolic and ethyl acetate) was also investigated. A progressive decrease in fluorescence was obtained at the most effective concentration. There are reports that oxidative stress induces DNA breakage, accordingly the study was extended to evaluate the protective effect against Fenton reaction induced DNA damage. Overall, the *in vitro* studies showed that the bioactive from pineapple residue have significant therapeutic property to ameliorate diabetes related complications.

Health food & nutraceuticals formulations

Processed foods enriched with nutraceuticals, dietary supplements and herbal extractives were formulated with health promoting, disease preventive and/or medicinal effects. These include the anthocyanins of Njavara rice and Santalum album fruits, red yeast rice, carotenoids from coriander leaves and *Tinospora cordifolia* fruits, polysaccharides from sea weeds, chlorogenic acid and caffeoylquinic acid from low grade coffee beans, plant extracts for antioxidant and antimicrobial properties and bioactive peptides from whey proteins. Further the health benefits of probiotics, spice bioactives, health foods based on rice bran, xylooligosaccharides and lactic acid bacteria were studied by CSIR-CFTRI for formulating functional foods. The fish industry waste was used to recover carotenoids and other bioactives. Annatto dye formulations were prepared with enhanced bixin content. The cultivation of the mushroom *Lentinula* for uniform mycelia ramification was achieved. Value addition to bamboo shoots in the form of cured slices chutney and spreads and small millets resulted in the formulation of ready-to eat and ready-to-cook foods.

Innovative food processes and products

A coconut processing machine was developed which integrated grating, slicing, trimming, shelling and paring operations. An online prototype instrument to determine the quality

parameters of edible oil using NIR was developed. The functional specification for a hand operated model to separate annatto seeds was designed. Cereal brans, legumes and multigrains were processed for incorporation into products like instant vermicelli, pasta, parota, cookies in order to enhance nutritional quality of the products. Downstream processing of enzymes and colorants were achieved through ultrasound assisted ultrafiltration. The aerodynamic behaviour of food grains during roasting were studied. Using energy efficient processes such as infra red dry blanching resulted in the higher retention of some bioactives and reduced the energy requirements by 12% over the conventional water blanching. The functional design for a super heated steam processing system for blanching of onion and capsicum was completed. Theoretical aspects of aeration of gels suggested fracture strain increased with aeration, which are useful for developing specially fabricated gels with bioactives.

Innovative processes such as microwave-assisted extraction for bioactives from tea and coffee revealed that the yield and active principle of the bioactives like polyphenols were found more effective than the conventional solvent extraction method. A three dimensional Computational fluid dynamics model for pilot scale electric heating for baking operations was developed and validated at CSIR-CFTRI.

Stress tolerance mechanism in rice

Stay green mutants have been identified at CSIR-CCMB that can tolerate prolonged drought and heat conditions in field and show reduced Reduced Oxygen Species (ROS) accumulation under heat stress. Genes/alleles involved directly in improving yield and grain quality yield enhancing Quantitative Trait Loci (QTL) were characterized from wild rice. Putative candidate genes have been identified from the wild species. Further, additional genes acquired from wild rice that could be contributing to increased yields in the background of the cultivated Indica rice were identified. The knowledgebase developed would be helpful in improving yield and grain quality per se or in various types of stress in rice.

Stress tolerance mechanisms in arabidopsis

CSIR-IHBT has cloned the gene of superoxide dismutase (SOD), the enzyme responsible for dismutating superoxide radical, from *Potentilla astrosanguinea* and a Himalayan high altitude alpine plant. SOD was over-expressed in *Arabidopsis* and the transgenic plants were analysed under varied level of stresses. A significant difference was observed in the rate of germination of wild type and transgenic *Arabidopsis* under salt stress. 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.

Biodiversity mapping

Land cover and land use classification of entire Kangra district, Solang Nala in Kullu district, and Bhabha valley in Kinnaur district in Himachal Pradesh have been mapped by CSIR-IHBT. Satellite images and ground verification data of bamboo bearing localities in Kangra, Hamirpur and Una districts of Himachal Pradesh has revealed approximately 6040 acre area under bamboos. For development of the spectral Library of Himalayan flora at CSIR-IHBT, spectral responses of 39 plants were achieved.

Germplasm characterization and diversity analysis

Tea: CSIR-IHBT carried out DNA fingerprinting of 34 accessions of Indian tea germplasm and for the first time discovered that eleven genes are involved in biosynthesis of catechin in tea. Regional fingerprints of volatile aroma components and potent odorants of Kangra orthodox black tea have been identified for Geographical Indications. Aroma components have been encapsulated in different matrices for application in perfumery, food and beverages. Resin-based purification and enrichment of catechin gallates and immobilized polyphenol oxidase (PPO)-mediated techniques have been developed for conversion of catechins into theaflavins.

Bamboo: Genetic structure, diversity and relationships within 224 accessions belonging to five species of major economic importance were inferred from Amplified Fragment Length Polymorphism (AFLP) markers at CSIR-IHBT. The AFLP study detected admixed individuals and will be useful in understanding pattern of diversity, differentiation and gene flow within and between species, which ultimately aid the management strategies of priority bamboo species as well as in conservation of overexploited bamboo species. AFLP analysis have shown medium level of genetic diversity and cluster analysis placed majority of species according to existing classification with few exceptions.

Podophyllum hexandrum: At CSIR-IHBT, AFLP analyses were carried out to elucidate genetic diversity among 93 accessions belonging to 12 population of western Himalaya. A total 429 polymorphic alleles were used for the analysis. The analyzed Jaccard similarity ranged from 32 to 88% within the accessions of the populations. However, few accessions showed close relationship. The analysis of inter population diversity indicated distinct geographical locations with high genetic diversity. Most of the populations showed 80% of the diversity within themselves.

Ginkgo biloba: Genetic diversity analysis of germplasm growing across the country was analyzed at CSIR-IHBT using AFLP marker. A total of 174 polymorphic bands were obtained from four AFLP primer combinations and the relationship suggested a common source of introduction.

Microbial diversity

Bacteria: A culture repository has been developed at CSIR-IHBT including psychrophilic, mesophilic and thermophilic microorganisms and plant endophytes. Several 'hit cultures' have also been identified for: β -lactamase inhibition, anti-NIK1 activity, α -glucosidase inhibition, AChE inhibition, and antimicrobial activity against multi-drug resistant clinical strains; and cold active and alkaline resistant proteases and cellulases of industrial importance. Diversity analysis has

revealed distinctive pattern of biogeographic distribution of pea root-nodulating bacteria in the Lahaul and Spiti valleys of the Indian trans-Himalayas. At CSIR-IIIM, the bacterial diversity in the forest soil of Kashmir was investigated through molecular phylogeny. Several bacterial populations in the soil were classified under phyla such as Firmicutes (33.3%), Bacteroidetes (13.3%), Proteobacterium (6.6%), Planctomycete (3.3%), and Deferribacteraceae (3.3%). However, 36.6% of the retrieved bacterial sequences could not be grouped with any phylum/lineage, implying them to be novel groups of bacteria. Two small insert metagenomic libraries were also constructed from Apharwath soil/cold desert of Ladkah, and one cosmid metagenomic library Kargil soil, and screened for cellulase, protease and amylase using functional screening assays. Full length sequencing of one protease positive clone, one amylase positive and one cellulase positive clone was done and annotated.

Plant Viruses: Surveys were undertaken by CSIR-IHBT in H.P. and J&K to understand the seasonal incidence of Apple mosaic virus (ApMV). Phylogenetic analysis of the sequences with 10 other apple isolates showed maximum and minimum relatedness to Korean (Acc. no. AY125977) and Spanish (Acc. no. U038570) isolates respectively. Variation in amino acid sequences was also observed.

Complete Genome of Apple stem pitting virus (ASPV) has been characterized. Coat protein, movement protein and partial replicase gene from ApMV was characterized in Apple stem grooving virus.

Capsicum frutescens (chilli) were found associated with a begomovirus and a betasatellite like molecule. In phylogenetic analysis, the sequence grouped with an isolate of Papaya leaf curl virus-[Pakistan: 2010] (FM955601) reported from *Rhynchosia capitata* and Tomato leaf curl New Delhi virus-[India:2006] (DQ629102) reported from tomato. The betasatellite showed maximum identity (94%) with chilli leaf curl betasatellite (AM279671) from Pakistan.

Apple: CSIR-IHBT raised virus free apple root stocks through tissue culture. Multiplex RT-PCR

was developed for simultaneous detection of major viruses of apple: Apple mosaic virus, Apple chlorotic leaf spot virus, Apple stem pitting virus, Apple stem grooving virus and Apple scar skin viroid. Assay for early detection of pathogens at an early stage causing alternaria blotch and apple scab was also developed.

Ornamentals: Breeding of ornamental rose is being done at CSIR-IHBT to improve shape, size and colours of flower. Attempts are also underway to improve perpetual flowering, oil quality, and size of hip for utilization of vitamin C enriched pulp in food industries. The laboratory has developed four new rose root stocks. Breeding and gamma irradiation experiments are in progress for developing new and high yielding varieties of gerbera. Elite disease-free quality planting material of liliun, lisianthus, cymbidium spp, have also been raised through tissue culture. Cultural practices were standardized for propagation of a rare Himalayan medicinally important plant *Incarvillea emodi* which could also be used as indoor flowering foliage and bedding plant.

Natural colors from plant extracts of using green methods

A green and cost effective process was developed at CSIR-IHBT for preparation of natural colors from plant extracts with multi-fold benefits like non-hygroscopic crystalline nature, reproducibility in production of colors and solubility in both water and alcohol besides improved stability. Promising biological activities including antioxidant activity was observed in some of them. Pilot scale study of one plant has been conducted to obtain brick red natural dye.

Exploratory study on climate change and adaptation of species complexes

In order to improve carbon sequestration capability in plants, a novel pathway was transplanted in arabidopsis using a combination of three genes, that enhanced carbon fixation and seed yield by 30%. Novel genes were identified and used to develop plants tolerant to drought, and salt stresses. Microbial consortium involving *Brachy bacterium*

saurashtrise (JG-06), *Brevibacterium casei* (JG-08) and *Haererohalobacter* (JG-11) was identified and utilized from coastal ecosystem for conferring salt tolerance to commercial crop *Arachis hypogaea*. Also, salt modulated ESTs were developed for *Salicornia brachiata*, an important salt tolerant halophyte. Superoxide dismutase was engineered for enhanced thermostability with wide catalytic temperature range to develop drought and temperature tolerant plants. Adaptability studies on *Salvia sclarea* showed the potential of this important crop for commercial cultivation in Ladakh.

Pd-catalyzed heterodominio Knoevenagel-decarboxylation-Heck sequence: A new approach for direct olefination of benzaldehydes into hydroxy functionalized OPV's

First one step-one catalyst olefination of benzaldehydes into hydroxy functionalized Di and Tristyrylbenzenes has been developed by CSIR-IHBT which is a conceptually new hetero-domino sequence involving anionic-metalcatalyzed mechanistic pathway. This protocol eliminates any need for isolation of polymerization prone hydroxy

styrenes and deprotection manipulations. In addition, one of the synthesized compounds was also found to show visible and fluorescent fluoride sensing in aqueous/organic medium.

Novel and highly efficient environment friendly approach for cinnamic acids and coumarins

During studies on exploiting the catalytic promiscuity of crude porcine pancreas lipase (PPL) in ionic liquid for C=C bond formations, bovine serum albumin (BSA) was found competing for these reactions. After a detailed investigation, work conducted at CSIR-IHBT established that these transformations are possible by unspecific protein catalysis rather than catalytic promiscuity of "PPL" - a first insight into the role of protein impurities in crude enzyme. Thus, a novel and highly efficient environment friendly approach involving synergistic catalysis by BSA-[bmim]Br is developed for the synthesis of (E)- α,β -unsaturated compounds including one-pot cascade synthesis of cinnamic acids and coumarins via aldol, Knoevenagel and Knoevenagel-Doebner condensation.

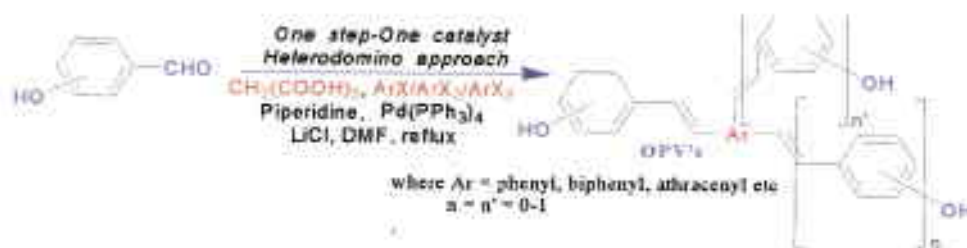


Fig. 1.9. Schematic of one-step, one-catalyst process for tristyrylbenzenes

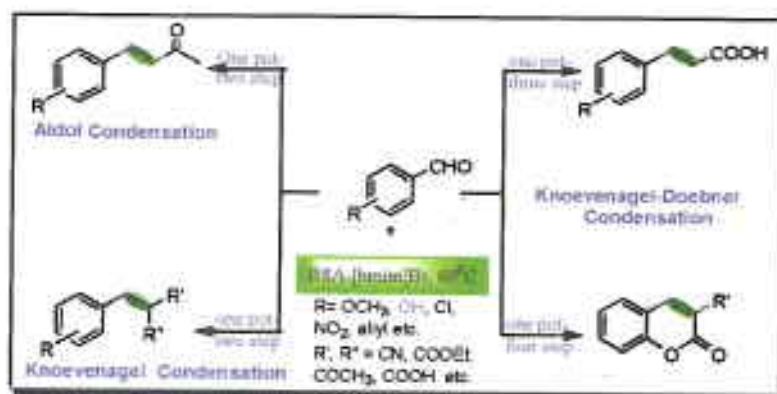


Fig. 1.10. Schematic of one-pot synthesis of cinnamic acid

Post harvest biology and biotechnology of fruit, flower and vegetable

Post harvest deterioration in several perishable fruits like banana, mango leads to large scale economic losses to farmer. CSIR-NBRI has attempted to address this problem through genetic manipulation of fruits using genes involved in ripening/softening. As a test system, transgenic tomato plants were developed with increased shelf life up to ten days without affecting other attributes of fruit or plant. The same is now in progress with banana as the target plant. Transgenic banana plants carrying anti-sense gene constructs of various ripening related genes from banana have been developed in collaboration with BARC Mumbai and are being analyzed for their ripening behaviour and other attributes. Efforts are also in progress towards manipulation of ornamental vase life through selective manipulation of genes that have shown delayed senescence in model systems like tobacco.

Pathway engineering for enhanced synthesis of flavonoids

Secondary plant products such as alkaloids, flavonoids and phytosterols are known to be beneficial for human health and are being utilized as phytochemicals in various disease conditions. The aim is to engineer non-leguminous plants for biosynthesis and accumulation of isoflavonoids. For this purpose, CSIR-NBRI isolated isoflavone synthase (PcIFS) gene from a traditionally acclaimed medicinal plant *Psoralea corylifolia* abundantly growing in tropical and subtropical regions. Over expression of PcIFS in non-leguminous tobacco plant led to accumulation of isoflavones in petal tissue but not in leaf due to limited substrate flux. To increase substrate flux, we used a flavonol specific transcription factor, AtMYB12, which enhanced expression of most of the genes of phenylpropanoid pathway leading to increased synthesis of important flavonoids in tobacco including substrate flux for IFS. Global-gene expression and metabolom analysis of leaves in the transgenic lines of tobacco revealed that AtMYB12 regulated a number of pathways, leading to flux availability for phenylpropanoid

pathway in general and flavonol biosynthesis in particular. The tobacco transgenic lines developed resistance against the insect pests, *S. litura* and *H. armigera* due to enhanced accumulation of rutin. Suppression of flavonol biosynthesis by artificial miRNA reversed insect resistance of the AtMYB12-expressing tobacco plants. The study suggests that AtMYB12 can be strategically used for developing safer insect pest resistant transgenic plants as well as increasing substrate flux for IFS. Transformation of tobacco with construct containing AtMYB12 and IFS succeeded in synthesis of isoflavones in leaf tissue in similar amount as in flower petals. This suggests that use of AtMYB12 and IFS together can produce isoflavones in heterologous systems in tissues which have limited substrate for IFS.

Cotton molecular markers

Molecular markers have an edge over conventional markers as their robustness, reproducibility and ease in use make them suitable for selection and breeding approaches in crops like cotton. CSIR-NBRI has made lead in developing SSR (Simple Sequence Repeats) and SNP (Single Nucleotide polymorphisms) markers in diploid as well as tetraploid cotton. In *Gossypium herbaceum* (diploid desi cotton), CSIR-NBRI has developed 584 genomic SSRs and 12784 expressed SSRs and the details of markers developed have been deposited to the cotton marker database (<http://www.cottonmarker.org/projects/nbri/>). A modified-HMPR (Hypo Methylated Partial Restriction) method for gene-enrichment has been adopted for genomic sequencing of *G. hirsutum* (tetraploid upland cotton). By sequencing gene-enriched libraries of six diverse genotypes, NBRI has identified 16,993 novel SNPs and 41,660 novel SSR marker. The developed markers may be utilized for the genome wide association studies, marker assisted selection and in breeding approaches.

Effect of arsenic contamination on rice cultivation

The effect of Arsenic (As) exposure on genome-wide expression was examined in rice (*Oryza*

sativa L., ssp. *indica*) by CSIR-NBRI. It was also observed that arsenic tolerance in rice has a predominant role in transcriptional regulation of a set of genes including sulphur assimilation pathway and antioxidant system. Over a period of two years, 89 rice genotypes were cultivated at three different sites with purpose to screen low arsenic rice lines for arsenic contaminated environments. In another study, arsenic accumulation pattern in 12 Indian ferns was evaluated as arsenic hyperaccumulator(s). Potential of *Adiantum capillus-veneris* was assessed in comparison to *Pteris vittata*.

Gene for inducing male sterility in plants

A novel gene for inducing reversible male sterility in plants was developed to facilitate the development of F1 hybrid seeds. Microspores are surrounded by tapetum, which is known to provide nutrition to developing microspores especially exine of pollen grains, the main structural

components of the pollen wall. The tapetum degenerates during later stages of pollen development. Proper timing of cell death in tapetum is essential for normal microsporogenesis. CSIR-NBRI has identified a novel use of the *BECLIN1* gene of *Arabidopsis*, in inducing male sterility in plants, when expressed in the anther tapetum of tobacco. Over expression of this gene in tapetum cells affected development of pollens, thus conferring male sterility.

Improved samba mahsuri

CSIR-CCMB, in collaboration with ICAR-Directorate of Rice Research (DRR), Hyderabad, has used marker assisted technology to develop new variety of Samba Mahsuri rice that exhibits excellent resistance against *Xanthomonas oryzae*, which causes bacterial leaf blight and blast in rice (Figure 1.11). The variety has been released for commercial cultivation.

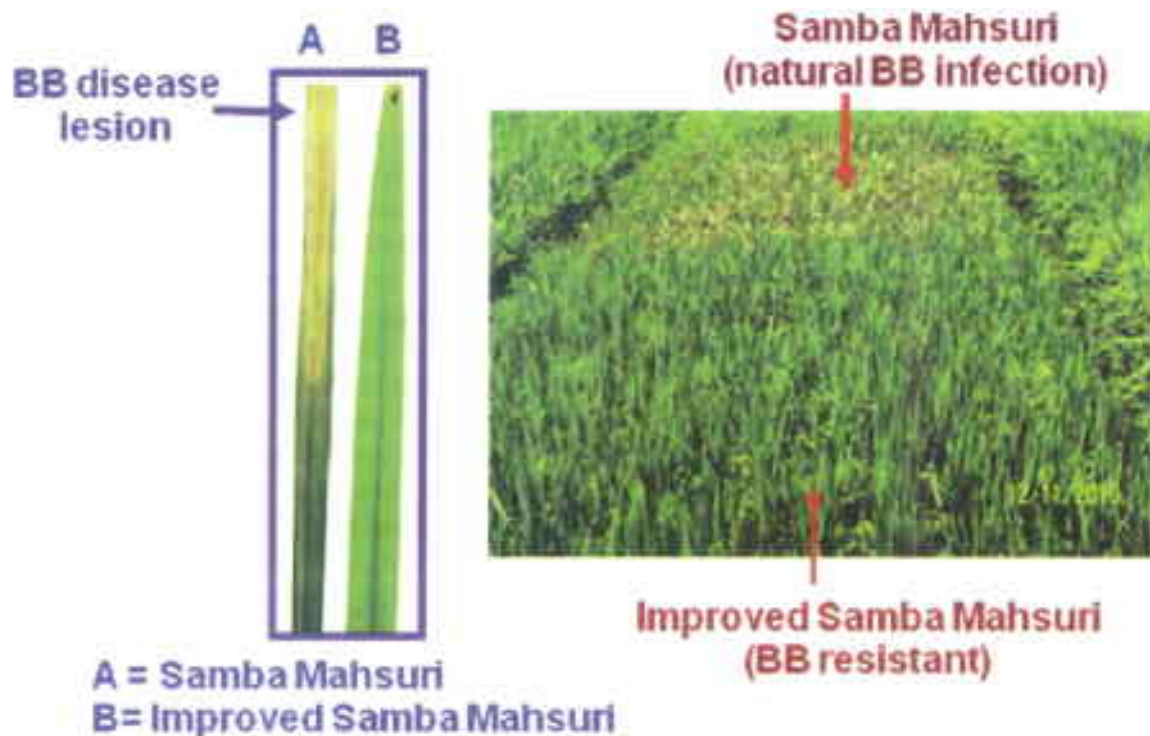


Fig. 1.11. Improved Samba Mashuri in Field

Herbarium and database

CSIR-NBRI has digitized taxonomy and biodiversity related data over 17623 herbarium specimens and information on Bryophytes (390); Pteridophytes (580 species); Lichens (652 species); Algae (478 species); Gymnosperms (70 species); Flowering Plants: Pedicularis (85 species); Astragalus (71 species); Citrus & wild relatives (79 species). The laboratory launched two plant diversity databases online. These are PADAP (www.nbri.res.in/padap) & NBRI-LWG VIRTUAL HERBARIUM (www.nbri.res.in/herbarium).

An Information System for flora in Himachal Pradesh himFlorIS was developed which provides information on 1141 plant species regarding landscape elements (LSE), LSE types, physiographic factors, abundance of the species at a particular location, geographical locations of a plant on the map, taxonomic classification of the species along with its photographs and ethnobotanical uses.

Homologous and heterologous expression of high-value phytochemicals

CSIR laboratories, namely CSIR-CIMAP, CSIR-IHBT, CSIR-IICB, CSIR-IIIM and CSIR-NBRI have generated differentially annotated ESTs for *Artemisia annua* covering artemisinin biosynthesis, *Papaver somniferum* covering morphine and papaverine biosynthesis, genotype Poshita of *Withania somnifera* containing high Withaferin A in leaf and from chemovariant, *Podophyllum* covering podophyllotoxin biosynthesis and *Picrorrhiza kurroa* covering picroside biosynthesis. In addition, full length genes including 7 genes of *Artemisia annua*, 8 genes of *Papaver somniferum*, 3 genes of *Picrorrhiza kurroa*, 13 genes belonging to *Withania somnifera* and 4 genes of *Podophyllum hexandrum* biosynthetic pathway have been isolated and their functional analysis is in progress.

Transcriptome sequencing of *Podophyllum*, *Picrorrhiza*, *Papaver*, *Withania* has been completed. Bioinformatics analysis of *Podophyllum* is in

progress. In *Picrorrhiza*, all the genes of mevalonate, non-mevalonate, phenylpropanoid pathway were identified including monoterpene synthases. In *Papaver*, transcriptome of wild type and high papaverine synthesizing mutant (*pap1*) has been sequenced. All the known genes involved in alkaloid biosynthesis were identified. In *Withania*, to identify complete gene family for SGTs, transcriptome data have been established for root and leaf tissues of three chemotypes.

Breeding and genomic studies are in progress in Opium poppy to enhance alkaloids in poppy. The regeneration and transformation protocol was developed for *Artemisia annua* and *Picrorrhiza*. SGTL1 and SGTL4 of *Withania somnifera* have been transformed in tobacco and transgenic plants have been analyzed for phenotypic and biochemical changes. An efficient regeneration protocol has been developed for *Papaver somniferum* through somatic embryogenesis.

Novel approaches for production of hybrid seeds with improved insect resistance and higher yield

As part of new initiative under NMITLI programme for strengthening synergy among academia and industry, CSIR has taken an endeavour to develop hybrid seeds in rice and cotton using existing knowledge on molecular approaches and tools for genetic improvement of yield parameters and tolerance to abiotic and biotic stresses.

One of the major constraints to large-scale commercial cultivation of good quality hybrid rice



Fig. 1.12. Improved rice cultivation

in India is low levels of heterosis since all commercially released rice hybrids in the country are based on a single cytoplasmic source i.e. WA.

In case of rice, for the first time germplasm collected from different places had been brought to one place and grouped according to their period of maturity. Based on morphological data and molecular mapping with 40 SSR markers, hybrids were developed. Sixteen of the most promising hybrids have been shortlisted for multi-location trials. Rice transformation protocol has been standardized (Figure 1.12). For yield improvement in rice, male sterile lines and restorer lines are being generated through insertion of barnase/barstar system. For the purpose, two novel tapetum specific promoters have been isolated and characterized. Gene constructs with tapetum specific promoters and barnase/barstar system are being tested for rice transformation.

In cotton, two lectin genes from different plants and two cry genes have been isolated, characterized and identified for imparting resistance to major pests, namely, lepidopteran insects, aphids, jassids and white flies. Transgenic cotton lines with cry genes are being raised and tested. Anther-specific promoters in cotton have been isolated. Cotton transformation using barnase/barstar system is in progress for yield improvement. Through heterosis breeding, divergent cotton lines have been selected based on morphology and combining ability. Hybrids developed showed better performance than the two best bt check hybrids.

Peptides for treating cancer

CSIR-NCL isolated a novel peptide that could play an important role in treating or preventing cancer. The peptide, called cysteine protease inhibitor, isolated from *Streptomyces* inhibited the migration of cancer cells.

A novel peptide (736-842 Da) was isolated which has Cathepsin K and L inhibition activity in nanomolar range. Cysteine proteases play an important role in cell migration and tumour metastasis. The compounds which possess their

inhibition without harming the healthy tissues are of great significance, having potential to be developed as effective antimetastatic drugs for tumour therapy. A small molecule cysteine protease inhibitor, CPI-2081 (compound 1), a mixture of two novel pentapeptides, compound 1a and compound 1b, was isolated from *Streptomyces* species NCIM2081. It was found that compound 1 significantly inhibits tumour cell migration.

A novel modified peptidic thiol protease inhibitor (CPI-2081) was isolated from actinomycete (*Streptomyces* sp NCIM2081) which exhibit K_i in nanomolar (<100 nm) range and it can inhibit the tumour cell migration without any cytotoxic activity. Also, the CPI is able to inhibit the RANKEL induced osteoclast differentiation without having considerable cytotoxic effect.

New antimalarial compounds synthesised

CSIR-NCL have achieved the first total synthesis of flinderoles, a type of Indole alkaloids showing promising antimalarial activities. Flinderole A was isolated from the stembark of the plant *Flindersia acuminata* with 0.001 % dry wt. yield. The other indole alkaloids, flinderoles -B and -C were isolated from the stembark of *Flindersia amboinensis*, collected from Papua New Guinea, yielding 0.016 and 0.014% dry wt., respectively. CSIR- NCL achieved the total synthesis of two of the three flinderoles from 3-indole acetic acid, a commercially available raw material with 17.2 % overall yield. CSIR-NCL developed a highly selective [3+2] cycloaddition reaction between a tertiary alcohol and olefin for the synthesis of pyrroloindoles. The strategy can also be used for the synthesis of other natural products of the indole alkaloid category and their analogues.

Commercialization of floriculture

CSIR-IHBT has introduced and commercialized liliium cultivation in Lahaul & Spiti region of Himachal Pradesh. The laboratory has played a catalytic role in the promotion of commercial oriculture in Himachal Pradesh. The transfer of agrotechnology of liliium in the region was realized by the ower growers through sale of cut owers

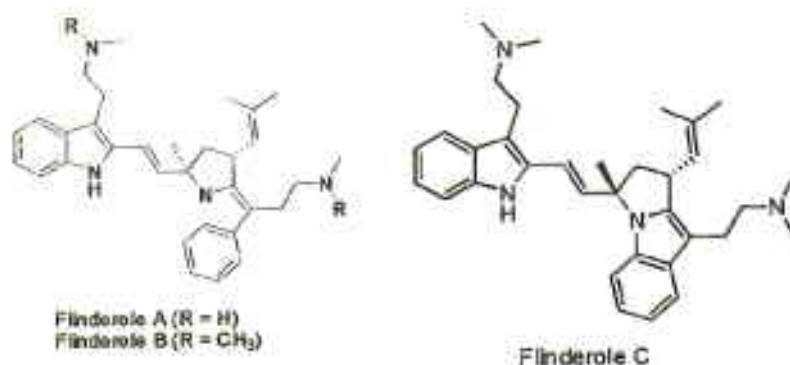


Fig. 1.13. Chemical structure of Flinderole A, B, & C

worth 50 lakhs at Delhi over market. Area under oriculture increased steadily from 30 ha (1993-94) to 813 ha with an estimated turnover of 77.26 crores in 2010-11. Presently, 3000 farmers are engaged in oriculture in Himachal Pradesh.

Technology for bioinoculants transferred

CSIR-NBRI has developed abiotic stress tolerant biofertilizer and biopesticides for use as plant growth enhancer and biofungicides. The technology has been transferred to Department of Agriculture, U. P. Govt's biofertilizer & biopesticide manufacturing units; Biotech International, New Delhi; Gujarat Agri Processing Company Ltd., Gujarat and Balaji Crop Care Pvt. Ltd., Hyderabad. Rhizobium and phosphate solubilising bacteria (PSB) technology was used at U.P. Government's 17 biofertilizer producing laboratories. The institute has also developed *Beauveria bassiana* spp. based technology package for bio-control of agriculture pests especially *Spodoptera* and termites in legume crops. The novel microbe isolated from the field is thermostable at higher temperature.

1.2 CHEMICAL SCIENCES CLUSTER

Study on the mechanism of the oxygen activation process in cysteine dioxygenase enzymes

Cysteine dioxygenase (CDO), a vital enzyme for biodegradation of toxic cysteine utilizes molecular oxygen to transfer two oxygen atoms to cysteine to form cysteine sulfinic acid products. The mechanism for this reaction is currently disputed, with crystallographic studies implicating a persulfenate intermediate in the catalytic cycle. To



Fig. 1.15. Tar balls on the Colava Beach



Fig. 1.14. Effect of plant growth enhancer

resolve the dispute, a study was performed by CSIR-IICT on quantum mechanics/molecular mechanics (QM/MM) calculations on substrate activation by CDO enzymes using an enzyme monomer and a large QM active region. A stepwise mechanism has been proposed whereby the distal oxygen atom of the iron(II)-superoxo complex attacks the sulfur atom of cysteinate to form a ring structure, followed by dioxygen bond breaking and the formation of a sulfoxide bound to an iron(IV)-oxo complex.

Excited state processes in Linear π -system-based organogels

CSIR-NIIST studied excited state interactions in organogels derived from linear π -conjugated molecules. The soft organogel scaffolds of such systems create an excellent ambience for the self-organization of the molecules allowing the modulation of their excited state properties and thereby opening a new world of fascinating materials with interesting physical properties at nano- and macroscopic levels. Noncovalent interactions provide opportunity for the molecules to interact electronically within space of defined size and shape. As a result, the photophysical



Fig. 1.16. Schematic of gels

properties of the molecules in solution and gel states are different from each other. CSIR-NIIST analyzed the role of the self-assembled organogel scaffolds of gels driven from linear systems in modulating the excited state properties such as excited state energy transfer, exciplex emission, phosphorescence, and aggregation-induced

enhanced emission (AIEE), when compared to the corresponding individual molecules.

Palladium nanoparticle-cored G₁-dendrimer as chemoselective, room temperature hydrogenation catalysts

Transition metals, especially palladium find great importance in the field of catalysis. Palladium nanoparticle-cored Frechet type G₁-dendrimer (Pd-G) stabilized by Pd-carbon bonds were synthesized and characterized by CSIR-NIIST using IR, NMR, UV-Vis spectroscopic methods. TEM analysis indicated the presence of nearly spherical, polydisperse particles with average diameter of 2.7 nm. Pd-G, was found to be a highly efficient, chemoselective and reusable catalyst for the room temperature hydrogenation of carbon-carbon multiple bonds. Reducible functionalities like CHO, CO, COOR, CN, NO₂ and halogens were unaffected. Pd-G, is an efficient catalyst for the selective hydrogenation in multifunctional organic molecules.

Gram-scale synthesis of taxol analogue

Taxol has severe water solubility problem for effective drug delivery and therefore requires elaborate secondary treatment. Moreover, the production of taxol from the slow growing yew trees leads to problems of environmental consideration as well as requirement of yew trees in large number. To overcome these problems, intensive search for suitable taxol analogue has been initiated. A viable approach for the production of taxotere from simpler diterpenoid baccatin III, by fixing a synthetic 3-phenylisoserine derived side chain has been reported by CSIR-NIIST. Because of this C-13 side chain, taxotere has become one of the most targeted compounds by the synthetic chemists.

Novel method for the preparation of A-ring annelated pyridosteroids

The heterosteroids are of great pharmaceutical importance because of inherent biological activities. Enormous efforts have been made to synthesize A-ring fused heterosteroids with

pyrazole, isoxazole, oxazole, pyridine, pyrrole and pyrimidine moieties. Among these, the synthesis of pyridine fused A-ring steroids draws renewed interests in view of the widespread occurrence and biological activity of pyridines in natural products and pharmaceuticals. On the other hand, enamides are synthetically important functionalities that constitute important building blocks of many biologically active compounds. However, steroidal enamides are less intensively studied in comparison to aliphatic or cyclic enamides. A novel method has been developed and reported by CSIR-NEIST for the preparation of A-ring annelated pyridosteroids from the Vilsmeier reaction of enamides in high yields.

A catalytic method for converting vinyllic furanoses into cyclopentenones

The conversion of carbohydrates into carbocycles is a very useful strategy in organic synthesis since it affords functionalized and optically active key intermediates for the total synthesis of various types of bioactive molecules. Furthermore, it is also reported as an excellent route to carbasugars, which are of pharmacological interest. A new strategy was developed by CSIR-IICT for the conversion of vinyl-substituted furanose derivatives into the corresponding cyclopentenones. This method appears complementary to the synthesis developed recently using the RCM reaction as the key step, which affords essentially cyclopentenones with a hydrogen on position 2.

Pheromone application technology

Pheromone Application Technology (PAT) that utilizes synthetic pheromones is one of the options available for effective control of insect pests of internal feeders like leaf miners, stem borers and dweller. CSIR-IICT as a 'National Centre for Pheromone Research' has taken up a lead role for popularisation of PAT under farmers' participatory approach and successfully controlled the devastating pests like Groundnut leaf miner (1000 Ha), Brinjal shoot and fruit borer (500 Ha), Rice yellow stem borer (500Ha) and Sugarcane inter node borer (100 Ha). Pheromone blends and the dispensers utilized for the control of above pests were developed at CSIR-IICT. The pest damage was effectively brought down in all the demonstrations with a significant yield increase (an average of 10%).

Tocopherols and phytosterols from soybean oil deodorizer distillate

Deodorizer distillate (DOD) is a by-product obtained during the refining of vegetable oils and is a good source for phytosterols and tocopherols. CSIR-IICT developed a process for the isolation and enrichment of tocopherols and phytosterols from soybean oil DOD and the technology was demonstrated to M/s. Perfect Vitamins Pvt. Ltd., Mumbai and M/s. Biopharma Pvt. Ltd., Hyderabad.



Delta sticky trap for Groundnut Leaf Miner



Trapped insects (GLM)



Insects trapped in Funnel sleeve trap

Fig. 1.17. Application of Pheromone Application Technology

Phenolipids with antioxidant activity

Phenolics are well known natural antioxidant, but their poor solubility in nonpolar medium limits their application in lipid-based food product. CSIR-IICT carried out lipophilic modification of natural phenolics, exemplified by ferulic acid and capsiates in order to assess their change in antioxidant activity in polar, nonpolar and micellar medium. Phenolic pseudotriacylglycerol, structured phenolipid, lipophilized capsiates etc. are some of the classes of phenolipid synthesized. These synthesized phenolipids exhibited superior antioxidant activity both in nonpolar and micellar medium.

DMSO recovery from pharmaceutical effluent

An aqueous effluent known as ZDV2 mother liquor is generated during the manufacture of Ziduvudine anti retro viral drug. This effluent typically contains 15% of dimethylsulfoxide (DMSO) solvent (reaction medium) along with 2-3 % salts viz., the hazardous sodium azide (NaN_3) which is a reactant and ammonium chloride (NH_4Cl). The salts need to be removed completely to recover the DMSO solvent, which is widely used in bulk drug manufacture as

reaction medium. Presently the effluent is being sent to the ETP for disposal, resulting in heavy losses of the expensive DMSO, which also contributes to excess COD of the effluent. An appropriate separation scheme was developed for the removal of the explosive sodium azide to enable recovery of DMSO. The desalted feed was then sent to a two-stage distillation process for water removal and recovery of pure DMSO. Commercial electrodialysis stacks capable of treating a total capacity of 7500 L/batch were commissioned at M/s Astrix Laboratories Limited and about 30 Metric Tonnes of DMSO solvent has been recovered so far. The drug manufactured with recycled DMSO meets all the necessary specifications.

Electrocatalysis on gold clusters

CSIR-CECRI has recently demonstrated that CTAB-assisted aqueous electrodeposition yields

gold atomic clusters (with Au_5 being abundant). The clusters are molecule-like and electro-catalyze the reduction of oxygen to water through a direct four-electron pathway in acidic solutions. More importantly they show a transition of the oxygen reduction reaction mechanism from four-electron to two-electron reduction, which reflects the transformation of gold atomic clusters possibly to bigger nanocluster. Electro-synthesized surfactant-stabilized gold atomic clusters electro catalyze the oxygen reduction reaction in acid solution at low overpotential. Depending on the surfactant concentration, the oxygen reduction reaction mechanism gradually transforms from a direct four electron to a two electron pathway, which suggests the transformation of atomic clusters into nanoparticles.

CuMgAl ternary hydrotalcites as catalysts for the hydroxylation of phenol

Hydrotalcite-like compounds comprise a class of anionic clays or layered double hydroxides that have received increasing attention in recent years because of their diverse applications as ion exchangers, catalysts, catalyst supports and polymer additives. CSIR-CSMCRI reported preparation of CuMgAl ternary hydrotalcites with a $(\text{Cu} + \text{Mg})/\text{Al}$ atomic ratio of 3.0 and a Cu/Mg atomic ratio of 5.0, 3.0, 1.0, 0.33, and 0.2 involving co-precipitation under low supersaturation. Powder X-ray diffraction (PXRD) of all of the samples showed the pattern characteristic of hydrotalcite without any detectable impurity phases. In situ PXRD studies revealed varying phase evolution processes depending on the concentration of magnesium. Catechol and hydroquinone were the main products produced in the hydroxylation of phenol over these catalysts, with H_2O_2 as oxidant and H_2O as solvent.

Gold-Prussian blue nanocomposite for detection of hydrogen peroxide at nanomolar levels

Prussian blue and its analogues have been considered interesting materials for reduction of hydrogen peroxide. A one-step electrochemical deposition of gold-Prussian blue (PB) nanocomposite films has been reported by CSIR-

CECRI. The catalytic activity of gold nuclei toward the decomposition of ferricyanide to free ferric ions and controlled generation of gold nanoparticles from HAuCl_4 solutions during potential cycling are exploited to form these nanocomposites. Concomitant electrochemical formation of both PB and gold phases leads to a "perfect blend", in which each phase controls the growth of the other.

Low cost bimetallic catalysts for selective hydrogenation of aldehydes

High surface area supported transition metal-based bimetallic catalysts M-MI/SiO_2 ($\text{M} = \text{Co, Ni}$ and Cu ; $\text{MI} = \text{Ni, Cu}$ and Co) were developed by CSIR-IICT for selective hydrogenation of furfuraldehyde and cinnamaldehyde to their corresponding alcohols. There is a lot of demand for non-noble metal based catalysts as a substitute for more expensive noble metal catalysts for selective hydrogenation reactions in the chemical and pharmaceutical industries. The designed nanosized Cu-Co/SiO_2 and Ni-Cu/SiO_2 combination catalysts exhibited a high conversion and product selectivity in the transformation of furfuraldehyde to furfuryl alcohol and cinnamaldehyde to cinnamyl alcohol.

Novel catalysts for value addition to bioglycerol

Novel green solid acid catalysts were designed by CSIR-IICT for acetylation of glycerol with acetic acid to synthesize monoacetin, diacetin and triacetin having interesting applications as bio-additives for petroleum fuels. Among several catalysts investigated, a novel metal oxide based catalyst ($\text{MoO}_3/\text{TiO}_2\text{-ZrO}_2$) exhibited highest conversion (~100%) with best product selectivity, and a high time-on-stream stability. The designed catalyst is quite stable and recyclable for several runs.

Novel nanosized ceria-based mixed oxides for auto-exhaust purification and other applications

At CSIR-IICT, novel nano-sized CeO_2ZrO_2 , $\text{CeO}_2\text{-HfO}_2$, $\text{CeO}_2\text{-La}_2\text{O}_3$, $\text{CeO}_2\text{-Tb}_2\text{O}_3$, etc combination solid solutions were prepared and characterized by various physicochemical techniques. The

relative influence of SiO_2 , TiO_2 and Al_2O_3 on the oxygen storage capacity was also systematically investigated. Further studies are under active progress to exploit these catalysts for commercial applications. Two patents (USA) were filed on this work in view of its commercial importance. The developed materials are well suited for auto-exhaust purification and other applications.

Thermally stable organic-inorganic hybrid membrane

Organic-inorganic hybrid membranes based on poly(vinyl alcohol) and SiO_2 have been developed by CSIR-CSMCRI with sulfonic acid groups introduced at the inorganic segment. These membranes were extensively characterized for their morphology, intermolecular interactions, thermal and mechanical stability, physicochemical properties and water uptake studies. Schematic models for acid-catalyzed linear weakly polymeric clusters and for base catalyzed highly branched polymeric clusters were proposed. A higher ion-exchange capacity, permselectivity, and conductivity for the acid-catalyzed hybrid membranes than for the base-catalyzed membranes with the same composition indicated that the former route is suitable for the preparation of ion-exchange membranes.

Transformation of carbon nanotubes to graphene nanoribbons

CSIR-NCL developed a new method of transforming carbon nanotubes (CNTs) to nanoribbons comprising a few layers of graphene. This was achieved electrochemically by the oxidation of CNTs at controlled potential, followed by reduction to form graphene nanoribbons (GNRs) having smooth edges and fewer defects. Such an "unzipping" of CNTs (single-walled, multi-walled) in the presence of an interfacial electric field provides unique advantages with respect to the orientation of CNTs, paving the way to many new applications enabling possible production of GNRs with controlled widths and fewer defects. CSIR-NCL invented an unprecedented method for transforming CNTs to GNRs by using an electrochemical approach, with

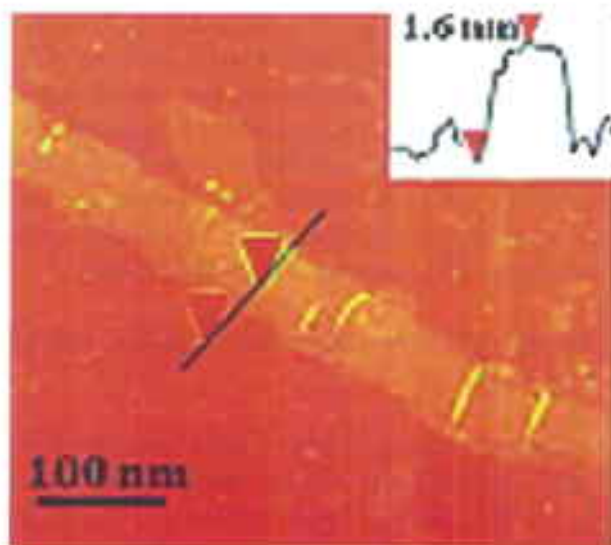


Fig. 1.18. Typical AFM image of graphene nanoribbon made from multi-walled carbon nanotubes

the unique advantage that it allows controlling the graphene layer thickness and orientation. The electrochemical approach is an effective way to modify electronic states by modulating the electric field (chemical potential) to change the Fermi level of the electrode materials. An interfacial electric field is expected to orient the CNTs in this method, and hence longitudinal unzipping is more likely with possible C-C cleavage initiated at topological defects having enough strain, rather than a random breakdown in chemical methods.

NMR monitoring of chain specific stability in heterotrimeric collagen peptides

A novel use of NMR spectroscopy to investigate the heterotrimeric nature of a collagen model peptide has been developed by CSIR-CLRI. Two distinct peptide chains (A and B) were synthesized to model a site in heterotrimeric basement membrane type IV collagen. For NMR studies, four amino acids in the B chain were labeled with $^{15}\text{N}/^{13}\text{C}$. CD spectroscopy and DSC thermal stability results on a solution with both A and B peptides (molar ratio 2A:1B) are consistent with the presence of one heterotrimeric triple-helical molecular species. HSQC experiments on homotrimers of the B peptide show trimer peaks which disappear at temperatures higher than 10°C , while the 2A:1B mixture has trimer peaks with increased stability and altered chemical shifts. The

reduction in the number of Leu trimer peaks from three to one and the increased stability of trimer resonances confirm the participation of B chains in an AAB heterotrimer molecule.

Tailored anisotropic magnetic chain structures

A great deal of research is focused on nanomaterials, particularly those with magnetic properties that can be exploited for the fabrication of ordered one-dimensional (1D) chainlike assemblies. Self-assembly of citrate-functionalized Fe_3O_4 nanoparticles and hydroxy pyrene trisulfonate (HPTS) catalysed by poly(L-lysine) forms magnetoresponsive fluorescent spheres (MFS) in glutaric dialdehyde (GA) medium. CSIR-IICT observed 1-D magnetic beaded-chain assemblies formed in presence of permanent magnet. A hierarchical assembly process to integrate functional nano- and molecular units was demonstrated that allows the formation of one-dimensional magnetic beaded-chain structures in a colloidal dispersion.

Glycerol-based carbon acid & base catalysts for green processes

CSIR-IICT developed heterogeneous carbon-based acid and base catalysts (patents filed) from crude glycerol. The carbon acid catalyst exhibited excellent esterification activity particularly for the conversion of free fatty acids present in indigenous non-edible oils to biodiesel thus reducing effluent load by avoiding sulfuric acid. The acid catalyst was modified to base catalyst with a very good transesterification activity for the production of biodiesel from neat vegetable oils. These carbon catalysts are very stable, water resistant and exhibited extra-ordinary recycling capability without any leaching into the reaction systems. The carbon acid catalyst was successfully employed for the preparation of variety of esters, protection and deprotection of alcohols and phenols. Apart from biodiesel preparation, the carbon acid catalyst has extra-ordinary potential to replace sulfuric acid or other heterogeneous catalysts.

Formohydroxamic Acid

CSIR-IICT developed a techno-economic process for the preparation of FormoHydroxamic Acid

(FHA). FHA is a useful chelating agent for selective separation of uranium from the spent nuclear fuel (UREX (Uranium Extraction process)). FHA has very low shelf life at room temperature due to rapid thermal decomposition into gaseous products, and this could be a potential explosion hazard. Hence, development of an economically viable and safe process for FHA was a challenging task. An indigenous process technology for this compound has valuable applications in Plutonium-Uranium Extraction (PUREX) process and is important for effective management of nuclear waste. The methods for the preparation of FHA are scarcely discussed in literature and yields recorded are less than 10%. CSIR-IICT developed a safe method for preparation of FHA in multigram scale with more than 50% yields at 99% purity. The process was optimised at 50g/ batch scale and demonstrated successfully to the sponsor. The uniqueness of the process is that it does not produce any aqueous effluent. The solvents used in the process were totally recovered and recycled. CSIR-IICT had delivered 0.5 kg of pure FHA to IGCAR for further studies.

H₂ production from biomass derived glycerol

CSIR-IICT developed Ni/SiO₂ a low temperature active and Ni/Alumina Sol or Ni/Alumina Pural high temperature catalysts at bench scale (2g scale) for H₂ production from biomass derived glycerol. The data was generated at a 50 g level and after

evaluation demonstrated to MNRE. Catalyst life is estimated to be approximately 500h.

Methanol reforming

CSIR-IICT developed catalysts for methanol reforming for 10 kW and 50 kW reformer.



Fig. 1.19. Methanol Reforming Plant

Accelerated aging studies have indicated that the catalyst life is ~ 1000h. The catalysts can potentially be used for on-board H₂ generation for stationary and mobile applications.

Warm gas clean-up process developed

An adsorptive separation process for removal of trace-level contaminants such as sulphur compounds, ammonia and alkali-metal vapour from the coal-derived fuel gases at 500°C & 20



Fig. 1.20. H₂ Production Plant



kg/cm² was developed by CSIR-IICT. Hot clean up of fuel gas would help retain the sensible heat in the feed to the combustion turbine resulting in additional power generation while protecting the environment and the equipment from corrosion.

Green process for the conversion of hemicellulose into chemicals

CSIR-NCL developed a one-pot process for the conversion of solid hemicellulose into xylose, arabinose and furfural using solid acid catalysts selectively from lignocellulosic materials. The major advantages of using solid acids are ease of separation of catalyst (solid) and product (water soluble) by simple filtration and working under neutral conditions without any corrosion in a totally green environment. The catalysts can be re-used up to five runs with almost same activity, which implies that catalysts are hydrothermally stable. Scientists of CSIR-NCL could achieved

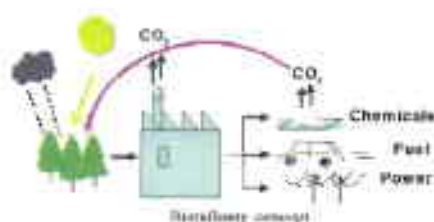


Fig. 1.21. Schematic of Biorefinery concept

40% xylose + arabinose yield at 170°C with water as a reaction medium and zeolite as a catalyst. Similar reaction conditions, without catalyst, yielded only 6% xylose + arabinose. Further, it was found that several other solid acid catalysts such as, zeolites HBeta & HMOR and clay were active for this reaction and showed xylose + arabinose yield of 30–40%.

Hierarchical mesoporous zeolites for production of aviation fuel from lipids

Hierarchical mesoporous molecular sieves with tunable zeolitic crystallinity, acidity and porosity were tailored by CSIR-IIP to develop a single-step process for hydroconversion of triglycerides and free fatty acids obtained from algae and *Jatropha* seeds. Ni-W catalyst supported on acidic zeolitic ZSM-5 with hierarchical structure and intra-

crystalline mesoporosity with composition similar to that for typical hydrocracking catalyst could yield 40–45% C₉–C₁₅ hydrocarbons and high isomerization selectivity (isomer/n-alkane, *i/n* = 2–6) from *Jatropha* oil. While Ni-Mo catalysts on the same support furnished 40–50% kerosene range hydrocarbons with *i/n* = 3–13.

For algal oil feed hydroconversion using sulfided Ni-Mo catalyst supported on high surface area semi-crystalline ZSM-5, unexpectedly high yield of jet-fuel range hydrocarbons (77%) with moderately high isomerization selectivity (*i/n* = 2.5) could be obtained.

Catalysts for processing of waste soya-oil and refinery-oil mixtures

Mesoporous SiO₂-Al₂O₃ and Al₂O₃ were used as supports to prepare hydrocracking (sulfided Ni-W/SiO₂-Al₂O₃) and hydrotreating (sulfided Ni-Mo/Al₂O₃) catalysts by CSIR-IIP. These catalysts were used under typical hydroprocessing conditions to convert waste soya-oil mixtures with refinery-oil into saturated hydrocarbons. The hydrocracking catalyst was more selective for the kerosene range (140–250 °C) hydrocarbons while the less acidic hydrotreating catalyst was more selective for the diesel range (250–380 °C) hydrocarbons. The hydrodeoxygenation pathway for oxygen removal from triglycerides seems to be favored over the hydrotreating catalyst, while decarboxylation + decarbonylation pathway is favored over the hydrocracking catalyst.

Commercialization of wax deoiling

Numaligarh Refinery (NRI), a subsidiary of BPCL is setting up a grass root wax deoiling unit using updated (CSIR-IIP)-EIL process know-how. The unit is based on state-of-the-art technology developed by CSIR-IIP. It will process low value wax distillates in a series of steps comprising of fractional crystallization and filtration. The wax facility being set-up by Numaligarh Refinery will have an annual design capacity to produce 50,000 tonnes per annum of food grade paraffin wax and 4500 tonnes of micro crystalline wax by processing two waxy streams, namely MVGO & HVGO.

Microbial fuel cells

Two chamber microbial fuel cells (MFCs) were constructed by CSIR-CECRI using single culture of *Acetobacter acetii* (A-MFC), and *Gluconobacter roseus* (G-MFC) and also using mixed culture (AG-MFC). Each MFC was fed with four different substrates viz., glucose, ethanol, acetate and bad wine. AG-MFC produced higher power density with glucose (1.05 W/m²), ethanol (1.97 W/m²), acetate (1.39 W/m²) and bad wine (3.82 W/m²).



Fig. 1.22. Bad wine fed MFC running a digital clock

COD removal (94%) was maximum for acetate fed MFCs. Higher coulombic efficiency was obtained with bad wine (45%) as the fuel. This work provides the scope of using these biofuel cells in wineries for performing the dual duty of bad wine degradation cum current generation. It has been demonstrated that the bad wine fed microbial fuel cells can be used for running digital clocks.

Nanocomposite polymer electrolyte membrane

A method has been developed by CSIR-CECRI for preparing sulphonated poly (ether-ether-ketone) (SPEEK)-zeolite-zirconium hydrogen phosphate (ZrP) nanocomposite polymer electrolyte membrane (PEM) by in situ infiltration and precipitation. This is the first report of the infiltration of zeolites in the pores/cavities created by water soluble surfactant in the polymer electrolyte, for accommodating proton conductor. Extremely low methanol permeability of these

PEMs enhanced their selectivity parameter by almost three times at 70°C in comparison to Nafion-117 membrane. This indicated suitability of these PEMs in fuel cell applications at moderate temperature. Furthermore, these PEMs can be identified as potential candidate for providing new technological applications in high temperature electrochemical devices including ion separations, water electrolysis, and electro-chemical sensor.

Dye-sensitized solar cells based on ZnO bifunctional nanoflowers loaded with gold nanoparticles

Development of nanomaterials as electrode materials is being explored extensively by scientific fraternity. CSIR-NCL synthesized ZnO nanoflowers loaded with gold (Au) nanoparticles (NPs) by hydrothermal route using mixed precursors under controlled conditions. The dye-sensitized solar cells based on the ZnO nanoflowers with gold NPs show power conversion efficiency of 2.5%, which is considerably higher than that of ZnO nanoflowers without gold NPs. Detailed characterization of those materials have also been carried out.

Materials for dye-sensitized solar cells and energy storage materials

CSIR-IICT is working towards the development of materials for excitonic solar cells, which are alternative to expensive p-n type solid state devices. Broad absorbing sensitizers based on Ru(II) polypyridyl, Ru(II)-organic, and phthalocanine-organic chromophores were developed. The sensitizer HRD-1 using liquid electrolyte has shown an efficiency of 10.60%. This sensitizer using polymer gel electrolyte has shown an efficiency of 5.66% and was highly durable in accelerated tests. Other Ru(II) polypyridyl complexes m-BL-5, m-BL-6 and BPFC have shown efficiencies of 5.40%, 4.92% and 4.60%, respectively. The sensitizers Pc-RD and Pc-Org-1 displayed broad absorption property.

Iron-nitrogen doped carbon nanofiber as cathode for PEMFC

CSIR-NCL demonstrated construction of iron nitride-doped carbon nanofiber (CNF) as cathode

for PEM Fuel Cell. The slit pores and rough edges along the inner wall of CNF were effectively utilized for increasing the number of active sites and consequently the oxygen reduction activity. The PEM fuel cells use platinum supported active carbon catalysts very thinly coated onto carbon paper or cloth as an electrode. However, the high cost of current platinum / carbon catalysts has been considered as the major stumbling block in realizing commercially viable PEMFCs in the energy market. The PtCNF showed an onset potential of 0.67 V for Oxygen Reduction Reaction (ORR) at 1600 rpm as compared to 0.54V for FeN_xCNF. Thus, even though platinum still retains an advantage in terms of the onset potential, FeN_xCNF has shown tremendous activity towards ORR compared to many other non-noble catalyst systems known. The FeN_xCNF (with less amount of nitrogen) showed better catalytic activity than the N-CNF, revealing the fact that it is not the amount of nitrogen but the nature of nitrogen in its coordination with the graphene framework that is more important in deciding the ORR activity. In addition, the ability of FeN_xCNF to reduce oxygen through a four electron pathway highlights the importance of metal in the catalyst system to determine the reaction kinetics and thus opens great scope for considering new paths and strategies to develop effective non-precious electrocatalyst for PEMFCs.

Nafion-Mesoporous zirconium phosphate composite membrane for PEM fuel cells

Mesoporous Zirconium Phosphate (MZP) acts as surface-functionalised solid-superacid-proton-conducting medium as well as inorganic filler with high affinity to absorb water helping in fast proton transport across the electrolyte membrane suitable for PEFC operation especially at low RH values. Synthesis of MZP by coassembly of a tri-block copolymer, namely pluronic-F127, as a structure-directing agent, and a mixture of zirconium butoxide and phosphorous trichloride as inorganic precursors has been carried out and reported by CSIR-CSMCRI. Nafion-MZP composite membrane is obtained by employing MZP as surface-functionalised solid-super-acid-proton-conducting medium as well as inorganic filler with high affinity to absorb water and fast proton-transport across the electrolyte membrane even under low relative humidity (RH) conditions. On operating the PEFC employing Nafion-MZP membrane electrolyte with hydrogen and air feeds at ambient pressure and a RH value of 18%, a peak power density of 285 mWcm⁻² at the optimum temperature (60 °C) was achieved.

Carbon bed electrolyzer for treatment of liquid effluents

CSIR-NEERI carried out feasibility studies on



Fig. 1.23. Demonstration of Carbon Bed Electrolyser unit at Nagarjuna Industries, Gujarat

pretreatment of segregated recalcitrant wastewater for Common Effluent Treatment Plant of M/s Nandesari Industries Association, Gujarat. The treatability studies involved physico-chemical treatment, chemical oxidation, electrochemical oxidation and bio-oxidation. The basic design of the pretreatment option comprising physico-chemical treatment followed by sand filtration and two-stage electro oxidation was delineated. On the basis of these studies, CSIR-NEERI also successfully demonstrated its new invention – 'carbon bed electrolyzer (CBE) unit' at this industrial site for treatment of recalcitrant wastewater. This CBE unit is useful for electrolytic treatment of liquid effluents having very high concentrations of Chemical Oxygen Demand (COD), Total Kjeldahl Nitrogen (TKN) and Biochemical Oxygen Demand (BOD), and Total Dissolved Solids (TDS). This unit has also been useful for improving biodegradation of the effluent.

Stage biooxidation (TSB) process for treatment of effluent at agrochemical industry

CSIR-NEERI developed and demonstrated the TSB process at Nagarjuna Agrichem Limited (NACL), Srikakulam (A.P), which is involved in manufacturing insecticides, herbicides and fungicides (Tricyclazole, Propiconazole, etc.). The performance of the ETP was also evaluated under

the existing operating conditions and carried out extensive treatability studies. Based on the lab scale studies, a two-stage biooxidation (TSB) process was applied to treat the effluent from the pesticide industry. A new treatment scheme was recommended based on the TSB process. A full scale ETP based on the scheme developed by CSIR-NEERI has been constructed and commissioning of the ETP is in progress.

Analysis and source apportionment of tar balls deposited on the coast of Goa

CSIR-NEERI carried out the studies related to analysis of tar balls deposited on the coast of Goa, as pollution of beaches in Goa by tar balls is a matter of concern. Tar ball samples were analyzed for hydrocarbon fingerprints through GC-MS and GC-FID techniques. Signature verification and identification of the likely sources was done with samples of crude oil, weathered crude oil and burnt oil samples. The study indicated that the major source of tar balls is crude oil, as evident from the fingerprints. The possible routes could be spillage during transportation through the vessels along the marine routes and leakages in the sub-sea pipeline network used for transporting the crude oil from offshore processing platforms to onshore terminals. Minor contribution to waste cleanup materials used for machinery equipment installed on the vessels / ships and also the bilge water



Fig. 1.24. Based on the process developed by CSIR-NEERI, a full scale ETP of 600 m³/d design capacity comprising (A) ammonia stripper and (B) Two Stage Biooxidation (TSB) process has been implemented at Nagarjuna Agrichem Ltd, Srikakulam

generated during the process of cleaning maintenance and discharges of treated drilling and produced wastewaters from respective platforms in deep sea, offshore areas. All these wastes and spilled materials containing oil and grease periodically undergo changes through weathering effects (dispersion, dissolution, emulsification, evaporation and decomposition) depending on the marine environment and sea conditions, and take the shape of tar balls which travel with waves and currents and other meteorological conditions prevailing due to monsoon setup in the offshore area. It is also observed that the composition of the tar ball is related to the availability of maximum greasy and asphaltic materials.

Novel dye-adsorbent catalyst

The “Magnetic Dye-Adsorbent Catalyst” is a unique product used as a dye-removal material synthesized through a new process developed by CSIR-NIIST. The product consists of a nano-composite having a “core-shell” structure with the core and shell made up of a magnetic ceramic particle and a dye-adsorbing material in the form of nanotubes. This structure of dye-removal material shows both the dye-adsorption and magnetic properties. It can remove an organic textile-dye (both cationic and anionic) from an aqueous solution (textile-effluent) via surface-adsorption mechanism in the dark-condition. The catalyst when dispersed and stirred in the textile-effluent, quickly adsorbs on to the dye surface and slowly settle down to the bottom due to gravity. An external magnetic field is also effective in

setting and separating the catalyst from the top clear-water due to its magnetic nature. The catalyst can be recycled several times in dark condition for decomposing the adsorbed dye from its surface by treating in a typical bath.

Environmental Monitoring

CSIR-NEERI is operating a nationwide air quality monitoring network to maintain and update the database on Indian air quality. The database enables assessment of long-term air quality trends for health related critical air pollutants. This also forms the basis for air pollution management plans. Stack emission characterization studies and monitoring of gaseous pollutants including VOCs, in indoor and outdoor air have also been carried out for various industries and locations. Monitoring of pesticide residues in groundwater and soil at national level has also been done. The pesticide residue data generated would be instrumental in justifying India’s presence in World Trade Organization (WTO) and in CODEX in foreign trade.

Environmental genomics

CSIR-NEERI evolved the use of genomic tools to address problems related to environmental contamination. The microbial and functional diversities of effluent treatment plants have been analyzed to improve the efficiency of treatment of wastewater generated in various industries. The hitherto unknown microbial population (non-culturable) of activated biomass has been assessed with bacteria identified by sequencing the 16S rRNA followed by deposition in the public

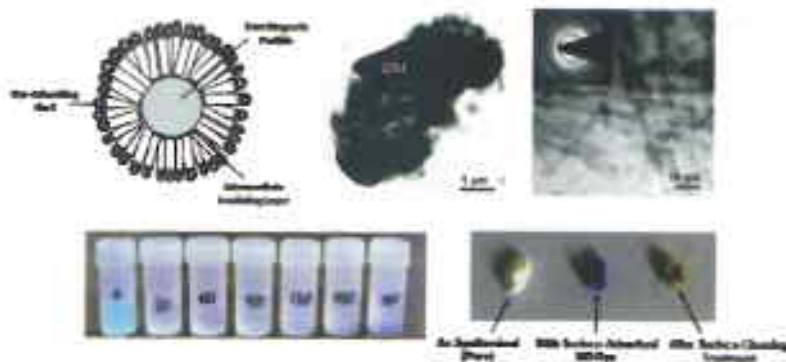


Fig. 1.25. Novel dye-adsorbent catalyst

database of GenBank. The metagenomic studies carried out will lead to unfolding of various biochemical pathways in biodegradation and biotransformation for the first time.

Zero wastewater discharge process

Zero wastewater discharge process was developed and demonstrated by CSIR-CLRI to M/s Amar Brothers and M/s Iqbal leathers, Kanpur

Mesoporous ceria catalysts and adsorbents for air purification:

Ceria has been of great scientific interest for its potential application in air pollution abatement. CSIR-IIP, for the first time reported development of a novel bimodal mesoporous crystalline ceria having nanometer-sized, pseudo-spherical, monodisperse particles. This mesoporous ceria was prepared using block copolymer templates and non-aqueous solvent. The surface areas, mesopore structure and thermal stabilities of the final product depend on the gel composition. The material shows very high sorption and catalytic properties for the elimination of acetaldehyde compared to semicrystalline mesoporous ceria and non-porous crystalline ceria materials. The material also showed acetaldehyde elimination ability twice as high as that of conventional materials.

Remediation of phosphate-contaminated water by electrocoagulation

Scientists are looking for alternative ways for remediation of contaminated water. CSIR-CECRI developed an electrocoagulation process for the

remediation of phosphate-contaminated water using aluminium, aluminium alloy and mild steel as the anodes and stainless steel as the cathode. Various parameters like effect of anode materials, pH, concentration of phosphate, current density, temperature and co-existing ions, adsorption capacity, etc. were studied using both Freundlich and Langmuir isotherm models. The adsorption of phosphate preferably fitting the Langmuir adsorption isotherm suggests monolayer coverage of adsorbed molecules. The results showed that the maximum removal efficiency of 99% was achieved with aluminium alloy anode at a current density of 0.2 A dm^{-2} , at a pH of 7.0. The adsorption process was observed to follow second-order kinetics.

Formaldehyde free synthetic tanning agent

Conventional synthetic tanning agents employed in leather processing are predominantly based on phenol-formaldehyde condensation products. It has been found by several research groups that the free formaldehyde in such products is beyond permissible levels for safe use. As an alternate, a multi functional matrix with sulfonated aromatic compound, free of formaldehyde has been developed, which is first of its kind in the world. In the leather industries, use of these syntans in tanning enhances the uptake of chromium to above 93%. The syntans provides a means for pickle free chrome tanning thereby reducing the total dissolved solids in the effluent. The presence of this syntan enables a reduction in the offer of filling syntans in wet finishing 30-40%. The technology



Fig. 1.26. Electro-Oxidation (EO) Cell Installation on reuse experiments at M/s Amar Brothers, Kanpur

developed by CSIR-CLRI has been transferred to M/s Balmer Lawrie and Co. Ltd., Chennai.

Natural shades of leather

Twenty four natural shades have been developed by CSIR-CLRI using combination of seven natural colorants by mordanting with three metal ions. Multifunctional syntan from solid wastes and biodegradable natural materials developed. Copper(II) complex of NN'-ethylene bis (salicylidene-aminato) (salenH₂) encapsulated in super cages of zeolite-Y found to be a potential catalyst for removal of anionic dyes. Biosorption of basic yellow dye on to the green macroalgae *Caulerpa scalpelliformis* shows maximum uptake



Fig. 1.27. Various natural shades of leather developed by CSIR-CLRI

of 27 mg of dye per gram of seaweed at pH 6.0, 5 g/L of adsorbent and 150 mg/L dye concentration

Synthetic tanning agents –Alutan & Alcrotan

Alutan and Alcrotan are two mineral synthetic tanning agents (syntans) which at the time of their development had no international equivalents. Alcrotan is an innovative light fast syntan based on chromium and aluminium, and ensured uptake of more than 90% of chromium and aluminium. Alutan is an aluminium based syntan with irreversible binding of aluminium (III) (which affords fuller leathers making suede processing easy with colour richness. By combining Alutan with basic chromium sulfate in tanning a zero waste closed-loop tanning methodology has become a reality. These two high performance tanning agents improved the quality of leather and reduced the environmental problems. The

technology developed by CLRI has been transferred to M/s Balmer Lawrie and Co. Ltd., Chennai.

Commissioning of nano filtration plant

CSIR-IICT successfully commissioned Commercial nano filtration plant (Six stage process for a feed capacity of 4000 liters per day) at the site of M/s Consolidated Fibres and Chemicals Ltd., Kolkata for recovery of impurity free sodium thiocyanate solvent from aqueous process stream. This process is employed in the production of Acrylic Fiber. Training to the industry personnel on plant operation and membrane maintenance through experiments as well as audio visual presentation was also given as part of the technology transfer agreement.

Catalytic process for fragrance chemicals

Chemical industry uses reagents for synthesis of intermediates for fragrance chemicals. CSIR-IICT has developed a new process for synthesizing intermediates for fragrance chemicals using supported catalyst. The process knowhow has been transferred to M/s Givaudan, Vernier Switzerland.

Fungal protease for application in leather processing

CSIR-CLRI conducted a study on fungal strain of *Paecilomyces lilacinus* grown in conventional solid-state fermentation medium under controlled conditions for development of viable alternative technology for pre-tanning process using enzymes. The resulting mass is dried and pulverised. The proteolytic enzyme is extracted by solvent extraction method. The enzyme is water soluble and hence finds wider application in various aqueous based processing industries. The study concludes that the enzyme has potential application as soaking agent, depilant as well as bates in tanning industry.

Less salt curing system

The CSIR-CLRI technology provides an option to replace a substantial amount of salt with other

agents like boric acid, biocide for the purpose of curing of raw hides and skins. Whereas the enormous amount of salt (about 40% on raw weight) used in conventional method of curing contributes to a large extent for the environmental pollution relating to Total Dissolved Solids (TDS), this technology does not employ more than 5% salt, thereby providing an eco-benign method for curing of raw hides and skins. The process has been investigated using goatskins. It has been found effective in field testing, carried out in one of the tanneries.

Lime free fibre opening

The technology developed by CSIR-CLRI relates to the use of bio-product in order to avoid lime, which is conventionally used for the purpose of fibre opening of pelts. When coupled with lime free unhairing, this technology offers possibilities of direct pickling without resorting to deliming after fleshing. The technology has been found to be effective for all the substrates – cow, buffalo, goat, sheep. Finished leathers processed through such fibre opening technique were found to be comparable with conventionally processed leathers in all aspects.

Ammonia free delimiting of skins/hides

The process developed by CSIR-CLRI is an eco-friendly option for delimiting of hides/skins which involves passing carbon-di-oxide while agitating the delimiting bath, at a temperature of 30-34°C. The process has enormous potential, especially in view of the emerging stringent regulation in certain countries against the use of ammonium salt, which is conventionally used for the purpose of delimiting.

Microbial enzymes for hair removal– zero emission initiative

CSIR-IICB has produced proteases from the fungus *Termitomyces clypeatus* to analyze degradation of proteinaceous materials (and other relevant components) in wastes generated at different steps in leather processing. The unhairing efficacy of the proteases in culture medium (without purification) has been successfully tested also at CSIR-CLRI.

Process for making high strength proppants

Oil exploring companies use high strength proppants in fracturing operations, among other. The process of making high strength proppants is not available in India and hence proppants are imported to meet the country's requirement. CSIR-NEIST developed a process for making high strength proppants utilizing native raw material like Bauxite which is abundantly available in India. The proppants thus produced, conform to American Petroleum Institute (API) specifications.

In an important milestone in the project, a regular diesel (Tavera) vehicle under full load condition was successfully test-driven on B20 biodiesel prepared from mats of microalgae found growing naturally in the west coast of India. The demonstration has established the road-worthiness of microalgal biodiesel.

1.3 ENGINEERING SCIENCES CLUSTER

CNM5 from CSIR-NAL and Mahindra Aerospace

Designed and developed through a public-private partnership in civil aircraft, the CNM5 is a 5-seater all-metal aircraft. The aircraft was test flown first in the first week of September, 2011 and then had subsequent successful test flights. It is powered by a Lycoming IO-540 engine and features non-retractable landing gear and a spacious cabin with large access door. The cabin interior is reconfigurable to adapt the aircraft to different roles, while simplicity of systems and ease of maintenance are design drivers throughout the aircraft. The CNM5, a light utility aircraft, is designed to meet the latest global standards, while operating in environments with limited infrastructure at extremely low costs per seat mile.

Regional Transport Aircraft (90-seater)

For National Civil Aircraft Development (NCAD) programme, CSIR has prepared a Feasibility Report which provides road map for development of a 90-seater turbo fan configuration aircraft. The NCAD programme will have two phases: design

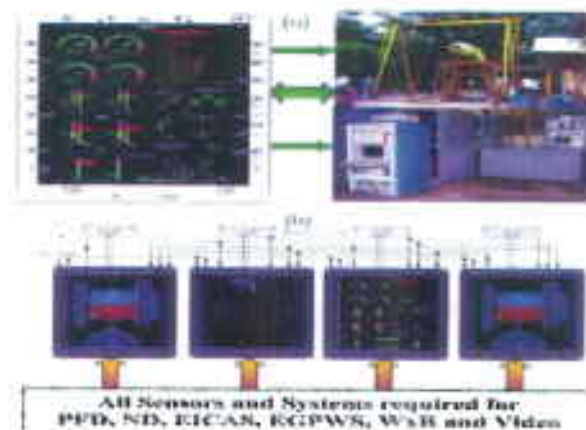
& development and manufacturing. It is envisaged to involve private sector industry in both the phases. CSIR proposes to take up NCAD program as a mega national project in 12th Five Year Plan.

Autonomous Underwater Vehicle (AUV)

July 17, 2011 was a historic day for CSIR when, deep into the heart of the Bay of Bengal, buffeted by a choppy sea amidst inclement weather, the AUV-150 – an Autonomous Underwater Vehicle designed and developed by CSIR-CMERI, Durgapur with inputs from the IIT- Kharagpur – literally plumbed a sea depth of 150 m within its estimated mission time. This event marked the end of a protracted effort for obtaining self-sufficiency in the design development underwater robotic systems, for which the country had to depend solely on foreign sources. Courtesy CSIR-CMERI, Durgapur, India now has the wherewithal of manufacturing its own functional Automated Underwater Vehicles. The successful sea trial of AUV-150 marked a momentous entry into the annals of robotic research in India and marked the beginning of a more ambitious underwater robotic programme for venturing to 3000 m of ocean depth, to be taken up during the 12th Five Year Plan period.

Vision navigation system

CSIR-NAL demonstrated expertise in the field of electronics, system and software engineering

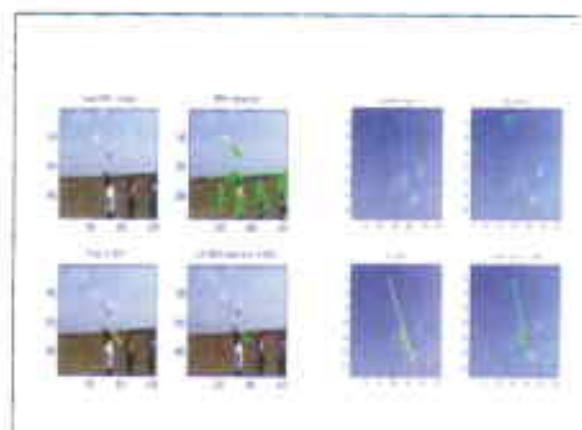


(a) Successful integration on the engine part of EGR
(b) Complete avionics display system

including certification standards like DO160, DO254, DO178, electromagnetic for aerospace applications and signal processing. During the year, the Engine Instruments and Crew Alerting System (EICAS), designed and developed for SARAS, successfully completed its Test-Readiness Review and obtained clearance by the expert committee constituted by DGCA for its integration with the aircraft (Figure 1.28) Phase-I of CSIR-NAL-Boeing Collaborative Electromagnetic (EM) projects, certification of frequency selective surfaces (FSS)-characterization system, and EM material characterization system have also completed successfully. An engineering model of an active noise control system for the Tejas Pilot Helmet has been developed and demonstrated at laboratory level.

Two-Kg class Fixed Wing Mini UAV (FWMUAV)

CSIR-NAL in association with DRDO-ADE jointly developed a “Two-Kg Class Fixed Wing Mini Unmanned Air Vehicle” (FWMUAV) for specific user application. This fully autonomous mini UAV would have a range of ten km, an endurance of sixty minutes and provide real-time video surveillance by day-light electro-optic and thermal imaging sensor. A sign of the confidence and maturity of this technology at CSIR- NAL is that, a full composite airframe for the prototype Sly bird mini UAV was quickly developed as shown below. Although Sly bird mini UAV was



MAV tracking and localisation of the hand launched NAL MAV

Fig. 1.28.



Fig. 1.29. Prototype of Stybird Mini UAV

designed to fly in high-altitude conditions (14,000 ft), preliminary flight tests conducted at sea level and at 3,000 ft altitude demonstrated very encouraging flight performance of the UAV.

Pulse Jet Engine Technology

CSIR-NAL successfully demonstrated pulsejet engine as a possible propulsion system for MAV for both valved and valve-less engines at higher scales with hydrogen as the fuel. Scaling of the engine was made for both the engines types. Detailed measurement of unsteady pressure and thrust were carried out to understand the flow physics. A thrust stand was specially designed and made to quantify the thrust developed by the engines. A suitable air frame was designed, fabricated and successfully test flown with an in-house developed valved pulsejet engine.



Fig. 1.30. MAV test flight with Pulsejet engine

Density field measurements of a micro-explosion using background oriented schlieren (BOS) technique

An attempt to quantify the density flow field of a micro-explosion for the first time using BOS was carried out at CSIR-NAL. In this study, a micro-explosion was generated using non-electrical NONEL® tube and a detonating device. The spatio-temporally evolving density field was captured by precise triggering circuit used to control the illumination and imaging. Using the axis symmetry the flow density field was successfully reconstructed. The study shows the enormous potential of BOS data for both density as well as validation of CFD models.

Boundary-layer transition induced by free-stream turbulence

Boundary-layer transition at different free-stream turbulence levels has been investigated by CSIR-NAL using the particle-image velocimetry technique. The measurements by show organized positive and negative fluctuations of the stream-wise fluctuating velocity component, which resemble the forward and backward jet-like structures reported in the direct numerical simulation of bypass transition. The similarity in the dominant eigen functions at different Reynolds numbers suggests that the flow prevails its structural identity even in intermittent flows. This analysis also indicated the possibility of the existence of a spatio-temporal symmetry associated with a travelling wave in the flow.

Wankel Engine - powered unmanned air vehicle (UAV)

Four core proto-type 55 hp Wankel engines running at 8000 rpm delivering a thrust of around 90 kgf were designed and fabricated by CSIR-NAL for the NISHANT unmanned air vehicle of ADE/VRDE. Suitable modifications were incorporated into the earlier prototypes based on the experiences gained from their testing. The Wankel engine successfully completed around six hours of NISHANT mission profile endurance testing on the ground. The engine was tested for around 45



Fig. 1.31. First-ever indigenous Wankel engine on the Nishant Launcher (Inset, Wankel engine)

min on the NISHANT launcher before the actual flight at Kolar.

Structural Health Monitoring Activities

Structural Health Monitoring (SHM) technology has become increasingly important as an approach to increase the safety and reduce the maintenance costs of aircraft structures. The key to an effective SHM system for aircraft structures is not only the appropriate sensor selection but also the processing of the sensor data to predict the flight load and the damages in the structure. CSIR-NAL, DRDO_ADE and IMOD (Israeli Ministry of Defense) jointly conducted flight trials on UAV Nishant on October 28, 2010 in Kolar Airfield, Karnataka, in which the SHM technological of CSIR-NAL using fibre optic sensors was successfully demonstrated. The SHM system consists of the FBG sensor instrumentation comprising of FBG interrogator, on-board rugged computer and battery. Initial analysis of the In-flight data acquired indicates that the system has worked very well and all the important maneuvers have been successfully captured by the embedded

FBG sensors during the flight. This is indeed a historic moment as this is probably the first flight trial of an SHM system on an UAV anywhere.

Smart fatigue meter

Smart fatigue meter developed by CSIR-NAL is being used in Jaguar aircraft; eight units have been supplied to IAF through private industry collaboration.



Fig. 1.33. Smart Fatigue meter used in aircraft to sense changes in 'g' levels

Mark-III Autoclave

CSIR-NAL has designed, developed and commissioned the state-of-the-art indigenous computer controlled high pressure and high temperature autoclave (Mark III). Several innovative features have been incorporated in the autoclave and its systems to meet the stringent requirements of high pressure and high temperature. It has working dimensions of 2 m diameter, 4 m length, operating conditions of 350°C temperature and 15 bar pressure. It can be used for development of high temperature composite structural components like the rear fuselage of fighter aircrafts, engine components. So far the autoclaves have been imported from abroad; the indigenous development of autoclave will pave



Fig. 1.32. FBG Sensor and SHM system assembled in Nishant UAV; Right, Nishant in flight

way for manufacturing high end autoclaves in the country.

Helping India to build a modern fighter aircraft

It is the endeavour of CSIR-NAL to support the national strategic sector programmes in a big way. The National Control Law Team led by CSIR-NAL continued to play a pre-eminent role in the activities leading to the Initial Operational Clearance (IOC) of the LCA Tejas air force variants. The achievements of the year include successful validation and update of the wind tunnel aero database of Tejas aircraft from flight test data using sophisticated system identification techniques, release of the IOC-version of flight control laws and air data system algorithms. It was a proud moment, indeed, for all the institutions and CSIR-NAL and its scientists associated with the Tejas programme when the Defense Minister formally announced induction of Tejas into the IAF on the completion of IOC during the year.

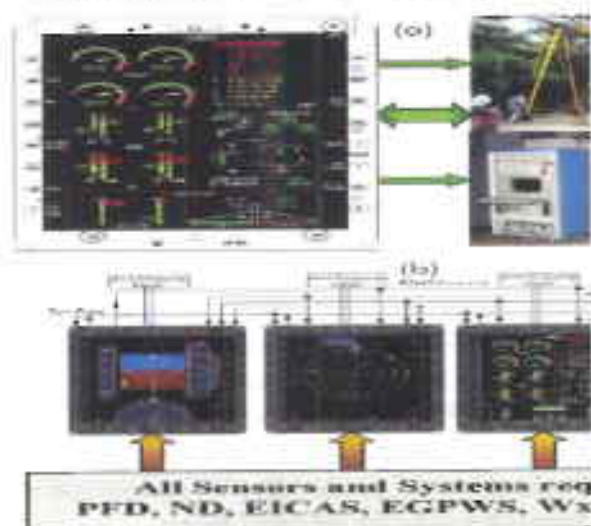


Fig. 1.34. Successful integration tests on the engine for EGR and complete avionics display system

Airport Instrumentation

For the first time in the country, a thirty-metre baseline DRISHTI-II Chopper-less model was installed at the Lucknow Airport in November 2010 to measure runway visibility under foggy conditions. The visibility data obtained from Drishti during the fog season of December 2010

and January 2011 were compared by CSIR-NAL with the data obtained from manual observations by counting runway lights; the comparison was found to be excellent. Presently, DRISHTI data is being used by the Air Traffic Control authorities for operational purposes. Under an MoU with IMD three more DRISHTI-II systems were supplied to IMD, and have been installed at IGI Airport at New Delhi for further evaluation.

Processing of titanium foam for structural applications

Ti foam has been synthesized by CSIR-AMPRI, employing powder metallurgy route. Irregular titanium powder particles were used as the matrix and urea particles as the space holder. Pore morphology and compressive behaviour of the resulting foam have been studied. The pores were elongated (acicular) type with a size up to 500 μm . The foam delineated a distinct plateau region suggesting an energy absorption capacity of up to 55 MJ / m^2 and compressive strength of 275 MPa. It has potential for application in aerospace and naval industries.

Copper-based shape memory alloy for high temperature applications

Cu-Al-Ni-Ti shape memory alloy was prepared by CSIR-AMPRI through mechanical alloying of the elemental powders at different ball-to-powder weight ratios (BPR) for varying durations in an Attritor Mill. Microscopic and XRD studies confirmed the presence of self accommodated martensitic structure [β (18R) and β (2H) phases] which is essential for the realization of shape memory effect. The shape memory tests showed 100% recovery after 25 thermomechanical cycles at 2% pre-strain level. Efforts are underway to process the sintered compacts in the form of strip using secondary mechanical working processes. The strip produced can be useful for applications such as fasteners, couplings, dampers and electric circuit breaker.

Metal Foam

Al foam filled channels were made and joined in the shape of a bracket (1751X428X625 mm^3) for

carrying out the inverters and batters in hybrid buses. The bracket is under performance evaluation in real work environment for noise and vibration attenuation.

Geotechnical Studies carried out for removal of loose boulders and stabilization of Ajanta caves

The Ajanta caves have suffered consequences and ill effects of water seepage over a very long period as a result of which damage to the ancient cave painting has been caused. Besides such damage to invaluable art, the seepage has also weakened structural integrity of the rock mass in which the caves are located. Ensuing CSIR-CIMFR study has revealed that basalt rock type present in the area appears to be competent enough from stability point of view. The scientific investigation, based



Fig. 1.35. A photographic view of the Ajanta Caves

on GPR survey, seismic profiling study, numerical modelling and geo-hydrological assessment has provided solutions for treatment measures. The solutions provided also include stability assessment of accessible cave structures and slopes in which they are housed. For the precariously loose boulder's treatment and water seepage related problems, the pointed out control measures/management measures are tailor-made and spot-wise.

Assessment of mining induced stress development during underground coal pillar extraction

Considering the importance of empirical approach and nature and amount of stress redistribution for underground coal mining, systematic field and laboratory studies conducted by CSIR-CIMFR to assess strata equilibrium dynamics around depillaring faces. Observed variations of mining



Fig. 1.36. Installation of a vibrating wire stress meter in a horizontally drilled hole

induced stress (vertical) over pillars, standing in and around the depillaring panels of different Indian coal mines, did not exactly fit to any reported model. The obtained results were divided into two parts as per depth of cover. It was found that depth of cover and characteristics of roof rock strata are vital parameters, which influence the value and range of mining induced stress. Statistical analysis of observed stress data provided improved empirical models for ultimate value of mining induced stress. The developed models of mining induced stress are being used for optimization of site specific SSR design, effective design of the natural support, improvement in confinement of the reinforcement ahead of the face and understanding the nature of rock mass.

Investigation of cavability of overlying strata and development of guidelines for estimation of support capacity for longwall faces

CSIR-CIMFR developed an integrated approach for assessment of caving behaviour, selection of the capacity of powered support and formulation of a strata and support behaviour monitoring scheme for successful longwall operation in Indian coal mines. Comprehensive geotechnical investigations were conducted and a scientific parameter, namely, Equivalent Main Fall Span has been evolved to develop a standard methodology for categorization of roof rock. Guidelines have been developed, based on numerical modelling

approaches, for proper assessment of cavability of overlying roof rocks and estimation of support capacity of powered support. Standard techniques for continuous strata behaviour and support performance monitoring have also been evolved using state-of-the-art instrumentation like data logger system and microseismic monitoring system. The study provided a total solution of strata control planning and selection of appropriate best equipment in longwall mining and its potential application to take up the challenging task of future planning of longwall workings in India.

Road and railway traffic induced vibration on the UNESCO heritage structures of Salimgarh Fort Complex, New Delhi

The old Railway Bridge connecting Shahdara to old Delhi Railway Station is nearly 140 years old. This bridge is a vital link connecting Delhi Main Station and the Eastern part of the country. Railways has planned to build a new bridge 30m away and parallel to the existing bridge and thus the connection from the new bridge to the existing railway line requires realignment of the railway line passing through Salimgarh Fort. Red Fort and Salimgarh Fort have been inscribed in the World Heritage list of UNESCO. As a part of Cultural Heritage Impact Assessment for Archaeological Survey of India (ASI) and Indian Railways, CSIR-CIMFR evaluated the impact of the proposed realignment of railway track in Salimgarh Fort on the built heritage and the archaeological remains of the World Heritage Site of Red Fort.

Institute carried out vibration study to assess the effect of vibrations generated by the traffic from

the adjacent railway line and surrounding road network on heritage structures of Salimgarh Fort. A mathematical model was developed using the recorded vibration to extrapolate the vibration due to proposed railway lines. The maximum peak particle velocity found in any of the structures of the Salimgarh fort remained well below 5.00 mm/s. Peak particle velocity of vibration induced by the traffic adjacent to Salimgarh fort complex was well below the recommended safe level as per international standards for continuous vibration. It is concluded that the damage potential of the vibration induced by existing railway and road traffic is insignificant.

Landslide monitoring and remedial measures of a potential landslide slope on Rishikesh-Uttarkashi Road

An unstable slope situated at Agrakhal along Rishikesh – Uttarkashi highway (NH 94) having few houses, which were under distress, was studied by CSIR-CBRI to arrive at suitable control measures. The slope has undergone subsidence at the road level and there are few houses down the road level which have developed major cracks.

Slope Monitoring: There are six houses on the slope which have shown distress manifested by development of cracks on the walls and floor subsidence. A monitoring scheme was planned to monitor the horizontal and vertical movements of these houses using Total station from a far distance outside the unstable zone. Fixed points were installed as observation points on roof top of the six houses. A stable zone based on field observation was identified at a distance of 800 m from the unstable slope. The reference point was made at this location from where all the observation points could be seen without any hindrance. The movement data were collected for the period August 2009 to March 2011. The horizontal and vertical movements of the observation points were calculated from the periodic monitoring data. An automatic rain gauge was installed at the site to collect rainfall data which shows that in the monsoon period of 2009, the maximum rainfall was only 232 mm in the month of September. While in the year 2010 there was a heavy rainfall during July to Sept. and rainfall of 950 mm was recorded for the month of July only.



Fig. 1.37. Experimental set up at Salimgarh Fort

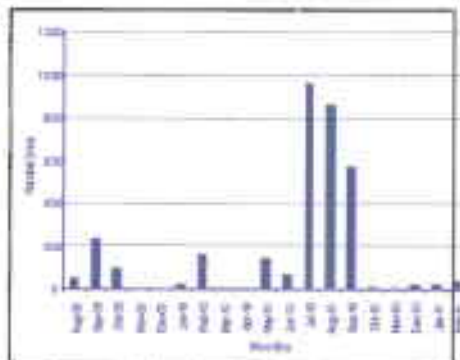
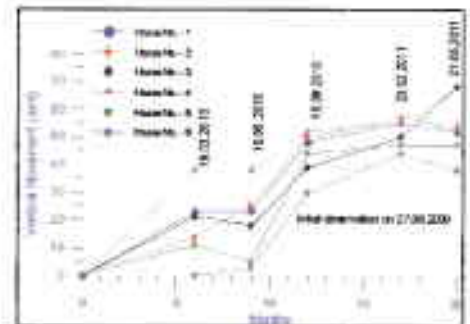
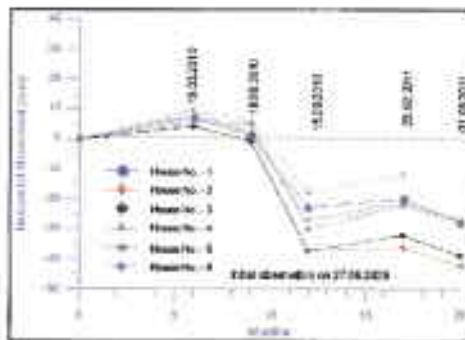
The movement monitoring data of the last two years has shown a cumulative vertical movement of 38-68 mm and cumulative horizontal movement of 20 to 40 mm. The monitoring study is being continued to assess the vulnerability of these houses against the slope instability.

Control Measures: A detailed geological and geotechnical study was carried out to arrive at a suitable control measures. Since the prime cause of the slope instability is the sub-surface water seepage and the local geological condition,

drainage measures were suggested. The general observation of the site revealed that the movement of the slope so far observed is mostly restricted during the rainy season; it is felt that proper drainage network is desired to be made to divert the surface flow of water to the central drain through the proposed radial drains. This will reduce the generation of excess pore pressure in the slope and consequently the effect of subsurface saturation manifested as slope movement will also reduce. In nutshell the slope will be stabilised against heavy rainfall at site.



Houses being monitored Horizontal Movement



Monthly rainfall data

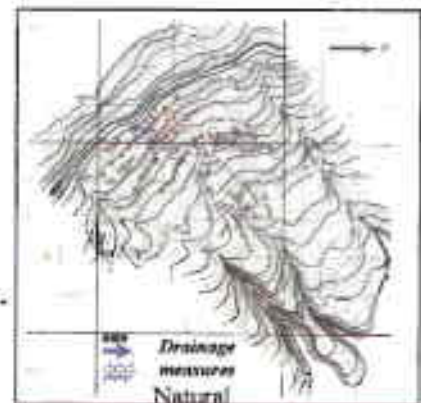


Fig. 1.38. Scheme of suggested control measures

Along with drainage measures few retaining walls were also suggested to provide support at active portion of the slope.

Construction of underpass below rail embankment

For the construction of Ring road Bye-pass from Kashmiri Gate ISBT to ITO, there was a challenge to construct an underpass on the Yamuna Bank under the railway track connecting Delhi Junction and Ghaziabad. It is a very busy rail track where

trains including passenger and goods train are continuously plying. It was not possible to stop the rail movement even for one hour. CSIR-CRRI applied soil nailing technique to build underpass at the embankment of Rail-road bridge without disturbing either the rail traffic or the road traffic. It is a part of Ring Road By-pass (from ISBT to ITO). They constructed concrete boxes and using soil nailing technique pushed the boxes underneath the railway track. The road is operational now. Following photographs present a glimpse of the technique.



Steel Truss Bridge Over Yamuna River



Top View of Railway Track



Train Movement on Completed Underpass



Inside View of the Box during Pushing



Finished Road Underpass

Fig. I.39. Various stages of Construction of Underpass

GIS based National Highway Information System

CSIR-CRRI developed a GIS-based software through which data management system can be established. The software includes various highway information as sub-modules viz., (i) Locational Referencing, (ii) Pavement Construction and Maintenance History, (iii) Pavement Inventory, (iv) Pavement Condition (v) Pavement Geometry, (vi) Pavement Crust and Strength details (vii) Environmental Condition, (viii) Traffic and Vehicle Information, (ix) Cross-rainage details and (x) Integration with HDM-4 software. There are three categories of users who can access the Web based NHIS application viz., Administrators, Engineers and Normal user. Desktop based NHIS application helps the user to have a control over the database and enable to perform all sorts of modifications and further analysis. About 40000 km of DGPS spatial data along with primary data collected using road Network Survey Vehicle has been incorporated in the software and provided to the Ministry.

Performance evaluation of rigid pavements on high density traffic corridors

CSIR-CRRI validated and verified the actual relationships between various design parameters



Fig. 1.40. Web-shot of National highway Information System developed by CSIR-CRRI

assumed in theoretical design and those actually observed under the rigid pavements. The results of the study are to be used for furthering the actual design consideration and incorporating modifications in the design- methodology to be used in future.

Response of concrete pavement slabs to environmental and traffic loadings were captured through instrumentation at Allahabad by-pass on NH-2; Kota, Rajasthan, on NH-76 and Siliguri, West Bengal, on NH-3. The sensors, embedded into the concrete pavement slabs during construction, included Vibrating Wire (0/W) type temperature sensors and strain gages, VW joint meters, and resistance type dynamic strain gages. VW temperature sensors measured temperature



Sensors Embedded in Concrete Pavement



Load Testing of Instrumented Pavement

Fig: 1.41

within the concrete slabs at various depths. VW strain gages measured the strain induced at different depths due to the temperature. Joint meters installed at transverse joints measured the amount of movement due to expansion and contraction at joints. Resistance type strain gages measured the strains induced within the concrete due to vehicle axle loads under dynamic conditions. Tests were conducted under road traffic to measure the strains induced at non-tied and tied edges at different speed of trucks with different axle loads. The analysis of the data led to the following major conclusions:

- Measured curling stresses significantly less than the theoretical stresses;
- Load induced edge stresses much less than the theoretically calculated stresses; and
- Tied shoulders and tie bars at longitudinal joint reduces edge load stresses considerably

Functionalised adsorbents and biopolymers for arsenic removal

CSIR-NEERI developed functionalized materials based on zeolites, mixed oxide, activated alumina and carbons. These materials have been screened for removal of arsenic. Out of 21 materials, 4 materials, namely copper oxide incorporated alumina, copper incorporated zeolite, iron manganese mixed oxide and biopolymer based iron composite were selected for detailed studies. The arsenic contaminated water from arsenic affected areas of West Bengal was collected

and these materials were evaluated for arsenic removal using this water. The newly developed materials overcome limitations of conventional materials particularly low capacity for As(III), narrow pH working range etc. The treated water quality conforms to BIS 10500 for drinking water quality. One of the materials, CuO-Alumina, can remove multiple pollutants, namely As, F and Cr. The work related to designing and development of household filter based on these materials is in progress.

Molecularly imprinted polymers

CSIR-NEERI developed molecularly imprinted polymers (MIPs) by co-polymerization of a cross-linking agent with the complex formed from a template and polymerizable monomers that have functional groups specifically interacting with the template through covalent or non-covalent bonds. After the template is removed from the resulting polymer matrix, binding sites having the size and shape complimentary to the template are generated. These MIPs contain "tailor-made" binding sites for a template and interact with the template. Therefore, MIPs have been utilized in variety of applications in separations and analytical chemistry. MIP-based solid phase extraction (SPE) has been demonstrated in a number of proof concept studies and applied to pre-concentration of environmental samples. Molecularly imprinted polyurethanes were used as sensitive coating for detection of polycyclic aromatic hydrocarbons (PAHs) to the ppt (parts per trillion) range with hardly any matrix effect by humic acid. The double



Fig. 1.42. SEM and TEM of CuO incorporated alumina

molecular imprinting has been applied to prepare MIPs for PAHs detection in water. Measurements of PAHs in water were performed with quartz crystal microbalance which shows that humic acid interference is not found and hence fluorescence property of MIP had no change. The resulting MIPs for PAHs were evaluated for repeated removal of PAHs from spiked groundwater simulating contaminated water. The MIP reuse potential in this study further demonstrated the material cost-effectiveness when compared with commercial activated carbon.

Transmission line towers

CSIR-SERC conducted tests on the complete spectrum of semi-rigid connections, namely endplate connection, single web angle, double web angle, top seat-angle with and without web angles connections under static loading to study the connection characteristics. A simplified design approach using the provisions of IS: 800 (2007) was evolved for endplate connection. The results were used to evaluate the frye-morris model which is suggested in IS:800 (2007). Using the test results and the parametric studies carried out, an improved model is proposed for the endplate, double web angle and top seat angle connection. The provision for tension member design in the revised IS: 800 (2007) was evaluated by conducting test on steel tension specimens.

Remote structural health monitoring (RSHM) of civil structures

RSHM technology CSIR-SERC developed for long-term monitoring of civil structures for the first time in India and one of the very few available internationally. Salient features of the RSHM technology developed are: Simultaneous monitoring of a number of structures geographically located at different places; A versatile platform to acquire data from assorted sensors / integrate different data acquisition units; Global System for Mobile Communications (GSM) network, Public Switched Telephone Network (PSTN) and Radio Frequency (RF) are used to remotely transfer data from the instrumented structure to the monitoring station;

operate in any mode of communication, i.e. RF/PSTN/GSM, send alarm messages (SMS) in case of any abnormal event, integration with other data acquisition devices, and data synthesis/reduction to reduce data transmission load

Performance evaluation studies on a full-scale composite antenna cabin prototype

Performance evaluation studies on a full-scale 'Composite Antenna Cabin Prototype' under extreme shock loads. CSIR-SERC carried out in the three orthogonal directions namely vertical, horizontal and longitudinal for the first time in the world using a newly developed experimental facility. The shock loading adopted in the vertical direction consisted of applying a specific number of half sine shock pulses of 25g magnitude and 6 milli-second duration. Similarly, the shock loading adopted in the horizontal and longitudinal



Fig. 1.43. Vertical Shock Test Fixture Layout

directions consisted of applying a specific number of half-sine shock pulse of 12g magnitude and 6 milli-second duration. Instrumentation consisted of accelerometers and strain gauges and the displacements were captured using a high speed motion camera and processed by image processing software.

Dynamic stability of spent fuel trays under seismic excitations

CSIR-SERC evaluated the Seismic performance of spent fuel tray assemblies. Seismic stability of the trays stack cannot be easily evaluated through finite element analysis, due to the various imperfections like friction and slip and other non-linearities in the system. Hence shake table testing is considered to be the best alternative for evaluating the seismic stability.

Performance of LRC storage structure in actual field trials

CSIR-SERC developed Laced reinforced concrete (LRC) as an alternative blast resistant construction material. LRC is found to possess high rotational capacity as high as 4° support rotation and maintain structural integrity even at large deformation. Blast resistant design procedure for large capacity LRC storage structures based on unit risk principle has been evolved. The design recommended by CSIR-SERC is unique and has been proved successful through field blast trials conducted on explosive storage structures. Instrumentation and

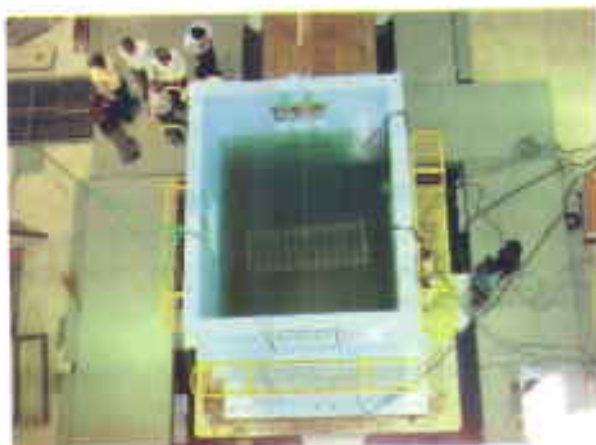


Fig. 1.44. Top view of the Spent fuel tank test model on shake table



Fig. 1.45. LRC wall in field trial

measurement during the blast trials has been carried out and the explosive storage structure survived the blast and is found to be reusable. Design knowledge has been transferred to CFEEs (DRDO) as type design. While storing explosives, the separation distance between two adjacent LRC structures has been reduced from existing requirement of $2.4W^{1/3}$ (in metres, W is the charge weight in kg) to $0.7W^{1/3}$. This reduces the land requirement for such construction and also results in efficiency in operation.

Use of mono-pole structures for transmission lines

Analytical & experimental studies conducted to study structural behavior of Mono-poles for



Fig. 1.46a. Experimental Tower erected at Test Bed



Fig. 1.46b. Bajaj Lighting Pole

maximum foundation bolt force, stress concentration at openings & buckling of base plate stiffener. Based on the R&D studies carried out, Bureau of Indian Standards (BIS) entrusted to CSIR-SERC for developing "BIS Code of Practice for Mono-Poles".

Simulating the response of cracked structures during Seismic loading

Safe guarding critical engineering components against natural catastrophe such as seismic events are of paramount engineering importance. Even though the structural integrity for the normal operating conditions is generally fulfilled, some of the material behavior, for example, the fracture resistance, can be drastically altered due to the large load excursions during the earthquake. The design codes now-a-days thus mandate establishing the fracture response of materials used in critical components under seismic loading

conditions to ensure safety. However, standard test procedures/methodologies are not available for conducting such experiments.

Following the international trend in this area and to obtain engineering consensus, CSIR-NML evolved a method in which specimen level fracture behavior of materials can be studied by varying the amplitude and frequency of load excursions. The method has been successfully tested in a variety of materials used in primary heat transport piping and pressure vessels employed in Indian nuclear power plants. The material data thus generated are being used by the Indian nuclear industry for their design and safety verification practices such as leak-before break design codes. The fracture resistance is generally noted to be drastically decreased due to load excursions. Crack tip re-sharpening due to load reversals is one of the primary reasons for this behavior.

Slurry infiltrated fibrous concrete (SIFCON) design for use in underground reinforced hardened shelters

SIFCON structural elements possess better properties as compared to their counterparts built using conventional reinforced concrete. Construction of underground hardened shelter requires prefabrication of various structural components at factory for better quality control. For transporting these structural components to the required site, weight of each element is a major concern. Normal RCC construction requires larger thickness and highly congested reinforcement to resist the blast loading. The study was carried out by CSIR-SERC to throw more light on the design and construction aspects of underground reinforced hardened shelters, using SIFCON. It was found that use of SIFCON material resulted in complete elimination of rebar and also in significant reduction in the thickness of the shell for construction of underground reinforced hardened shelter.

Seismic performance evaluation of chimney and cooling tower

Elasto plastic dynamic analysis of chimney and cooling tower subjected to seismic load have been

carried out by CSIR-SERC. Appropriate procedures have been developed for carrying out seismic performance evaluation of chimney and cooling tower. Guidelines have been developed for wind induced magnification factor due to interference between two chimneys.

Wireless communication systems for underground mines using RFID based sensor network

Underground mines require fool-proof mine-wide communication systems for smooth functioning of mine workings and ensuring better safety. Proper and reliable communication systems not only save machine break-down time but also help in immediate passing of messages from the vicinity of underground working areas to the surface for day-to-day normal mining operations as well as for speedy rescue operations in case of disaster. CSIR-CIMFR developed following wireless communication systems using Radio Frequency IDentification (RFID) devices: (i) Miners' tracking system, (ii) Proximity warning device for heavy earth moving machinery, (iii) System for preventing vehicle collisions, (iv) Route tracing system for opencast transport vehicles, (v) System for providing warning signals when miner entering unsafe area, (vi) Underground gas monitoring system, and (vii) Message communication system for underground mines. The core system component is ZigBee-compliant active RFID devices working on 2.4 GHz Industrial, Scientific and Medical (ISM) band. The devices can be programmed to act as coordinator, router, end

device/tag, gas monitoring device and messaging device. Coordinator, router and end devices form an IEEE 802.15.4-based dynamic wireless mesh network using the developed resident hardware specific embedded software. It uses a unified wireless mesh networking infrastructure to locate, trace and manage mobile assets and people as well as monitor different environmental conditions using sensor. The system has been tested and certified for its Intrinsic Safety (IS) compliance. Successful field trial of the system has been conducted at Churi underground mine of Central Coalfield Limited.

Radar imaging to develop an enhanced fog vision system for collision avoidance

Developing an enhanced fog vision system with radio wave to improvise the way outs of severe problems is really a big challenge for researcher. According to Rayleigh scattering Law, direct wave RF signal have high chance of failure to work in such weather for detection of any object. Therefore suitable region in the RF band that can help in detecting objects with proper shape was required. In order to understand the weather effect on radio frequencies for different ranges, analytical & experimental studies were conducted at CSIR-CMERI for object detection using 912 MHz band with successful detection of the persistence of any object coming under the trajectory of a vehicle navigating in indoor and outdoor environment. The developed images are finally transformed to video signal to enable continuous monitoring.



Fig. 1.47. (A) Coordinator; (B) Router/End Device; (C) Gas Monitoring Sensor and (D) Messaging Device with enclosure

Serpentine robot

CSIR-CMERI designed and developed two prototype Serpentine robots. It can slide, glide and slither and could be used in many applications like exploration of hazardous environments, inspection and medical interventions.



Fig. 1.48. Serpentine robot

Outdoor Mobile Robot (OMR)

A prototype outdoor mobile robot with tracked configuration has been designed and developed by CSIR-CMERI. The prototype designed is primarily a caterpillar type and can be interchangeable to wheeled configuration. Graphite brushed motor is used in the development with a tracked belt transmission. Double sided timer belts are used as tracks. These tracks are guided by flanged timing pulleys.



Fig. 1.49. Outdoor Mobile Robot

Vision guided mobile robotic system

Yet another contribution from CSIR-CMERI i.e. design and development of vision guided mobile robotic system equipped with stereo vision system and Laser range finder. The environmental data acquired by the sensors will be processed by the on board computer. The robot is capable of navigating in specific area for searching of hazardous material. During this searching it will navigate and develop the map of the surrounding simultaneously. For the subsequent search missions the developed maps may be used for map based navigation purpose. The operator can interact with the robotic system with the help of a remote computer, which is connected to the autonomous vehicle by wireless LAN.

Braille character recognition using generalized feature vector approach

A technique has been developed by CSIR-CMERI for vision based braille printout quality assessment system. A generalized feature vector approach is used to extract the braille dots from the digital braille print, which is further utilized to measure the dot spacings for examining the printing quality. This helps in providing the necessary feedback to the design team so that they can improve the printer prototypes accordingly. A simple but elegant approach to convert the braille code to running text using single sided and interpoint Braille print is also proposed. It can also be utilized in regenerating braille print from existing ones.

Reconfigurable micro factory test bed

The Micro factory has been designed to perform four operations: μ -milling, μ -turning, μ -EDM and μ -laser ablation. The test bed consists of four workstations; each workstation is built-in with 3-axis translation features. The z-axis is used for feeding tool/energy sources. The translation stages have been mounted on semi-kinematics links to minimize the ramp-up-time for reconfiguration of this micro factory for different part families. The feature based methodology for process sequencing and operation clustering has been developed in-house to design appropriate reconfiguration planes



Fig. 1.50. Reconfigurable micro factory test bed

using micro factory for different product mix. The key aspects of the new development include design modularity, multi-operational capabilities and desktop micro manufacturing system with 600mm x 600 mm footprint.

Nickel wick for space application

Loop Heat Pipes (LHPs) are used for thermal management of satellites, spacecrafts and many electronic appliances including computer. Wicking structures are the heart of the LHPs and capillary pumped loops (CPL). Wicks, most difficult part of LHP to manufacture and of the highest cost, are being manufactured either by wire meshing or sintering. CSIR-CMERI developed a novel route of wick manufacturing for India's strategic space programme. The 275 mm long tubular nickel wicks

have been developed with in-built vapour removal grooves through the developed inverse metal injection moulding (MIM). Instead of maximizing the density, porosity has been maximized by addition of the polypropylene powder in the feedstock. Porosity, pore diameter and permeability can be controlled by controlling process parameter. The nickel wicks for more than 600W LHPs for space application have been developed with 55 volume % porosity, average 2.6 micron capillary pore diameter, around 20×10^{-12} m² permeability and 9.37W/m.K effective thermal conductivity. The effective thermal conductivity is consistent over a temperature range of -140 to 200 °C.

Synthesis and characterisation of nanosilica and its subsequent use in calcium-silicate-hydrate systems

In the construction sector, nanotechnology is being used in a variety of ways to produce innovative materials. Using nanotechnology as a tool, it is possible to modify the nano/basic structure of the materials to improve the material's bulk properties such as mechanical performance, volume stability, durability and sustainability. Dispersed, spherical particles of nano silica (n-SiO₂) with controllable size have been synthesised by CSIR-CBRI using a metal alkoxide, tetraethoxysilane, as starting material and ammonia as base catalyst by sol-gel method. The particle size of nano silica can be well controlled by adding non-ionic surfactants.



Fig. 1.51. Developed nickel wicks with in-built vapour removal grooves

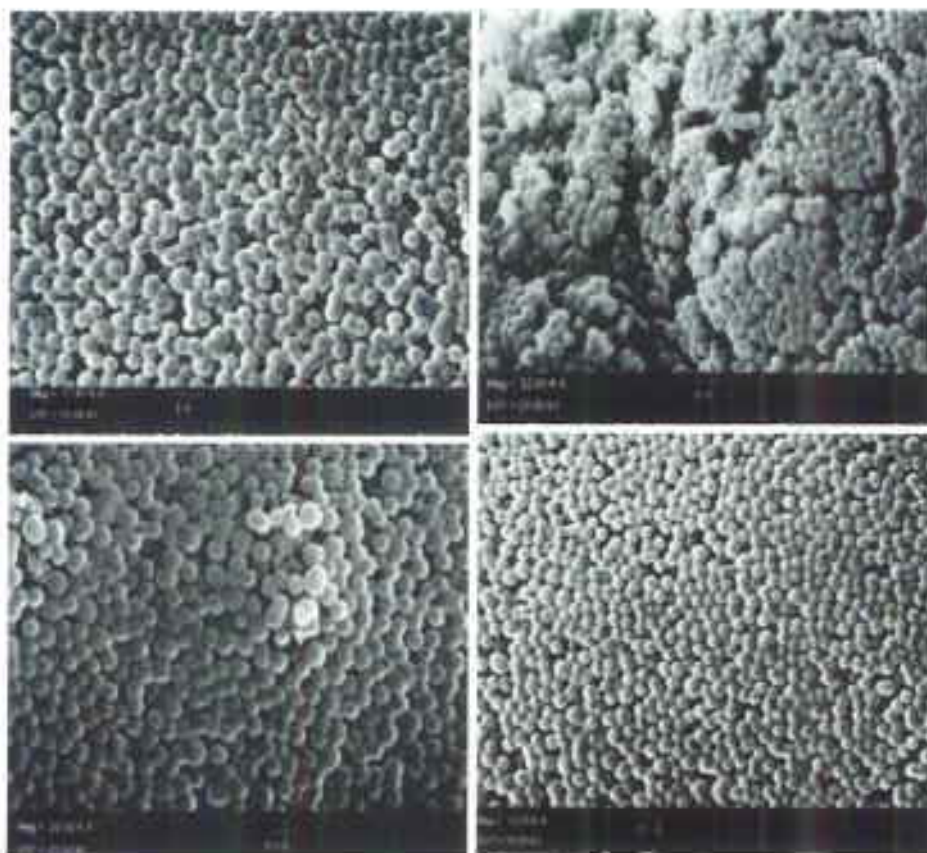


Fig. 1.52. SEM micrograph of n-SiO₂ particles (80-200nm) prepared without surfactant (A), span 20 (B), span 40 (C) and span 60 (D)

Increase in chain length of surfactant resulted in decreasing particle size of silica nano particles.

These nano-particles were incorporated in cement paste for compressive strength and calcium leaching resistant. It was observed from SEM, XRD and TGA studies that addition of n-SiO₂ to cement reduced CH leaching by reacting at early stage of hydration and forming additional C-S-H gel which also enhanced the mechanical strength. It was found that, CH content in n-SiO₂ incorporated cement paste reduced 90% at 1 day and upto 59% at 28 days. Therefore, addition of nanoparticles significantly improves the engineering properties of the cementitious materials.

NiTi shape memory alloys developed

CSIR-NAL developed and fabricated NiTiPt (Ni₃₀Ti₅₀Pt₂₀) and a NiTiPt wire of 263 μm diameter and 5 m length. The NiTiPt HTSMA wire



Fig: 1.53 A typical NiTi Shape Memory Alloys

processed at CSIR-NAL exhibited a high tensile strength of 1380 MPa (cold worked).

Silver nanoparticles synthesized in an aqueous suspension of graphene oxide sheets and its antimicrobial activity

Graphene, a single layer of carbon atoms closely

packed into honeycomb two-dimensional (2D) lattice, has attracted enormous attention recently. CSIR-NEIST synthesized silver (Ag) nanoparticles by chemical reduction of AgNO_3 in a graphene oxide (GrO) suspension. X-ray diffraction and transmission electron microscopy indicate that the Ag nanoparticles, of size range 5–25 nm, were decorated on the GrO sheets. The size and shape of the Ag nanoparticles are dependent on the concentration of the AgNO_3 solution. Antimicrobial activity of such hybrids materials are investigated against the gram negative bacteria *Escherichia coli* and *Pseudomonas aeruginosa*. The bacterial growth kinetics were monitored in nutrient broth supplemented with the Ag nanoparticle–GrO suspension at different conditions. It was observed that *Pseudomonas aeruginosa* is comparatively more sensitive to the Ag nanoparticle–GrO suspension.

Novel synthesis of SiC ceramics from processed cellulosic bio-precursors

CSIR-NEIST synthesized SiC ceramic from processed cellulosic bio-precursor. Bamboo plants (abundantly available in Assam) and Coir fibres (available in Kerala) were used to prepare bio-carbonaceous preforms (carbon templates). Ceramization of carbon templates were done by reactive melt silicon infiltration into porous channels at $\sim 1600^\circ\text{C}$ under vacuum. The final ceramics were adequately dense (%theoretical density > 99%), showed negligible linear dimensional changes (indicating net-dimension formation capability), presence of crystalline Si and SiC phases and duplex microstructure with complete preservation of fibrous architecture of plant bio-structure. The Si/SiC ceramic composite synthesized from coir fiber board gave room temperature 3-point flexural strength and Young's modulus values of 121 MPa and 276 GPa, respectively. Both the ceramic composites showed adequate oxidation resistance during heating at 1300°C for 7 h in air.

Hydrazine-induced room-temperature transformation of CdTe nanoparticles to nanowires

CSIR-NEIST investigated the effect of hydrazine on the photophysical and morphological properties of water-soluble thioglycolic acid-capped cadmium telluride (CdTe) nanoparticles at room temperature. At lower concentrations of hydrazine (0.5 M), a large enhancement in the luminescence of CdTe nanoparticles was observed without any shape change; hydrazine saturates the Cd dangling bonds on the nanoparticles' surface through coordination. Interestingly, highly crystalline CdTe nanowires with hexagonal wurzite structure were obtained at higher concentrations of hydrazine (2.0 M) through the recrystallization of linearly assembled aggregated CdTe nanoparticles with a zinc blend structure. Strong dipole-dipole interaction between the nanoparticles in the presence of hydrazine assists their linear aggregation, and low activation energy for phase transition drives their recrystallization to nanowires. Extremely simple methodology presented opens up novel pathways for the synthesis of one dimensional semiconductor nanostructures at room temperature and provides valuable information about the growth mechanism of *nanowires*.

Nanocrystalline $\text{Li}_4\text{Ti}_5\text{O}_{12}$ as high-rate performance Li-ion battery anode

Novel materials for efficient transport of Li-ions are important for development of electrodes in Li-ion batteries. CSIR-CECRI developed nanocrystalline $\text{Li}_4\text{Ti}_5\text{O}_{12}$ (LTO), which crystallizes into a cubic spinel-phase by single-step-solution-combustion method in less than one minute. LTO particles thus synthesized are flaky and highly porous in nature with a surface area of $12 \text{ m}^2/\text{g}$. During their galvanostatic charge-discharge at varying rates, LTO electrodes yield a capacity value close to the theoretical value of 175 mA h/g at C/2 rate. The electrodes also exhibit promising capacity retention with little capacity loss over 100 cycles at varying discharge rates together with attractive discharge-rate capabilities yielding

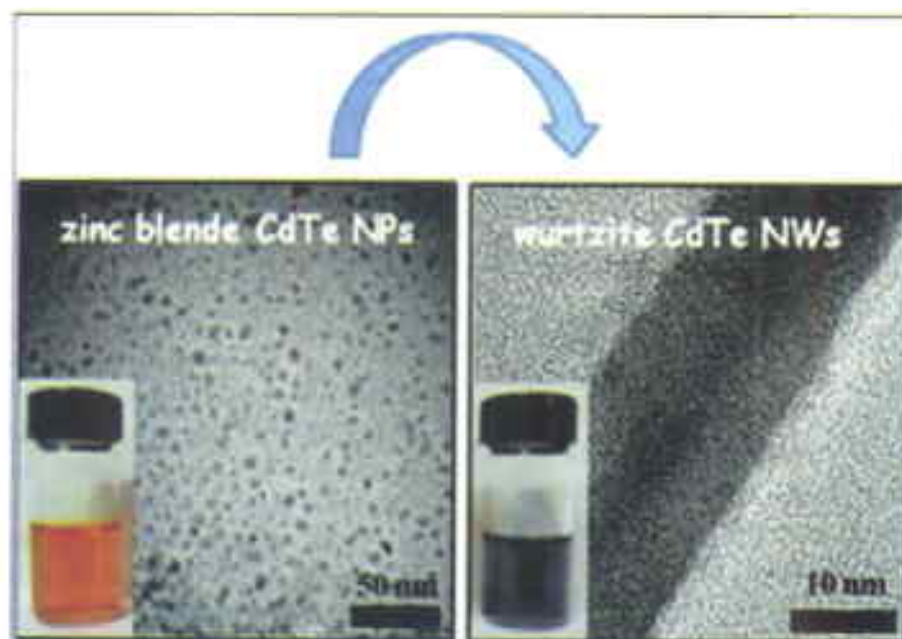


Fig. 1.54. Hydrazine induced 1-D growth at room temperature

capacity values of 140 mA h/g and 70 mA h/g at 10 and 100°C discharge rates, respectively.

Thermal plasma melting of e-waste for recovery of metal values

An innovative process for recovery of metal value from electronic waste material (e-waste) has been developed by CSIR-IMMT using plasma processing. The process obviates the tedious grinding and separation methods of different materials to recover valuable metals from e-waste. Process parameters during plasma melting have been optimized to ensure minimum energy requirement, least environmental pollution and maximum metal recovery. Leaching followed by cementation technique was carried out to enrich the concentrations of Au, Ag and Cu in the recovered metal/alloy.

Fabrication and characterization of amplified piezo actuators

PZT multilayered (ML) stacks of amplified piezo actuators were fabricated by varying processing and geometrical parameters at CSIR-NAL. The actuators were characterized for displacement and block force. A maximum block force of 1427 N was obtained for a sample area of 132 mm². The

maximum displacement was about 0.1 percent of the height of the actuator. Amplified Piezo Actuators (APAs) of different width viz. 20mm, 40mm and 60mm were also fabricated and characterized for displacement. A typical photograph of APA-60 is presented in (Figure 1.55). This was fabricated using six multilayered PZT stacks. Each multilayered stock consists of 100 layers of 90µm thick PZT tapes with cross-section areas of 8 x 6 mm². The stacks are placed in a diamond shaped aluminum metal frame in a pre-stressed condition. The displacement of the APA measured vertical direction was 173 µm (max.) at 175V compared to the combined displacement of ML stacks with six nos. was 38 µm, which implies that the amplification factor was 4.5.

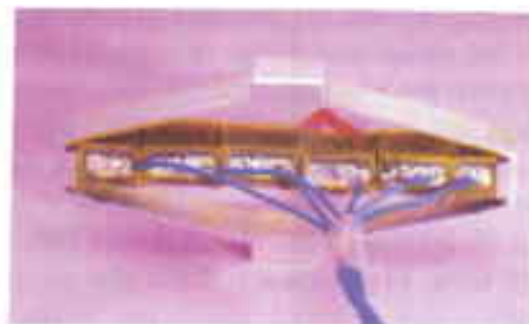


Fig. 1.55. Photograph of the fabricated APA-60mm amplified actuator

Cast austempered Fe-Mn-Si-ME (microalloying elements) steels

CSIR-NML investigated the influence of austempering temperature on the microstructure and mechanical properties of a low carbon high silicon (C-0.13%, Si-1.3%, Mn-1%, V-0.08%) cast steels. The microstructures consist of bainitic ferrite and retained austenite in an austempering temperature range 350 to 450°C. The morphology of bainitic ferrite however observed to be changed from lower bainite to upper on increasing austempering temperature. It is observed that UTS decreases but percentage El increases with increasing austempering temperature. The 400°C austempering temperature exhibited the best combination of mechanical properties at room temperature (UTS-663 MPa, EL-26%). The fracture mechanism dominated by dimple formation and coalesces indicating ductile fracture. With increasing holding time from 30 to 60 mins ductility is decreasing but strength is almost same.

Nanoindentation studies of TiB₂ films

TiB₂ is an important ceramic material with many potential applications as thin film. This requires accurate determination of the mechanical properties. CSIR-NML successfully deposited films of TiB₂ by magnetron sputtering and nano

indentation technique has been used to measure the mechanical properties such as hardness, modulus and fracture toughness. The hardness upto 33 GPa, and modulus of ~ 500 GPa have been achieved, which is very significant for wear resistance, protective coatings for cutting tool and industrial components. By incorporating different amount of nitrogen into film the hardness and toughness can be tailored. Further, a methodology for determination of fracture toughness and adhesion and deformation studies of coatings through nano-indentation has been developed for hard nano composite of TiSiBC, TiB₂, TiBN, SiCN coatings.

SHS processing of advanced materials

In-situ nano-composites and micro-composites of Al₂O₃-ZrB₂ and Al₂O₃-ZrB₂-TiB₂ with tailored microstructures with density as high as 98% dense are fabricated by CSIR-NML, utilising SHS dynamic compaction technique without sintering in a furnace. The grain growth has been controlled to very fine size of the order of 1-5 micrometer to submicron level for improved mechanical properties. Very hard composite with hardness values between 2300-4500 (Hv 0.2) have been achieved. A significant enhancement in modulus and hardness due to fine and nano dispersion of diborides and fine grain size of composite of alumina (20 Gpa, 350Gpa) matrix.

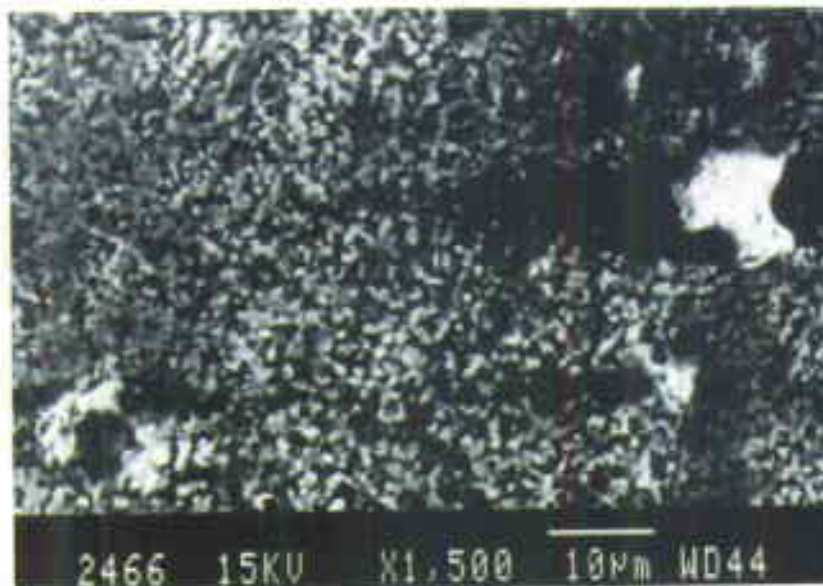


Fig. 1.56. Microstructure, hardness (38 GPa) and modulus (700 GPa) of Al₂O₃-TiB₂ Ceramic composite

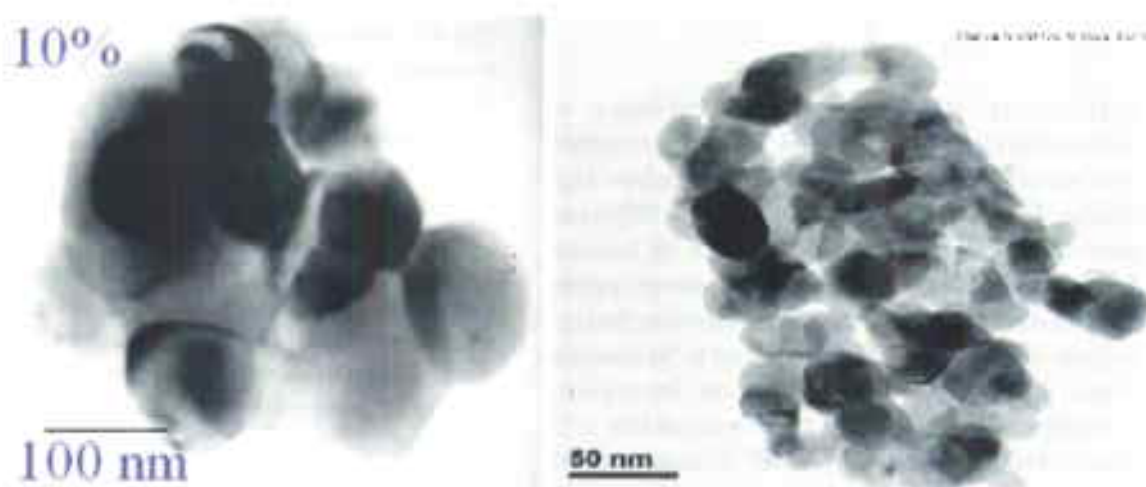


Fig. 1.57. TEM of nano a) TiB_2 and b) ZrB_2 powder

Nano titanium and zirconium diboride powder, which is a very high temperature materials with higher oxidation resistance have also been developed. These materials are very much required for strategic purposes e for high temperature abrasion resistance application.

An innovative process has been developed by SHS process to coat $Fe-Al_2O_3$ and $Al_2O_3-TiB_2$ composite coatings from cheaper raw materials inside the mild steel and other tubes. Such coated tubes are useful for transportation of abrasive

gases, medium and slurry transfer in many industrial process.

Super hard Coatings

CSIR-NML is working in the area of superhard and tough & high temperature coatings, which are required for automobile such as for piston rings, cylinders, cutting tool, space, turbine, strategic and other industrial applications demanding wear resistance, high temperature stable and oxidation resistance in components. CSIR-NML has developed and patented such nanocomposite newer



Fig. 1.58. $Fe-Al_2O_3$ and $Al_2O_3-TiB_2$ coating inside mild steel and other tube by SHS process

hard coatings developed by PVD process meeting these properties. Few of them are given below:

Nanocomposite TiSiBCN hard and tough coatings with low co-efficient of friction : Nanocomposite TiSiBC and TiSiBCN coatings have been successfully developed with tailored hardness and modulus having good toughness. The coefficient of friction 0.1-0.3 was achieved. The coatings hardness can be tailored from 10-40 Gpa and Modulus 110-450 GPa. The toughness value of 7 Mpa.m^{1/2} has been achieved. The coatings were thermally stable

upto 1000°C in air (tested only upto that temp yet).

Multilayered nano Si-C-N alternate hard and soft layer by sputtering using single target with a novel approach: A novel, economic, easy, more durable having less stresses approach of depositing multi layers of the alternate soft and hard coatings have been developed using a single target of SiC. By changing the deposition parameters, where we can tailor the properties of the deposited layer, leading to minimizing the problems of thermal and structural mismatch between the layer. The layers having layers of hard and soft nano composite

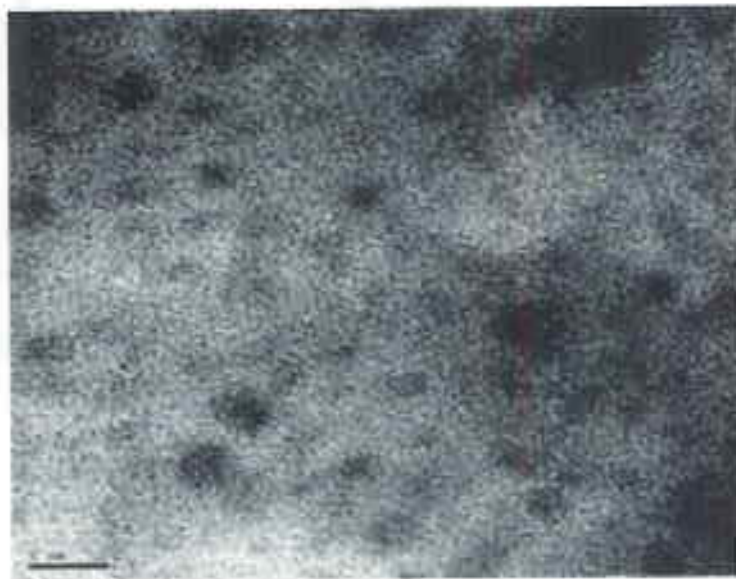


Fig: 1.59 Nanocomposite TiSiBCN film with 5nm crystallite distribution in amorphous matrix

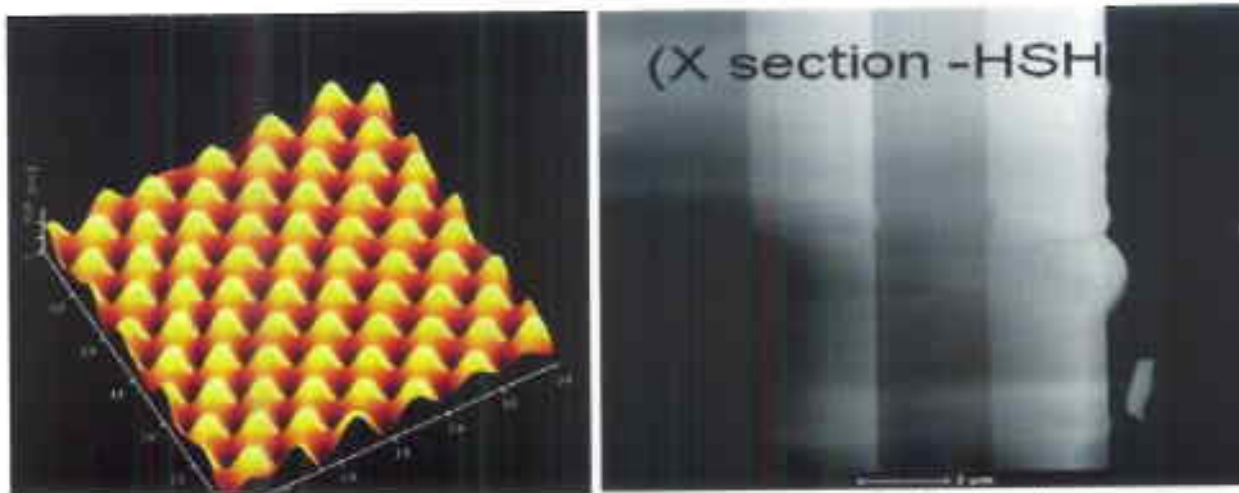


Fig. 1.60. Multilayer tough alternate hard/soft/hard layer a) Lattice imaging of top layer b) cross section TEM showing three layers

SiCN film with alternate soft and hard layers upto 3 layers have shown hardness in the range of 10 to 35 GPa with higher loading capability before fracture under indentation and higher toughness of the order of 10 MPam^{1/2} which is significantly higher than available coatings.

Mechanochemical Activation

Anomalous decrease in surface area is observed by CSIR-NML during mechanical activation of boehmite synthesized by thermal decomposition

context of Bayer process and tailoring the reactivity of Al-oxyhydroxides/oxides. Hybrid materials of drugs (piroxicam and meloxicam) with alumina, boehmite and gibbsite were prepared by planetary ball milling. The dissolution behavior of drug from the nanocomposites revealed that the drug release can be altered by changing the substrate..

Special glass powder in the form of nodules 2-6 mm dia

Glass Beads nodules are used for immobilization

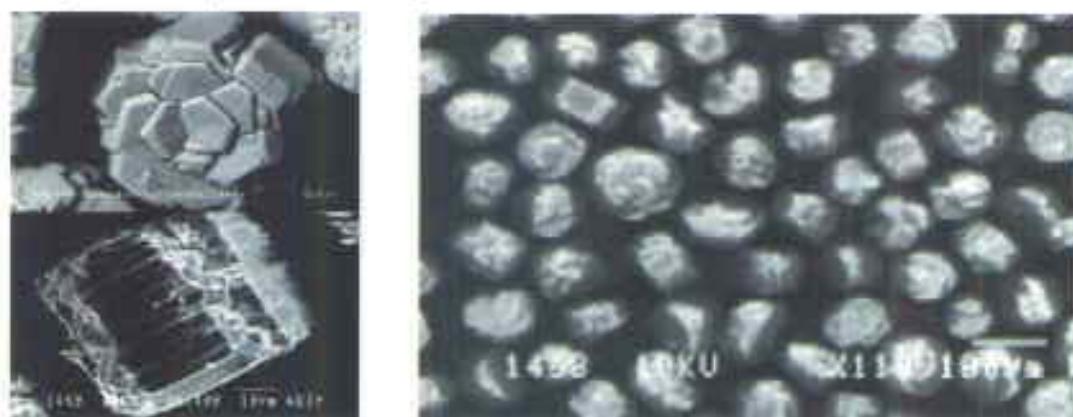


Fig. 1.61. SEM picture of boehmite, synthesized by thermal decomposition of gibbsite, showing (a) uniform size, (b) agglomerate structure, and (c) slot like pores

of gibbsite. Interestingly, in spite of decrease in surface area, the boehmite showed enhancement in reactivity which was manifested in enhanced leachability and lowering of transformation temperature of boehmite into γ -Al₂O₃. These results are of fundamental importance in the

of radioactive wastes from nuclear plants. CSIR-CGCRI had been producing the material at its premises and supplying the same to Department of Atomic Energy (DAE). Due to a quantum jump in the demand of the material in future, technology has been transferred to M/s. H R Johnson (India), Mumbai for utilizing the knowhow for manufacture of glass beads nodules. The signing of agreement took place on May 11, 2010. Under the agreement, HRJ has been granted permission to utilize the knowhow in India to make use and dispatch the product to Department of Atomic Energy after usual inspection, chemical analysis and certification by CSIR-CGCRI. Recently CSIR-CGCRI has supplied 3.5 tonnes of nodule material to Tarapur Atomic Power station through the company.



Fig. 1.62. Glass frit nodules

Ceramic humidity sensor for nuclear industry

Ceramic humidity sensors are used for on-line detection of moisture present in toxic/non-toxic industrial gases which are used in the nuclear



Fig. 1.63. Tape cast ($MgCr_2O_4-TiO_2$) Tape cast (Al_2O_3)

metallurgy, defense, navigation etc. CSIR-CGCRI developed and supplied thirty sensors with electronics sub-systems to Bhabha Atomic Research Centre, Mumbai. The sensors were tested at loss of coolant accident (LOCA) chamber over a duration of six days. The fabrication method involved tape casting of $\alpha-Al_2O_3$ and magnesium chromate with titania system ($MgCr_2O_4-TiO_2$). For leak detection, one complete electronic device was supplied and demonstrated which could read two stages: Low and High: Low without leakage and High for leakage.

Reaction bonded silicon nitride radome

Radomes are used to trace the track of guided missiles on the basis of the processed microwave signals sent from the target. CSIR-CGCRI developed the base silicon nitride material for the nose cone (radome) and also fabricated the



Fig. 1.64. Reaction bonded silicon nitride radomes

prototype radome of 183 mm dia x 385 mm height. The front portion or the nose cone of the missile is transparent to the micro-wave signal for easy transmission of the electromagnetic wave without aberration. Reaction bonded silicon nitride was observed which is transparent to such wave in the range 6-14 micro-meter. The di-electric constant (~ 3.0) and tangent loss (0.01) of the material in the spectrum is acceptable for the said application. Both the material and the radome qualified the test requirements for actual application.

Bioceramics based implants for rehabilitation

CSIR-CGCRI developed all ceramic hip joint prostheses and knee joint prostheses which have been successfully implanted to a number of patients. The first such series of operations took place in Jubilant Kalpataru Hospital, Barasat, West Bengal by the famous surgeon Dr K H Sancheti, Chairman of Sancheti Institute of Orthopaedics & Rehabilitation (SIOR) on four patients.



Fig. 1.65. (a) A specimen of implanted all ceramic hip joint prosthesis (b) Bipolar ceramic acetabular cups with ceramic head and bare acetabular cup



Fig. 1.66. A beneficiary of CSIR-CGCRI's prosthesis technology walking on the stage in the inaugural day of Institute's Diamond Jubilee celebration on September 4, 2010 before the watchful eyes of Dr. Sancheti

SiAlON cutting tool inserts

The modern generation production requires accelerated metal finishing at significantly greater machining speed. SiAlONs are oxynitride based engineering materials which have a combination of excellent hardness (HV10 ~17-22 GPa) and fracture toughness (~4-7 MPa.m^{1/2}) along with chemical inertness towards some metals. The cutting ability of SiAlON tools are in the range of ~3000 m/min in comparison to the conventional carbide tools (~150-300 m/min) for application in metals.

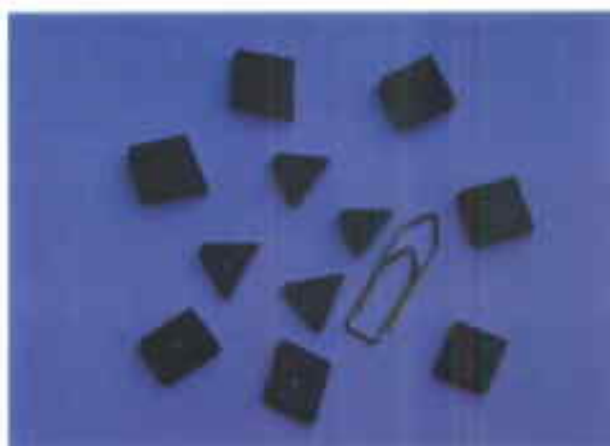


Fig. 1.67. SiAlON cutting tool inserts

Four patents (one in USA and three in India) were earlier filed on different SiAlON compositions and processes. Based on these, CSIR-CGCRI has successfully developed tool inserts of ~12mm

square, equilateral triangle and 80° rhombic with 5mm thickness and with (5mm D) or without hole in collaboration with a private entrepreneur Double Dee Technologies Pvt. Ltd., Mumbai. An agreement for transfer of technology of SiAlON based products is going to be signed with the Double Dee Technologies Pvt Ltd.

Technology development for manufacturing of vitrified ceramic tiles and blocks from sand stone dust waste

To address the environmental concern poised by Crystalline silica dust (mainly due to stone crushing, CSIR-CGCRI developed a process for producing a very high strength vitrified ceramic tiles and also pavement blocks of various colours which is expected to find massive application in the construction industry.

The product has flexural strength >60 MPa, porosity < 0.5% and scratch hardness= 7 in Moh's scale. The product could be vitrified at only 1125°C compared to 1300°C for normal triaxial porcelain composition effecting energy saving.

Au nano particles doped ZrTiO₂ films as plasmonic sensor for H₂ Gas

Plasmonic modification in gold (Au) can find important technological applications in the area of plasmonic optical sensing. CSIR-CGCRI developed Au nano particle doped ZrTiO₂ films which showed large plasmon shifting (10–11 nm) with appreciable enhancement of optical density when the film atmosphere was cycled between air and H₂ (1% and 0.1%) at 200°C. This plasmonic shifting could be reversibly cycled several times.



Fig. 1.68. Products developed from sand stone dust waste a) Pavement block, b) Polished tiles of various shades

Synthesis of surface imprinted nanospheres for recovery of uranium

CSIR-NIIST reported imprinted polymer nanospheres by synthesizing quinoline-8-ol functionalized 3-aminopropyltrimethoxysilane modified silica nanoparticles followed by surface imprinting with 4-VP (4-vinyl pyridine), HEMA (2-hydroxy ethyl methacrylate) and EGDMA (ethylene glycol dimethacrylate) as the functional monomers and cross linking agent, respectively. The reaction proceeds via cross linking with AIBN (2,2'-azo-bis-isobutyronitrile) as initiator and 2-methoxyethanol as the porogen respectively. Surface imprinted nano spheres synthesized by modified precipitation polymerization method offers higher retention capacity and imprinting coefficients for recovery of uranium from natural water.

Oxide based nanolayered multilayer coatings

Most of the transition metal nitride based nanolayered multilayer coatings and nanocomposite coatings have limitations for very high temperature applications. In search of newer extrinsic superhard coatings, currently efforts are being directed towards the oxide materials and a combination of oxide/nitride materials. CSIR-NAL developed nanolayered multilayer coatings consisting of highly stable oxide materials such as Al_2O_3 , Y_2O_3 , ZrO_2 , etc., which are stable at very high temperatures. The $\text{ZrO}_2/\text{Al}_2\text{O}_3$ and $\text{ZrO}_2/\text{Y}_2\text{O}_3$ nanolayered multilayer coatings exhibited hardness values as high as 30 and 28 GPa, respectively, which are very high as compared to rule-of-mixture values (15 and 13 GPa, respectively for $\text{ZrO}_2/\text{Al}_2\text{O}_3$ and $\text{ZrO}_2/\text{Y}_2\text{O}_3$). Furthermore, the $\text{ZrO}_2/\text{Al}_2\text{O}_3$ multilayers exhibited very high resistance to plastic deformation with their structural stability up to 1100°C in air.

Rare earth oxide varistors for medium and high voltage surge by protection

Nanocrystalline La_2O_3 and CeO_2 based ZnO varistor powder has been processed by CSIR-NIIST through sonochemical, urea and glycine decompositions methods. Cylindrical varistors

were fabricated and sintered at temperatures 1275, 1300 and 1350°C. They observed density of the samples sintered at 1350°C was 95% of the theoretical density with average grain size of $\sim 3\mu\text{m}$. I-V characteristics confirm that a medium voltage surge protection is possible in CeO_2 based varistors whereas a high voltage surge capacity can be possibly achieved in $\text{ZnO-La}_2\text{O}_3$ system. The nanocrystalline ZnO-CeO_2 and $\text{ZnO-La}_2\text{O}_3$ varistor powders are mixed with conventional micronized varistor powders up to 10 wt% for achieving dense, sintered varistors with nano/micro composite microstructures at sintering temperatures below 1300°C. These nano/micro composite micro structures resulted in break down field $V_b = 900$ v/mm with non linearity index $\alpha = 40$.

Low temperature co-fired ceramic tapes

Strontium zinc silicate and LiMgPO_4 low temperature cofireable ceramics were prepared by CSIR-NIIST through conventional solid state ceramic route. The sintering temperature of $\text{Sr}_2\text{ZnSi}_2\text{O}_7$ was reduced to 875°C by the addition of LMZBS glass. The fine ceramic powders with a specific surface area of 1-1.8 m^2/g of the ceramics were mixed to get slurry through standard route of tape casting. The slurry thus obtained was tape cast. The tapes were allowed to dry by keeping in air for about one hour. The tapes were 200 μm in thickness. Eight pieces of about 2 cm each in length and breadth were cut from the tapes and stacked together. The stack was then hot pressed at 70°C for 10 minutes. It was then sintered at temperatures in the range 800-850°C for 4 hour. Microstructures of the sintered composites were



Fig. 1.69. As cast green tape of $\text{Sr}_2\text{ZnSi}_2\text{O}_7$.

investigated by recording SEM pictures. The stacked and sintered $\text{Sr}_2\text{ZnSi}_2\text{O}_7$ tapes exhibited $\zeta_r = 7$, $\tan\delta = 0.001$.

MgB₂ based conduction cooled current leads (Rating: 1000 A)

As a part of the National Fusion Program (NFP) of the country, CSIR-NIIST in collaboration with Institute of Plasma Research (IPR), Gandhinagar developed MgB_2 based superconducting conduction cooled current leads (CCCLs) with a critical current rating of 1000 A and length in the range 10 to 20 cm for application in fusion magnet to confine of plasma. Optimized Cu end-leads designed for the rated current with provision for anchoring to the magnet were fabricated and fixed to both ends of the body of the superconducting lead. The critical current rating and length shall be scaled up to adequate levels for use in the fusion magnet.

Overseas plant audit

CSIR-IMMT audited a 1000-tph phosphate ore beneficiation plant at Industries Chiniques Senegal (ICS-Senegal) and evaluated the plant performance. This study established the feasibility of recovering additional phosphate concentrate of 10-12 tph with 28-31% P_2O_5 from the scavenger/global tailings of the existing beneficiation plant. The outcome of the study showed the possibility of exploiting the flotation tailing dumps by adopting the tailored flow sheet to produce



Fig. 1.70. 1000 tph phosphate ore beneficiation plant at Talba Mine, Senegal

phosphate concentrate of >35% P_2O_5 at appreciable recoveries. Troubleshooting measures to enhance the quality of the beneficiated global concentrate have been suggested to the plant management. ICS has initiated plant scale trials with the suggested new reagent and equipment layout to recover additional concentrate.

Removal of iron from bauxite for making calcined bauxite

India has large resources of high grade bauxite deposits to the tune of 3037 metric tonne mainly on Odisha, Andhra Pradesh, Madhya Pradesh, Gujarat, Maharashtra and Bihar which is expected to last for over 350 year. Removal of iron and titania to meet the refractory specifications is the main concern.

CSIR-IMMT developed a dry processing technology for removal of iron from bauxite. A plant of 300 tpd is being setup in Maharashtra to produce calcined grade bauxite based on the process developed by CSIR-IMMT. The process is expected to yield 38% nonmagnetic product and 32% magnetic fraction on feed LOI basis. This magnetic fraction is likely to be used as emery material or it can be used for making brown fused alumina for refractory purposes and hence has commercial value.

Evaluation of perovskite photocatalysts for water splitting

Perovskite type photocatalysts are important class of materials for water splitting due to their stability in water. Photocomposition of water has been studied over a series of rare earth ferrites for their activity towards water decomposition reaction under visible light-illumination. The catalysts are prepared by sol-gel method by taking $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$, $\text{Re}(\text{NO}_3)_3 \cdot 6\text{H}_2\text{O}$, $\text{C}_0\text{H}_8\text{O}_7$ as raw materials to prepare ReFeO_3 . Powder X-ray Diffraction (PXPD) Study exhibit that ReFeO_3 nanoparticles are active under the visible light illumination. Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) studies indicated that photoactivity of nano semiconductors follows the order of $\text{LaFeO}_3 > \text{EuFeO}_3 > \text{ErFeO}_3 > \text{GdFeO}_3 > \text{YbFeO}_3$ which is supported by the results

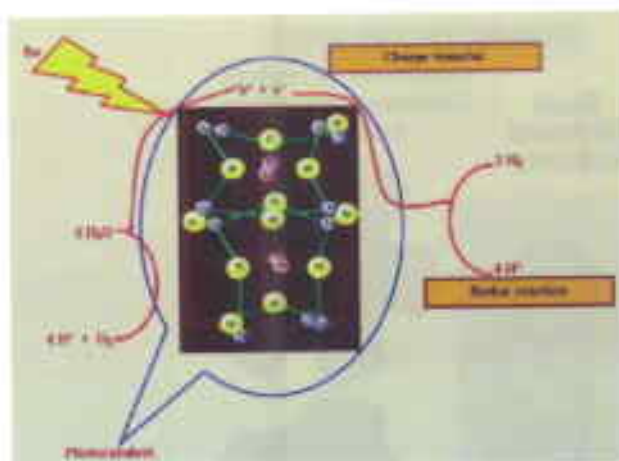


Fig. 1.71. Perovskite structure of LaFeO_3 ,

obtained from particle size analysis, Burner, Emmet and Teller (BET)-surface area and Photo Luminescence (PL) intensities. Photocurrent measurement showed that the prepared photocatalysts are of n-type semiconductor. Highest result has been obtained over LaFeO_3 producing $713.6 \mu\text{mol H}_2$ and $289.2 \mu\text{mol O}_2$ in 6 hours with apparent quantum efficiency 3.8% under visible light illumination.

Biocompatible coating on titanium metal

A hybrid coating of hydroxyapatite-titania (HAp- TiO_2) on Titanium (Ti) metal substrate is prepared by CSIR-IMMT by electrophoretic deposition technique followed by heat treatment. Top HAp coating is crystalline and porous, while intermediate titania layer is crystalline and dense. The thickness of top HAp layer is 30-35 μm ,

depending on deposition time, while the titania layer has a thickness of 4 μm . The strength of HAp significantly increased from 15 MPa in case of pure HAp coating on Ti metal to 48 MPa in HAp- TiO_2 hybrid coating. This enhancement in adhesion is due to diffusion bonding as well as mechanical interlocking evidenced by Raman spectra. Close proximity of thermal expansion coefficient of Ti and titania, and good chemical affinity of titania towards Ti as well as HAp strengthens the adhesion further. Micro porous nature of the deposited HAp favours biological tissue adhesion and proliferation. The process is simple, fast and cost effective.

Process for stabilization of water soluble chromium of dichromate residue by sintering technique

Solid residue, generated during manufacturing of sodium dichromate chemical by soda roasting of chrome ore, releases water soluble chromium which is a prescribed toxic waste. Disposal of this waste is a serious concern as hexavalent chromium contaminates the soil and ground water. A process for treatment and stabilization of soluble chromium of chrome chemical contaminated wastes has been developed by CSIR-IMMT by adopting a novel sintering technique. After treatment, the material can be used for value added application in building material and specially in making blended cement. The process was demonstrated on 50 kg batch scale to M/s Chrome Chemicals, Maharashtra.



Fig. 1.72. Cross-section of HAp and titania composite layer on Ti metal and the top porous HAp

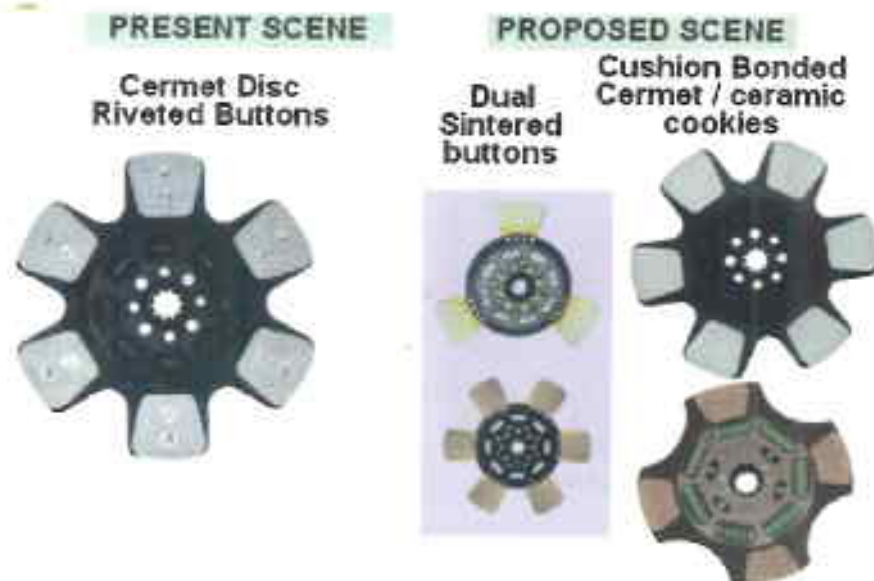


Fig. 1.73. Cushion bonded clutch disks

Innovative cushion bonded/rigid bonded organic, cerametallic and ceramic cookies & clutch discs

New and innovative designs of clutch discs by eliminating rivets and introducing new concept of simultaneous cushioning and adhesive bonding in clutch disc has been developed under NMITLI to extend the life of the clutch with 100% utilization of expensive friction material.

The cushioning between friction material and carrier plate ensures smooth engagement, offers better load & heat distribution, results in stable fade and friction characteristics, control on take up of drive, reduces inertia of drive plate which results in extended synchromesh life; fast gear shifts and fuel savings. Process and manufacturing technology for: (i) Cushion bonded adhesive formulation (capable of withstanding temperature up to 175 °C); (ii) Cerametallic/ Ceramic Rigid bonded adhesive formulation (capable of withstanding temperature up to 250 - 300 °C); (iii) Iron based cerametallic cookies; (iv) Ceramic cookies with chopped fibres; and (v) Dual sintered buttons have been developed.

Indigenous dental implant system

The medical implants are natural and synthetic material implanted in human body to assist various functions and at times to put in order the

deficiency/deformity occurred. A novel, cost effective, user friendly screw type dental implant system has been designed and fabricated under NMITLI that provides solutions for all edentulous situations including a missing tooth or multiple missing teeth. The dental implant system comprises of three components namely-Dental implant fixture, Multifunctional component and the Abutment screw. The dental implant system comprising of titanium implant, abutment and screws were designed and machined under the project and after successful animal trials are now undergoing human trial at Maulana Azad Medical College and Hospital, Delhi. Ten implants have already been placed. Of these, seven cases were completed with final prosthesis after 16 weeks of regular follow up. No signs of early failure, cytotoxic reaction, perimplant mucocitis or periimplantitis were observed.



Fig. 1.74. Various dental implants

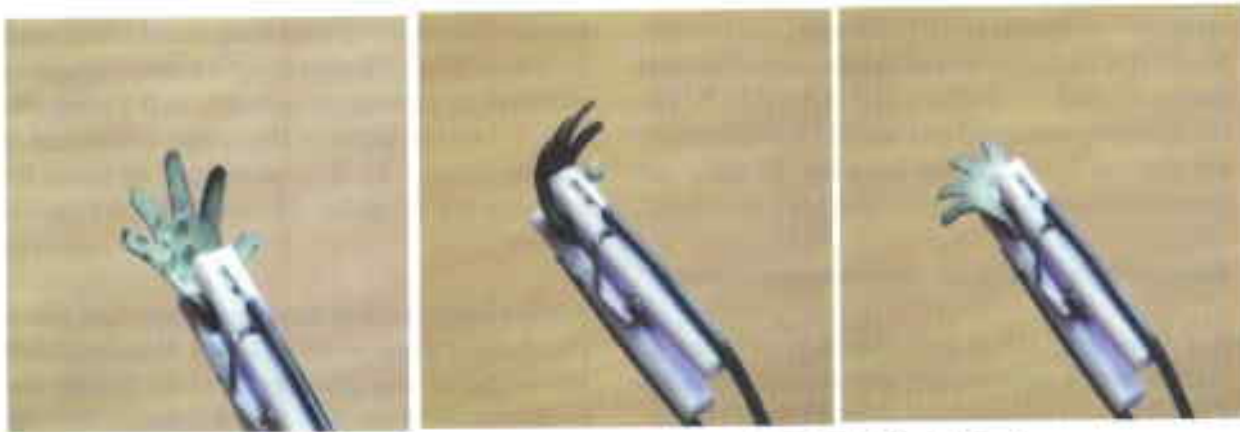


Fig. 1.75. Successive photographs of the five fingered IPMC mini-hand showing high actuation under applied voltage of 2.0 V.

Electro-active polymer based micro-actuators developed

Development of Ionic Polymer-Metal Composites (IPMCs) is a demanding area of research for various potential applications such as bio-mimetic sensors, actuators, transducers, and artificial muscles. These devices require an electrochemical triggering to cause the mechanical bending of the structure. CSIR-CMERI fabricated a mini-hand comprising five cantilever shaped micro-fingers of 5 mm length, 400 μm width at a pitch of 600 μm . It is based on Nickel based IPMC (Ion Polymeric Metal Composites) material by adopting mechanical 'micro milling' process. The micro-fingers were found to actuate effectively at the voltage range -2 to +2.0 V (Figure 1.75).

Technology demonstration

CSIR-IMMT has developed and released a process to M/s Vedanta Aluminium Limited for utilization of waste from aluminium plant. Red mud, fly ash, and lime grit as raw material has been used in the manufacture of brick and block mix design. The products meet the standard of Class-7.5 as per Bureau of Indian Standards (BIS) specification. M/s Vedanta has taken-up commercial scale production of red mud and fly ash bricks in its plants utilizing 60-70% w/w red mud and fly ash.

1.4 INFORMATION SCIENCES CLUSTER

CSIR's High Performance Computing facility

During the year, the most significant enhancement was the installation and commissioning of the 6th fastest supercomputer in the country (Dec '10). The system consists of 1152 processor cores (Intel Xeon 5670) and 2.3 TB of main memory distributed over 96 nodes, which are interconnected in the form of an enhanced hypercube using 4X QDR Infiniband technologies along with 30 TB of Lustre based parallel file system for fast I/O. The peak performance of the system is 13.5 TFLOPS and the sustained performance measured by the High Performance LINPACK (HPL) is about 11.83 TFLOPS. With this system in place, CSIR-CMMACS currently has a total compute power of about 16 TFLOPS (peak) across 7 High Performance Computing Systems. CSIR- CMMACS HPC facility is connected to the National Knowledge Network (NKN) through a 1 Gbps Optical Fiber Link. The supercomputing facility, which includes the largest shared memory system in the country, has been operational on a round-the-clock basis. Computational scientists from several CSIR laboratories have been remotely accessing the supercomputing facility.

Indigenous cloud seeding system developed

Cloud seeding system is an effective tool for precipitation (rain) enhancement. While its use has

increased within the country, Cloud Condensation Nuclei (CCN) Dispensers are neither manufactured nor marketed in India. CSIR-CMMACS has indigenously designed and tested CCN dispenser for ground based cloud seeding. In addition material for cloud seeding has also been developed.

Weather informatics for precision agriculture:

In a pioneering effort, Hobli-level forecasting of rainfall over Karnataka has been initiated through a collaborative effort with Karnataka State Natural Disaster Monitoring Centre (KSNDMC). The project is being implemented in a resource-sharing environment; while KSNDMC is providing funds for generating the forecasts and their web management, CSIR-CMMACS is providing domain expertise as well as High Performance Computing. The two institutions also share resources in generating high-precision observations, and ground-based cloud seeding for precipitation enhancement.

Global carbon cycle

CSIR-CMMACS has set up a station (as per World Meteorological Organization (WMO) standards) for the high precision measurement of CO₂

concentrations along with other green house gases in Pondicherry University campus which is expected to provide an accuracy of 0.1 ppm. The data is very valuable in the robust estimation of carbon fluxes as it is expected to have the fingerprints of India, SE Asia and the Indian Ocean.

Marine biota plays an extremely important role in the global carbon cycle. Only a comprehensive modeling of the biogeochemical cycles and synthesis of data will yield insight into the physical, chemical and biological processes which influence the carbon cycle on wider spatial and temporal scales. Model simulations in the northern Indian Ocean provide an insight into the carbon and nitrogen cycles, especially oxygen minimum zones. In the Southern Ocean, temperature and salinity, Chlorophyll and primary productivity from the model simulations and satellite data are being analysed at a few locations in the region where an Indo-German iron fertilization experiment (LOHAFEX) was carried out.

Deformation Modelling in Indian subcontinent

Global analysis of Global Navigation Satellite System (GNSS) data of Indian subcontinent was performed by combining it with the data observed at various parts of the globe to study the deformation pattern of Indian tectonic plate which is main component for estimating the seismic vulnerability. In addition the Indian GNSS network data was used to derive the impact of a priori zenith delay on temporal and spatial variability of water vapor and for probing the ionosphere to study the seismo-ionospheric coupling. For the first time in the country, CSIR-CMMACS initiated precise geodetic measurements at Barren and Narcondam volcanic Islands (Figure 1.77) of Andaman Nicobar to detect ground deformation.

The modelling and simulation of ground motion using different source types and the rupture mechanism for two different earthquake scenarios; one from Central Himalayas at a distance of 300 km and other at regional distance of 175 km have been carried out for Delhi city. Crustal and Mantle structure of Dharwar region have been studied

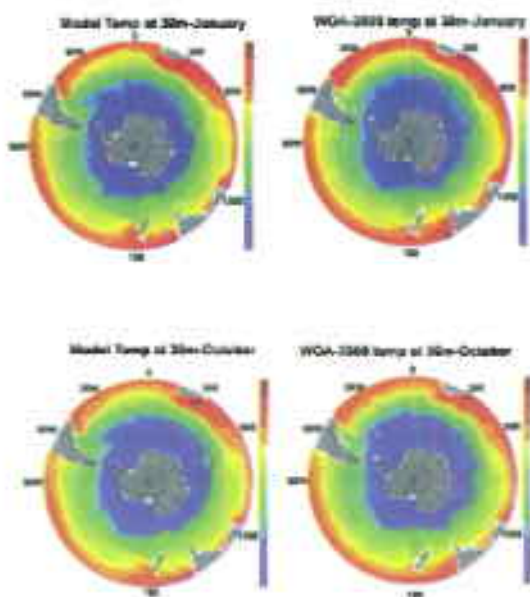


Fig. 1.76. Comparison of Model Temperature with World Ocean Atlas (WOA)-2005

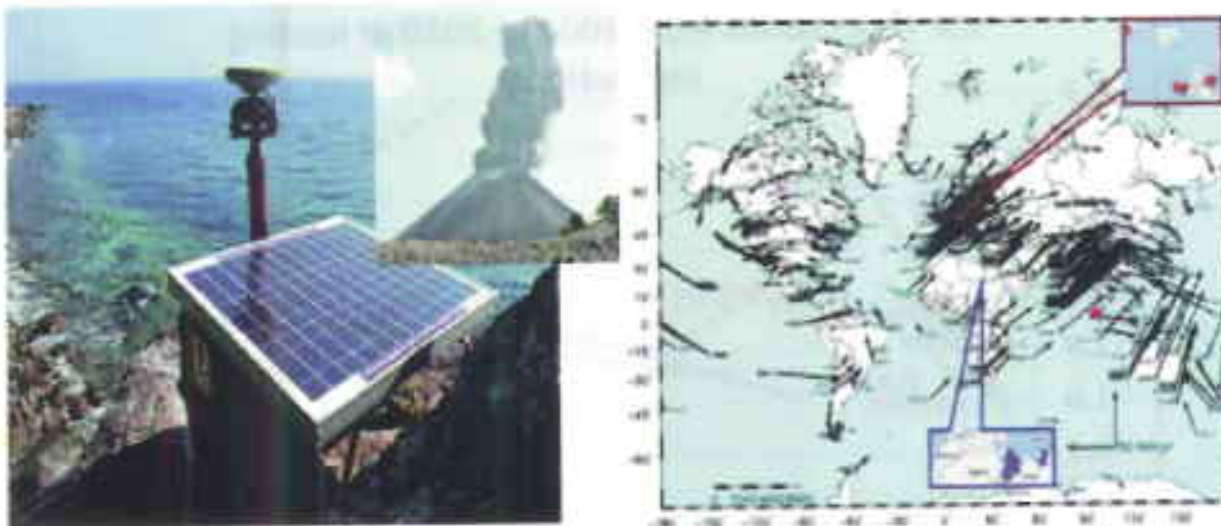


Fig. 1.77. Crustal velocity of Indian subcontinent derived from Global data analysis. In set boxes indicate the pole of rotation of Indian tectonic plate with reference to ITRF and Eurasia

using a network of five broadband seismic stations. Also attenuation of P- S- and coda waves completed for NW Himalayas.

CSIR-URDIP has created several specialized value added databases

- ◆ A database of patents issued to CSIR since its inception has been prepared and has been web-enabled (www.patestate.com). It is updated regularly.
- ◆ A database of patents on Medicinal Plants has been prepared for Indian Medicinal Plant Board, along with IHBT.
- ◆ A database of the patents on crop plants, forestry trees, animals, aquatic bio-resources and microorganisms has been prepared for DBT.
- ◆ A database on Metallopharmaceuticals
- ◆ A database on bioactive molecules and their bioevaluation data (including clinical trials and toxicity)
- ◆ A database on Enzyme Inhibitors along with their physico-chemical properties for all enzymes (4200) covered by Enzyme Commission

CSIR-URDIP has created Open Access Compliant Digital Library of Indian Theses Using Eprints (<http://eprints.csirexplorations.com/>) and CSIR-Central -A Centralized Harvester Service for Institutional Repositories setup at CSIR Institutes (<http://oa.csirexplorations.com/>)

Web-based information services

CSIR-URDIP has provided value added information services in the area of Patinformatics, Phytoinformatics and Toxininformatics to wide array of clients including start-up companies, SMEs, Research Institutes within and outside CSIR, large Indian Corporate and Multinational Corporations. URDIP's research output is used as input by R&D, legal, new business development and multifunctional corporate teams for Research and Business Planning.

In order to help Indian Patent Office to clear the backlog of patent applications, a MOU was signed between CSIR-URDIP and IPO to start a pilot programme under which CSIR-URDIP will prepare prior-art-search reports for pending patent applications. CSIR-URDIP has set-up a dedicated team to service the requirement of IPO. This activity was started from August/September 2010 and till now, CSIR-URDIP has completed prior-art-search reports for 800 + patent applications. A separate Portal to manage IP applications with four

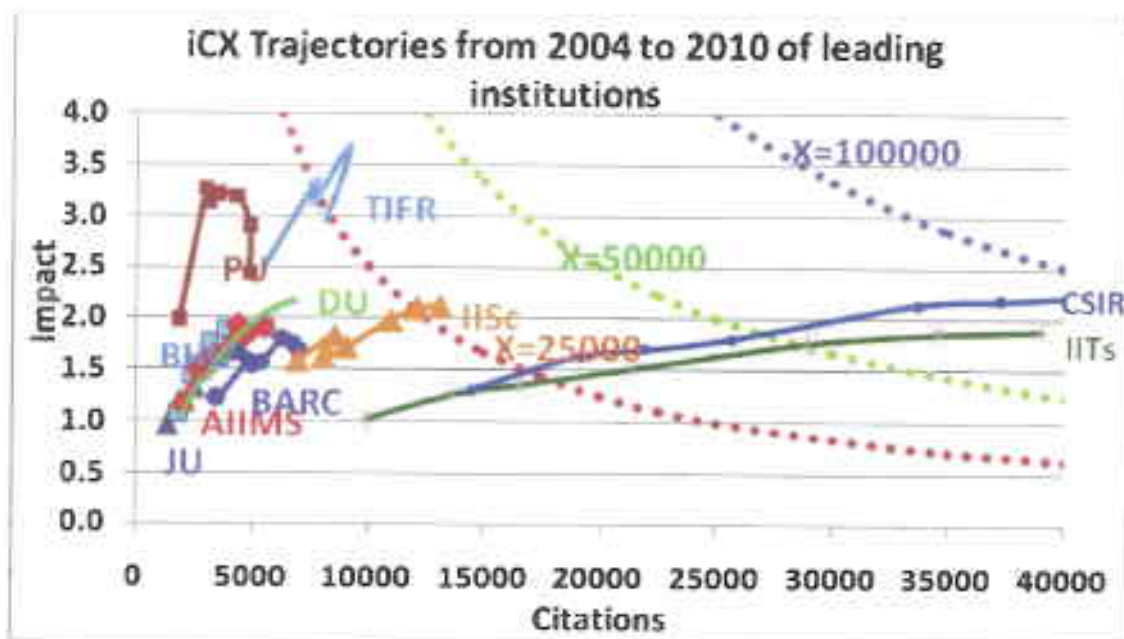


Fig. 1.78. Relationship between quality and size (quantity) is captured in an iCX (Impact-Citations-Exergy) Map. As performance is tracked over a five year rolling window from 2004 to 2010, an interesting dynamic picture appears. The IITs have surpassed the CSIR in terms of the number of papers published but has never overtaken the CSIR in quality terms.

Indian patent offices has been developed and deployed.

CSIR-URDIP is using new indicators such as the p-index and EEE-sequences for research evaluation. The (Figure 1.78) is an example of how bibliometric techniques can be used to evaluate the academic research done by various Indian scientific institutions and agencies using these new ideas.

1.5 PHYSICAL SCIENCES CLUSTER

Tapping Solar Energy: TAPSUN Project

CSIR has conceptualized a mega-project entitled 'Technologies and Products for Solar Energy utilization through networks (TAPSUN)'. The project is in network mode and provides a unique platform to CSIR laboratories to connect with research institutes, academia and industries with an objective to achieve technology development in the field of solar energy. The project is in alignment with the objectives and targets of Jawaharlal Nehru

National Solar Mission. CSIR is partnering with MNRE. The project will play a significant role in bringing the benefits of solar energy to the people of India.

Smart Pond Management System for Fresh Water Aquaculture:

An Electronic monitoring and control system for fresh water aquaculture ponds has been designed



Fig. 1.79. Fish Auto Feeder System (embedded version)

and developed by CSIR-CEERI. The developed embedded system can sense and wirelessly transmit pond parameters (dissolved oxygen, dissolved carbon dioxide, dissolved ammonia, water temperature) and determine stress factor on the fish. An auto fish feeder has also been developed as an ancillary to the main pond management system. The system has been developed in partnership with the Central Institute for Freshwater Aquaculture (CIFA), Bhubaneswar, which also field-tested the system.

RF MEMS switches for C, X and Ku band applications

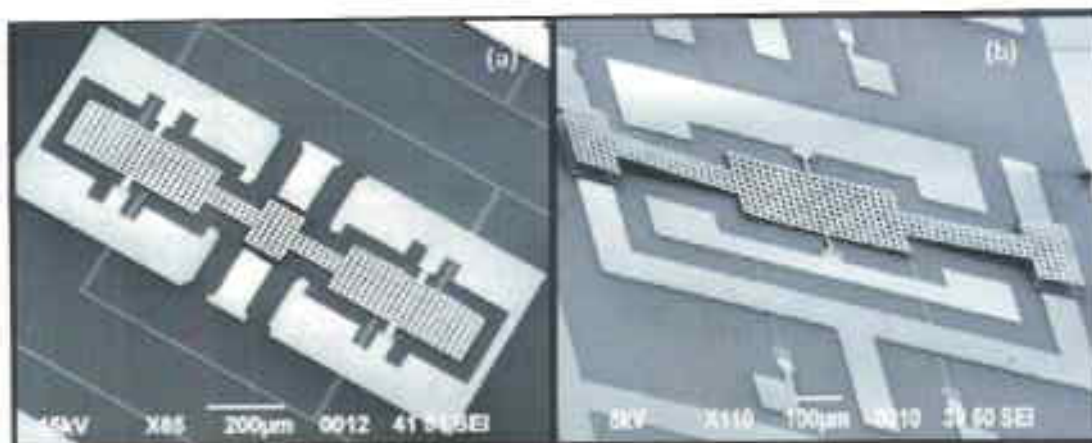
CSIR-CEERI developed Radio Frequency Microelectromechanical Systems (RFMEMS) devices for Space Application Centre (SAC-ISRO), Ahmadabad. The developed devices include C, X and Ku band RF MEMS switches (capacitive shunt SPST and SPDT switches) with low voltage (5-20 V) electrostatic actuation-based on symmetric toggle and flexible serpentine configurations. The switches have been successfully evaluated and tested by SAC-ISRO scientists. RFMEMS switches are important for developing compact transmit receive modules, microwave phase shifters for electronic steering of microwave beams in communication and radar systems.

Embedded processor for smart camera system

Fig. 1.81. Object Tracking by Smart Camera System
CSIR-CEERI developed a Field Programmable Gate Array (FPGA) based processor for smart camera system. The processor is designed to provide real-time video signal processing capability for object tracking algorithms in changing backgrounds so as to enable the camera to track objects in real-time. Development of such high throughput video processors is crucial for automated video surveillance functions in video based security systems.



Fig. 1.81 Object Tracking by Smart Camera System



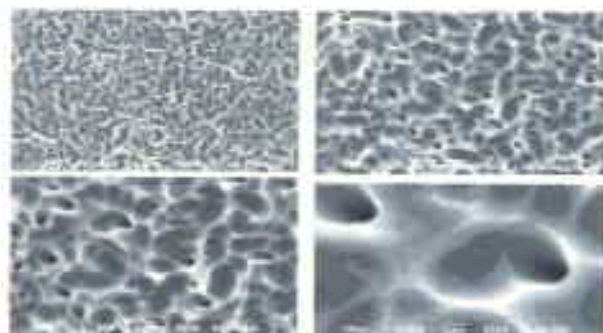
*Fig. 1.80. SEM Micrograph of a Capacitive Symmetric Toggle Switch (CSS-STS)
(b) Micro-Torsion Actuator based SPDT*



Fig. 1.82 Acid Texturisation System

Acid Texturisation System and Process of Multi-crystalline Silicon Solar Cells

CSIR-CEERI has developed an automated system and associated process for acid texturisation of multi-crystalline silicon solar cells. Texturised solar cells feature improved efficiencies owing to reduction in surface reflectance (and consequent enhancement of absorbance of incident sunlight by the solar cell). Developed system is suitable for 156 X 156 mm wafers, maintains an optimum constant temperature of the acidic solution (despite highly exothermic nature of the acid texturisation reaction) through fluoro polymer based heat exchanger plates and provides automated movement of wafer carrier from bath to bath. The system also has provision for changing of process parameters, logging of actual process parameters and continuous removal of acidic vapour. The system has been validated by BHEL, Gurgaon and is being used by them in their line,



SEM Photograph (plane view) of Multi-crystalline-Si Surface After Acid Texturisation

6 MW peak, 24 kW average power S-band Klystron

CSIR-CEERI undertook the design and development of a 6 MW peak, 24 kW average power S-band (2856 MHz) Klystron for DAE. Designs of the electron gun, RF interaction structure and collector of the Klystron have been completed, and validated using different codes. Axial magnetic field profile required for electron beam focussing in the Klystron has also been worked out and an electromagnet for generating the same has been developed. A gun-collector test module (GCTM) has also been assembled and tested to validate the design of the electron gun and the collector. After successful testing of the GCTM, and the cold testing of RF cavities and other parts, full Klystron has been assembled.



Fig. 1.83. High Voltage Solid State Modulator with GCTM Under Testing

Ku-band 140 W short length space TWT

CSIR-CEERI undertook the design and development of Microwave Power Module (MPM) based Ku-band 140 Watt Short Length Travelling Wave Tube (SL-TWT). Through simulations the tube assembly has been analysed from thermal, structural and high voltage points of view. The tube features a single section helix slow wave structure, Sm₂Co₁₇ periodic permanent magnets (PPM) for electron beam focusing and a four-stage depressed collector for collector efficiency enhancement. The tube design features 140 W of RF output power at 25 dB gain at an overall tube efficiency greater than 60%.

System level reconfiguration techniques for reconfigurable computing systems

Reconfigurable computing Systems (RCS) provide a new paradigm for high performance computing in which hardware is reconfigured statically or dynamically based on the needs of the computation. Reconfigurable computing systems can very substantially enhance the computational throughputs for specific applications. CSIR-CEERI developed a complete design methodology for the design of RCS systems and the associated Reconfiguration Flow, which can be implemented through Field Programmable Gate Arrays (FPGAs). The methodology supports dynamic partial reconfiguration to swap in and swap out hardware function blocks based on their requirement as the computation proceeds. Institute designed many digital signal processing (DSP) blocks such as FFT, DFT, DCT, IIR and FIR Filter units as partial reconfigurable units. Their implementations on ML 410 boards with Xilinx Virtex-4 FX60 FPGA device under a RTOS (VxWorks) environment as well as on a standalone basis have been fully tested using CSIR-CEERI developed reconfiguration flow.

6MV LINAC machines

Linear Accelerators (LINAC) machines are increasingly being used these days for treatment of patients suffering from cancer and with advancements like Intensity Modulated Radiation Therapy (IMRT) and Image Guided Radiation



Fig. 1.84. 6MV LINAC Machine

Therapy (IGRT), the dose delivery and treatment outcome have become far improved. A milestone was reached in the fabrication of two more 6MV LINAC machines using advanced optical positioning systems for range and precision enhancement. Each machine, bearing the CSIR-CSIO logo, is under constant use for cancer patient treatment at the leading hospitals. The process of technology transfer is under way for its commercial utilisation.

Electronic knee joint

The aim of this work was to design knee according to the gait parameters of the user to make it adaptive as per the needs of the patient. There are low-cost prosthetic products available in the international market but they are merely a poor cosmetic replacement of amputated lower limb. They are not able to perform coordinated and complex movements. Sophisticated electronic knee are available but they are far expensive. An Electronic Knee from leading companies costs around ₹ 18-20 lakhs.

The Electronic Knee developed by CSIR-CSIO consists of electro-goniometer and Force Resistive



Fig. 1.85. Electronic Knee Joint

Sensor as sensor mechanisms. Knee design is based on controlling a swing phase using a pneumatic cylinder mechanism attached with the drive (motor) control mechanism to its flow control valve. The required energy to extend the knee into new gait cycle is provided by a spring mechanism. The total length of knee is 40 cm, weight 1600g, flexion angle 60° having a weight-bearing capacity upto 100 kg. Interactions with AIIMS were made for clinical trials with possible patient feedback. Current cost of the knee works out to be approx. 50,000.

Anaesthesia delivery workstation

Balanced anaesthesia is the optimum control of its four distinct components i.e. hypnosis (unconsciousness), analgesia (pain), amnesia (loss of memory) and paralysis (loss of motor activity). These components are monitored for determining the Depth of Anaesthesia (DoA) during surgery. CSIR-CSIO already determined hypnosis component earlier and achieved Real-Time automatic estimation of drug for desired DoA. A Fuzzy PID controller was realised for automated drug delivery. The designed controller is able to predict the drug increment/decrement depending on the current anaesthetic depth of the patient. The controllers are provided with a feature of setting the range (higher fixed point and lower fixed point) of the Aspect Medical System's BIS index, where

the anaesthesiologist would like the patient's BIS Index to remain within the anaesthetic range during surgery. If the patient's BIS index goes outside this range, a continuous beep alarm will be initiated till the BIS index falls back to the predefined range.

Type approval to airborne unit of HUD accorded by the Center for Military Airworthiness & Certification (CEMILAC), Bangalore

The airborne unit of Head Up Display (HUD) developed by CSIR-CSIO was accorded type approval by the Center for Military Airworthiness & Certification (CEMILAC), Bangalore. The type approval certification is required for all airworthy equipments and systems before they are formally cleared for bulk production and induction in the actual production version of the aircraft. It is a milestone which indicates that the CEMILAC, which is responsible for according approval for airworthy systems, has approved the stability of design considering its performance during full scale qualification tests (FQT) and subsequent series of trials.

Opto-electronic instrumentation for studies of terminal ballistics

Opto-electronic instruments are widely used to study various parameters of the small caliber projectiles, particularly the events just before and after they hit the target. Choice of the instruments and techniques depend heavily on the projectile, the parameters to be studied/ measured and environment of the work place. One of the most common yet extremely useful techniques to study projectiles is high speed photography and shadowgraphy. Keeping in view the requirements of Terminal Ballistics Research Laboratory (TBRL), Chandigarh under DRDO, CSIR-CSIO developed two opto-electronic instruments namely Laser Based Projectile Velocity Measurement System and Ultra High Speed Multiple Laser Based Digital Shadowgraphy System for Terminal Studies of Small Arms & Ammunitions. The developed velocity measurement system was installed at TBRL and tested successfully using various guns like SMC, AK-47, SLR, Bolt Action, INSAS, SNIPPER etc.



Fig. 1.86. Nanoprobe and optical tweezer application

Optical fiber nanoprobe for nano photonics

CSIR-CSIO invented a novel technique for fabrication of best ever optical fiber nanoprobe, an indispensable optical element used in nanophotonics research and applications, namely, metamaterial, nano-optical tweezers, Near-field scanning optical microscopy (NSOM), tip-enhanced Raman scattering and nano-sensor. The technique has been well established with more than 70% yield. It is a very low cost technique and can be produced in mass. The probe has excellent quality of optics. The optical tweezer has been successfully used as unique probe for manipulating 200 nm silica particle in 3D from an aqueous solution. Such non-plasmonic nano-manipulator will be promising for research and application in the area of optical-tweezer.

Assessment of the protection quality of custom-made mouthguards using FBG Sensor

Individual sports like riding and skating puts a person at risk for injuries to jaws. There is no

standard technique yet to evaluate the performance characteristics of such custom made mouthguards worldwide. FBG strain sensors were specially designed, fabricated and experimentally validated by CSIR-CSIO to assess the protection quality of custom-made mouthguards with respect to various impact loads. Two sets of FBGs were used; one at the mouthguard surface and the other at similar position on a jaw model.

Fiber ring resonator (Knot Type) Sensor

CSIR-CSIO developed combined single-mode/multi-mode/single-mode fiber ring resonator structure using a novel but simple approach. The resonator produces consistent and uniform spectrum which is useful for various sensing applications. The resonator is highly sensitive to external perturbation especially the refractive index. The performance of this device has been tested as a chemical sensor for various liquids like Methanol, Ethanol, IPA, Glycerine etc. A sensitivity index of 172 nm/RIU was achieved.



Fig. 1.88. Knot type ring resonator made from etched micro multimode fiber

A dynamo model with double diffusive convection for Mercury's core

CSIR-NGRI generated Planetary Magnetic fields in liquid core through a dynamo mechanism. Core convection required for the dynamo action is



Fig. 1. 87. Jaw Model, Mouth guard and the Experimental Setup

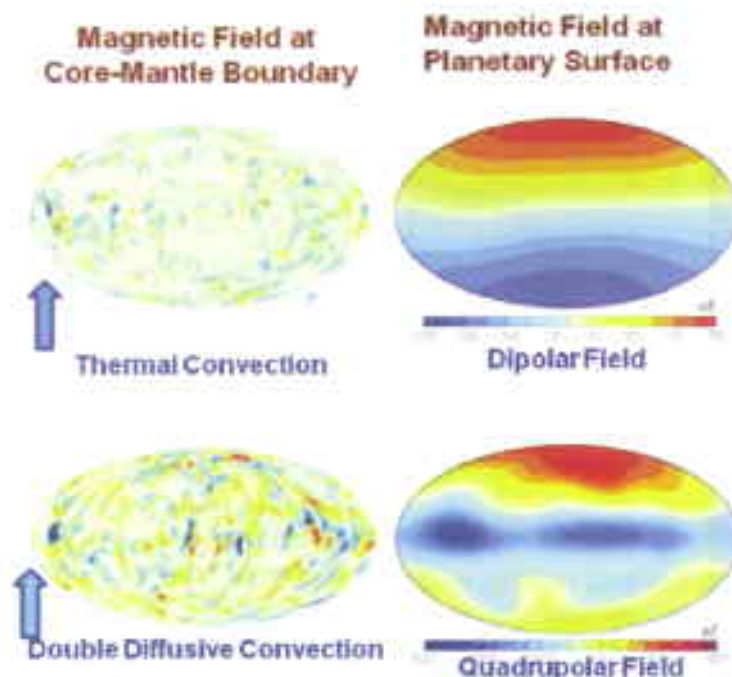


Fig. 1.89. Simulation Results

considered to be mainly driven by heat. Scientists of CSIR-NGRI considered the effect of several light elements (C,S, etc.) during solidification of the core (Double Diffusive-compositional and thermal Convection) in dynamo models taking the planet Mercury as an example. This effect significantly influences the strength and pattern of the simulated magnetic field and has implications for planetary evolution. The following picture illustrates the results of simulation.

Fluoride dynamics in granitic aquifer, Wailapally, Nalgonda, Andhra Pradesh

Most of Indian shield has a granitic basement and at many places geogenic fluorosis forms a major health hazard to communities dependant on groundwater. Nalgonda District, Andhra Pradesh is one of the worst effected by fluorosis. This is ascribed to high (3.5-7.5 mg/l) fluorine (F) content in groundwater (admissible limit <1.5 mg/l). Fluorine dispersal in the Wailapally watershed, Nalgonda district has been investigated by CSIR-NGRI. The study involved analyses of about 500 groundwater samples, few hundreds of soil samples and many rock samples. 95% of the groundwater samples contain Fluorine conc. higher

than the permissible limit. For the first time, this study clearly shows that calcretes (hydrated calcium carbonate that forms in the soil due to recurrent transportation / evaporation of soil moisture) play a crucial role in the Fluorine distribution pattern of groundwaters through fluorine retention during calcrete formation and release during their breakdown.

Genesis of phosphorites

CSIR-NGRI carried out extensive work in the offshore regions of the east and west coast of India with evidence of formation of phosphorites by microbial processes. The results suggested that the nodular phosphorites represent phosphate clasts related to phosphate stromatolites formed in intertidal conditions. At high energy conditions, the microbial mats were disintegrated into phosphate clasts and reworked into the shales in the form of nodular phosphorites. This emphasizes the fact that microbial processes play an important role in all the phosphorites and Quaternary phosphorites from the continental margins serve as analogs for ancient phosphorites.

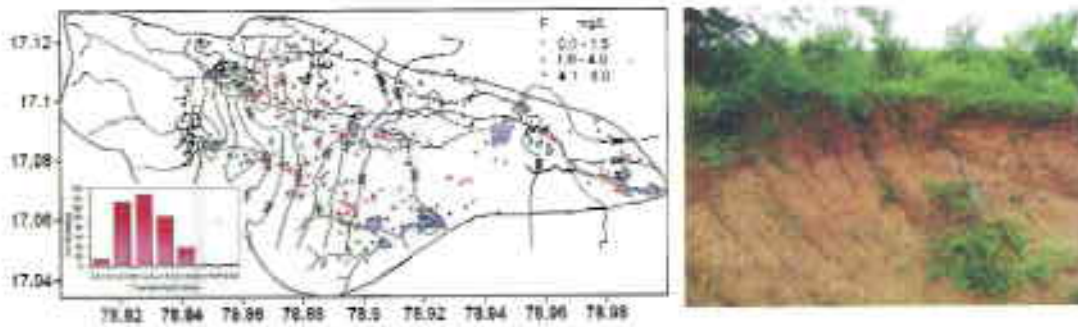


Fig. 1.90. Layer of calcareate in the soil

Surface water characteristics in the southern Bay of Bengal during the last 60,000 years

Stable oxygen isotopic studies on the planktonic foraminifera (*Globigerinoides ruber*) from a deep sea sediment core (SK157-14) of the southern Bay of Bengal have shown significant variations in surface water characteristics for the last 60,000 year. The variations in $\delta^{18}\text{O}$ of *G. ruber* are suggestive of large changes in the sea surface temperature and/or salinity since the last glaciation (Figure 1.91). The $\delta^{18}\text{O}$ values are significantly higher compared to the sediment cores in the northern Bay of Bengal and the Andaman Sea because of the diminished influence of riverine fresh water fluxes. The

chronology of this gravity core (water-depth 3306 m; lat. 5 \circ 11'N; long. 90 \circ 05'E) was established by CSIR-NGRI using Accelerator Mass Spectrometric (AMS) radiocarbon ages and oxygen isotope stratigraphy. Large variations in planktonic $\delta^{18}\text{O}$ during the Marine Isotopic Stage (MIS) 3.1 and 3.3 are probably caused by the changes in sea surface temperature. Glacial to Holocene $\Delta\delta^{18}\text{O}$ amplitude (1.8‰) in core SK157-14 is consistent with other published oxygen isotope records from the nearby locations. Maximum enrichment in $\delta^{18}\text{O}$ occurs at 24-19 and the minimum during 7-6 ka Before Present. Spectral analysis of planktonic $\delta^{18}\text{O}$ time series suggests a

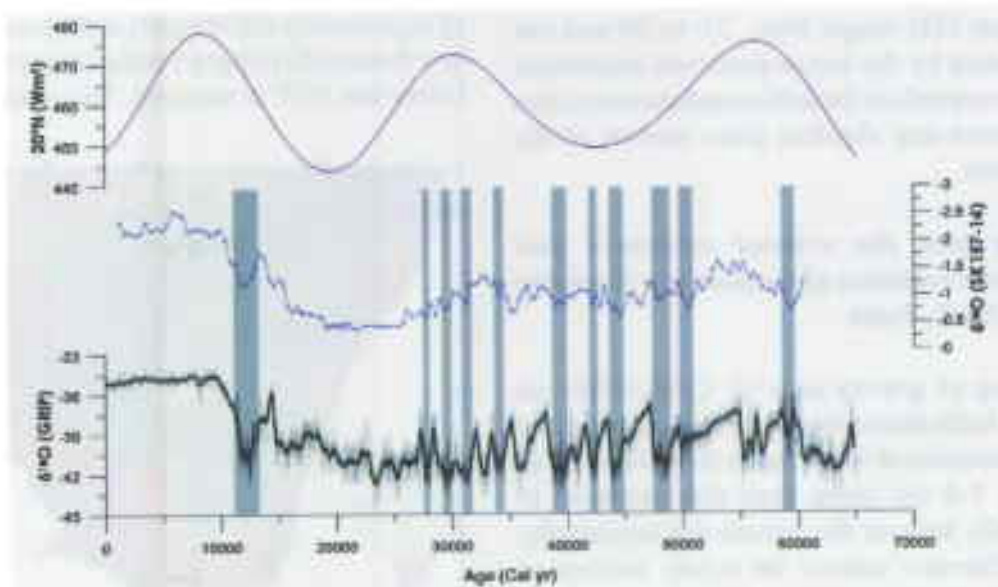


Fig. 1.91. Planktonic foraminiferal $\delta^{18}\text{O}$ record from core SK157-14 compared with GRIP ice core record to show correlation of cold (stadial) events of North Atlantic with enriched $\delta^{18}\text{O}$ values. Most of the cold events of North Atlantic coincide with $\delta^{18}\text{O}$ enrichment in southern Bay of Bengal. Top of the panel shows August insolation at 20°N.

teleconnection between surface water $\delta^{18}O$ in the southern Bay of Bengal and the North Atlantic climate oscillations.

Seismic anisotropy of South Indian shield

Shear wave splitting measurements from 51 digital broadband seismological stations spanning one of the most complex Archean Cratons of world, the Dharwar Craton and the Southern Granulite Terrain of India were performed by CSIR-NGRI using core refracted phases like SK(K)S and PKS. The variations of the fast polarization directions, suggest a complex anisotropic structure that cannot be adequately explained by a single anisotropic layer with horizontal axis of symmetry. The azimuthal variations have an apparent 90° periodicity and thus can be best explained by a two-layer anisotropic model with horizontal axis of symmetry. Unlike previous results, strong correlation was found between fast polarization direction (FPD) and the regional geology suggesting causative source of anisotropy to be from lithosphere. Modelling suggests that the whole Craton is consistently characterized by two layers of anisotropy. The FPD for the upper layer is in the range of 100° to 107° and is sub parallel to the pre-existing lithospheric structures whereas lower layer FPD ranges from 25° to 26° and can be explained by the lattice-preferred orientation of olivine crystals in the asthenosphere associated with present-day absolute plate motion of the Indian plate.

Insights into the crustal structure and geodynamic evolution of the Southern Granulite Terrain (SGT), India

Modelling of gravity data by CSIR-NGRI on southern India shows that the seismically derived crustal thickness of 43-44 km in the SGT is, on an average, 7-8 km more than that required to isostatically balance the present-day topography. This difference cannot be solely explained applying a constant shift in the mean sea level crustal thickness of 32 km. The isostatic analysis thus indicates that the present-day topography of the SGT is overcompensated and about 1.0 km of

the topographic load must have been eroded from this region without any isostatic readjustment.

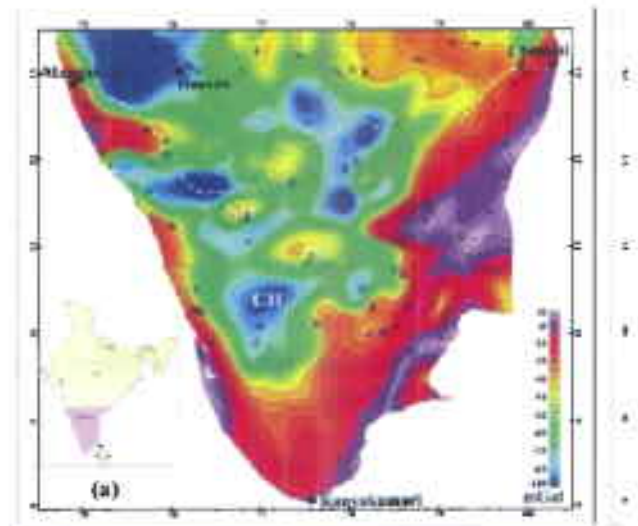


Fig. 1.92. Geoid corrected complete Bouguer anomaly map of the SGT

The observed gravity anomaly suggests that there is no such overcompensation. Thermal perturbations up to the Pan-African stage, present-day high mantle heat flow and low elastic thickness of the lithosphere together negate the possible resistance of the lithosphere to rebound in response to erosional unloading. To isostatically compensate the crustal root compatible to seismic Moho, a band of high-density (2930 kg m^{-3}) in the lower crust and low density (3210 kg m^{-3}) in the lithospheric mantle below the SGT is required. The resulting Moho

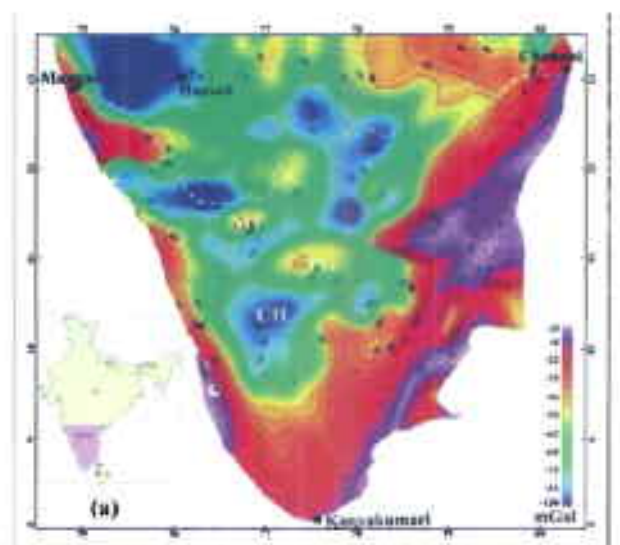


Fig. 1.93. Map showing depth to the Moho for the SGT

depth map is shown in a relatively denser crust and highly mobilized upper mantle reduced significantly the root buoyancy that kept the crust pulled downward in response to the eroded topography.

Seismic image of the Indian crust underthrust beneath Sikkim Himalaya

The seismic character of the underthrusting Indian crust in the Sikkim Himalaya is deduced by CSIR-NGRI through an analysis of ~3600 receiver functions (RFs) abstracted from waveforms registered at eleven broadband stations spanning a 110 km long N-S profile from the foothills to the higher Himalaya (Figure 1.94). Common conversion point stacks of receiver functions prominently trace the northward dipping geometry of the Indian Moho beneath the Himalaya. Monte Carlo inversion of the azimuthal variations of the RFs at individual stations adopting the nearest neighborhood algorithm approach reveals that the crustal thickness varies from ~40 km to 61 km from south to north, with a dip varying between 4° and 10°.

A Moho doublet prominently seen at a depth of ~40 km in the higher Himalaya to the north of Main Boundary Thrust (MBT), has been interpreted in terms of possible (partial) eclogitization of a granulitic Indian lower crust, akin to the finding beneath southern Tibet immediately north of the study area. A strong layer of anisotropy (~17%)

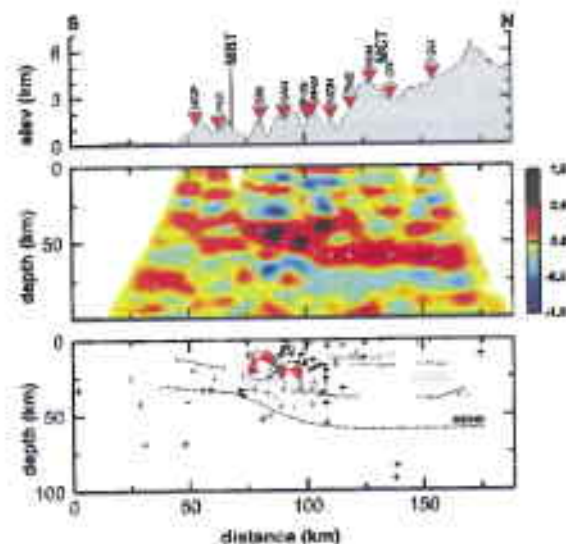


Fig. 1.94. Migrated image of SV receiver functions along a south-north profile at 88.55° longitude.

localized within a low velocity layer between 20 and 30 km has a NW-SE oriented fast polarization direction counter intuitive to the convergence-parallel and range-perpendicular alignment expected in a convergent setting, due to shear processes. Mid-crustal transcurrent deformation in Sikkim and Bhutan, evidenced by a conjugate system of strike slip faulting with NW to NE trending P-axis orientations is the most feasible mechanism for causing a near strike parallel oriented fast axis of anisotropy in this segment of Himalaya.

2D-High Resolution Seismic (HRS) Surveys for identification of Lignite in Rajasthan

High resolution seismic studies by CSIR-NGRI in the Kagau and Chokla blocks, Barmer District and

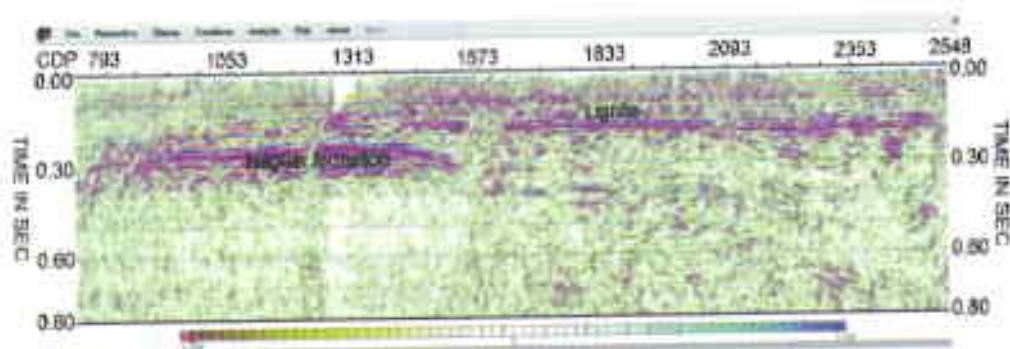


Fig. 1.95. 2D-HRS survey processed seismic section along Kagau block

at Merta city, Nagaur District of Rajasthan helped in delineation of lignite beds associated with the Nagaur Formation. (Figure 1.95) shows the reflections corresponding to the Nagaur Formations and lignite deposition in the disseminated form.

Short Term Earthquake Forecasts at Koyna, Maharashtra

Earthquake activity is being monitored by CSIR-NGRI in real time at the Koyna reservoir in western India leading to many successful short term forecasts of $M \sim 4$ earthquakes since August 2005. The basis of these forecasts is the observation of nucleation that precedes such earthquakes. A total of 29 earthquakes were reported in the magnitude range of 3.5 to 5.1 between August 2005 and May

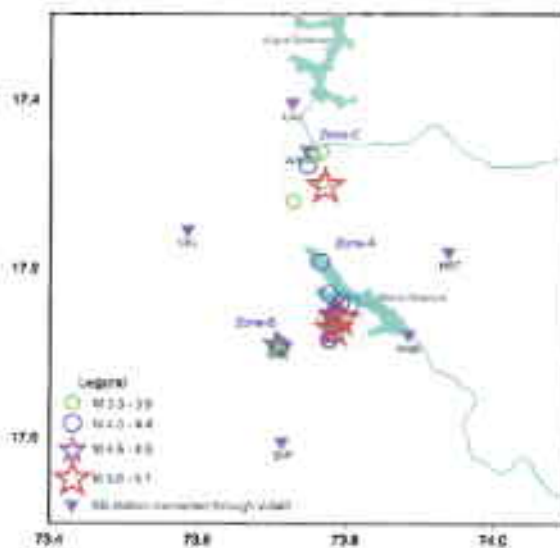


Fig. 1.96. Earthquakes of magnitude range 3.5 – 5.1 in the Koyna-Warna region between August 2005 and May 2010

2010. These earthquakes could broadly be put in three zones, A, B and C (Figure 1.96) with 18, 5 and 6 earthquakes respectively. Earthquakes in Zone-A are preceded by well defined nucleation, while it is not the case with zones B and C. This indicates the complexity of the earthquake processes and the fact that even in a small seismically active area of only 20 km x 30 km, earthquake forecasting is difficult.

Site amplification studies for seismic microzonation

(a) Jabalpur urban area, Madhya Pradesh

Site amplifications at over 100 sites in the frequency range of 0.1–10 Hz were investigated by CSIR-NGRI using the conventional Nakamura technique of computing H/V spectral ratios, to estimate the predominant frequencies and corresponding amplifications at each site. To validate these results, Multichannel Analysis of Surface Waves (MASW) technique was adopted, coupled with refraction measurements over short profiles (~100 m) and synthetic seismograms. The local site amplifications compare fairly well with the H/V results enabling proper interpretation of the composition and thickness of the upper soil cover and its hazard potential. The study indicates the importance of a multi-disciplinary approach for better understanding the site amplification characteristics in any seismically active region.

(b) Indo-Gangetic Plains

Site amplification studies assume significance due to its earthquake vulnerability owing to close proximity of the Himalayan seismic zone. New data was acquired from an array of 10 broadband seismographs operated by NGRI, across the central Indo-Gangetic Basin in a N-S direction. From the recordings of shallow earthquakes at soft sites and hard reference sites, standard spectral ratios (SSRs) were computed. Calculations based on reasonable earthquake source and attenuation models and application of random vibration theory suggest that Peak Ground Acceleration and Peak Ground Velocity at soft sites near the foothills, located 100 km from the epicenter, would be amplified by a factor of 2-4 and 6-12, respectively. All these results assume linear behavior of the sediments. Although, this assumption would not be valid during intense motions resulting from large/great earthquakes, the results, nevertheless, provide basic building block for incorporating nonlinear behaviour.

Integrated approach for hydrogeological management at Uranium mine sites

(a) Thummalapalle, Cuddapah district, AP

Micro-level resistivity imaging and ground magnetic studies helped in the delineation of buried dyke (an intrusive magmatic body). This helped in the realignment of the tailing pond bund axis at Thummalapalle uranium mine site (Figure 1.97). Hydrogeochemical studies based on two exploratory boreholes drilled on either side of the concealed dyke proved that the dyke serves as a hydrogeological barrier.

(b) Jaduguda and Turamdih, Jharkhand

Integrated geohydrological studies carried out in Jaduguda Tailings Pond Watershed characterized the closed tailings ponds and downstream of active tailings pond area in terms of soil physical & hydraulic properties; sub-surface hydrogeological conditions; surface and groundwater hydrochemistry; delineation of plausible palaeo stream channel pathway of pollutant migration; etc. Using the resistivity tomography, the tailings thickness and disposition was mapped clearly in one of the closed tailings pond (Figure 1.98). The effluent nature of the stream carrying the polluted groundwater was identified and remedial measures for arresting the migration of pollutants through groundwater were evolved.

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



Fig. 1.97 Micro-level resistivity images with ground magnetic image inside the tailings pond area

the bottom simulating reflection/reflector (BSR) and the gas hydrate stability zone thickness map of India. CSIR-NIO 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 geomorphology. 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

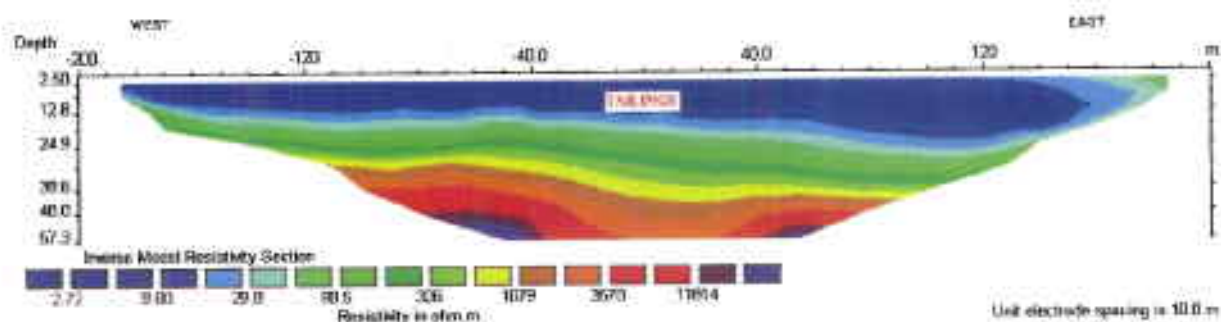


Fig. 1.98. Transverse Resistivity Image Section at Closed Tailings Pond

concentration with core depth. Total organic carbon varied from 0.6 to greater than 2.0% and CaCO_3 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.

Studies by the CSIR-NGRI contributed to: (a) Updating gas hydrates stability thickness map and provide information on the depth window within which proxies for gas hydrates can be looked into (b) Provide a method of estimating attenuation (Q-1) showing that gas-hydrate-bearing sediments are associated with low attenuation (c) Estimation of 5-15% gas hydrates in Andaman basin using the impedance inversion and calibration by log data (d) Demarcation of lateral extension of gas-hydrates (90-130 m) and free-gas (140-180 m) bearing sediments across a BSR in KK basin in the Arabian Sea using travelttime tomography of MCS reflection data (5) Identification of widespread occurrences of BSR (Marker for gas hydrates) in Mahanadi and KG basins from analysis of newly acquired MCS data, and (6) Improved seismic sections using state-of-the-art pre-stack depth migration of newly acquired MCS data in both KG and Mahanadi basins.

Record of early diagenetic conditions through quaternary and formation of authigenic Fe-minerals

Three sediment cores from the eastern Arabian Sea were investigated by CSIR-NIO for better understanding the bottom water oxygen history during the past 140 ka and record of early diagenetic conditions during the last 35 kaBP. The enrichment of redox sensitive elements (Re, U, Cd and Sb) at Marine Isotope Stage 5 (5b and 5d) and glacial termination II indicate suboxic bottom water conditions. Marine Isotope stages 1, 3, 4 and interstadials of Marine Isotope Stage - 5 (5a, 5c, & 5e) were associated with near oxic conditions. The lack of enrichment of Mo and V above crustal

abundance and a high Re/Mo (ppm/ppm) ratio (avg. 18.2×10^{-3}) suggest that sediments never contained free H_2S during the past 140 ka.

Placer chromite along south Maharashtra, coast of India

CSIO-NIO studied the onshore occurrence of placer chromite, its mineralogy, geochemistry and reserve potential from a 12.5 km stretch (Pirwadi-Talashil) of south Maharashtra coast, India. The sediments in these areas are moderately well to very well sorted. The heavy mineral concentration ranges between 0.69% and 98.80% (av. 18.87%), increases from north to south, and comprises of ilmenite, magnetite and chromite, whereas garnet, pyroxene, amphibole, zircon, tourmaline, rutile and staurolite are in minor proportions. The concentration of chromite within the heavy mineral fraction ranges between 0.64% and 12.35%, whereas in the bulk sediment it ranges from 0.05% to 10.90%. The chromite grains are rounded to sub-rounded, marginally altered along their border and are ferro- and magnesio-chromite varieties with 32.06 – 48.3% Cr_2O_3 , $\text{FeO} + \text{Fe}_2\text{O}_3$ between 23% and 27%, and MgO between 3.31% and 14.86%. The chromite grains have been derived from ultrabasic rocks and chromitites present at the upper reaches of the Gad river. The observed occurrence and variation in the distribution of chromite is due to the differences in the sediment supply from the Achara and Gad rivers, their sorting and associated oceanographic processes. The inferred reserve of chromite is about 0.032 mt.

Technology for disinfection of ballast water of ship

CSIR-NIO has developed an apparatus for disinfection of ship's ballast water such as sea water based on hydrodynamic cavitation. The disinfection of seawater / ship's ballast water was achieved by hydrodynamic cavitation and the method does not involve use of any chemicals or any chemical reaction. The invented apparatus and method is simple, eco-friendly and can be fitted on to existing intake and discharge systems of any ship with minor modifications. It poses no risk to

the health of the ship's crew unlike chemical methods and requires no special skill or additional manpower for its operation. The apparatus and method is capable of effectively sterilizing hazardous organisms contained in ballast water stored in a ballast tank.

Effect of total Solar Eclipse

Detailed study of solar eclipse delineates significant information about ionospheric responses. In recent past, India witnessed two total solar eclipses- first on 22nd July, 2009, and second on 15th January, 2010. CSIR-NPL studied both the solar eclipses, first one at Bhopal and second one at Thiruvananthapuram for investigation of ionospheric responses. During the events, the signature of induced gravity waves were detected, which is responsible for intensification of Es-layer electron density over the totality path. Observations of Total Electron (TEC) during the Annual Solar Eclipse event show depletion over the eclipse path. Validation of IRI-2007 model against the observed TEC values over Indian region was done. Signature of gravity waves in the troposphere was detected during the solar eclipse of 22 July 2009 at CSIR-NPL.

National energy sector GHG emission inventory

CSIR-NPL developed a national GHG emission inventory for greenhouse gases (GHGs) like CO₂, CH₄ and N₂O which are emitted from fossil fuel combustion in electricity generation from coal based thermal power plants in India. Based on the IPCC methodology, emissions estimates from this sector have been made for the period 1999 to 2008 for the country. These estimates reveal that while the Coal consumption has gone up from 225.7 million tons in 1999 to 356.2 million tons in 2008, the CO₂ emissions have increased from 425.8 Tg to 659.8 Tg. CH₄ emissions have increased from 4.43 Gg to 6.87 Gg and N₂O emissions have gone up from 6.65 Gg to 10.30 Gg during this period. The scenario of state level GHG emissions reveals significant increases during this period in states like UP, Maharashtra and Andhra Pradesh (Fig. 1.99).

Aerosols in the Indo-gangetic plain region

CSIR-NPL studied the sources of PM10 among the analyzed ions, on an average NH₄⁺, NO₃⁻ and SO₄²⁻ together contributed 87% of total mass of water soluble fraction in PM10 aerosols during Land campaign II at Allahabad. Potential source

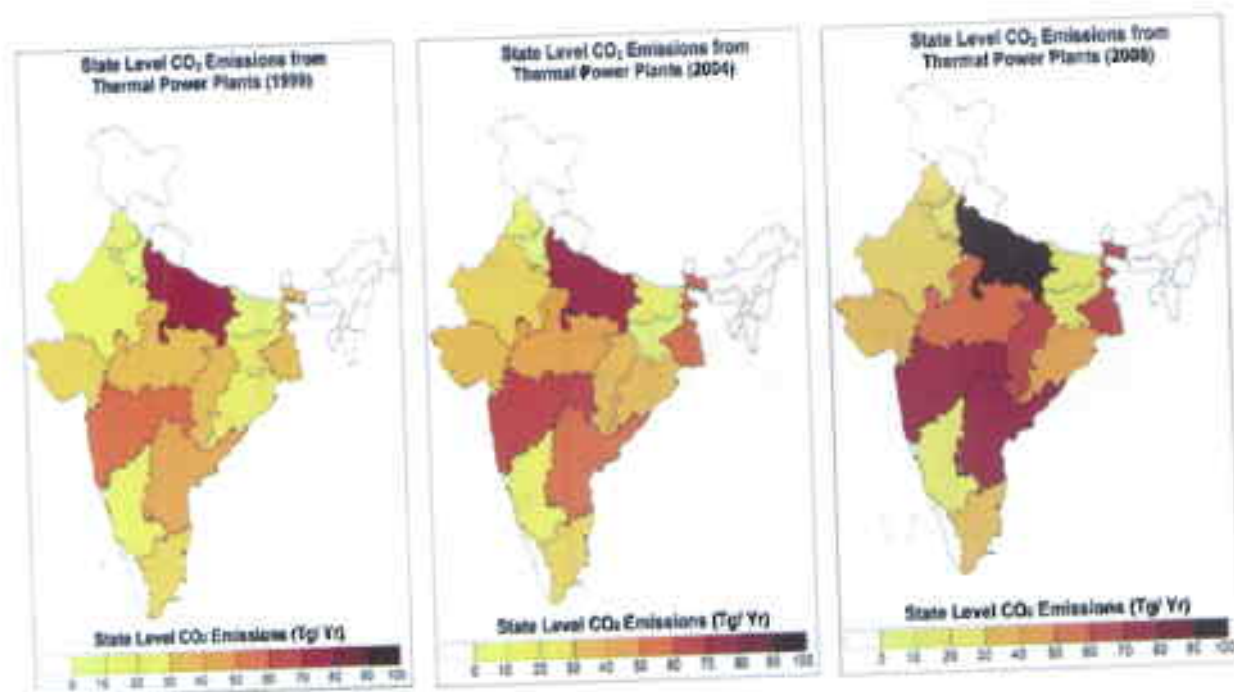


Fig. 1.99. State level CO₂ emissions from Coal Fired Thermal Power Plants

contribution function analysis identified Uttar Pradesh, Punjab, Haryana, and northern Pakistan as source regions for NO_x . The thermal power plants in UP and Haryana, agricultural farms along Punjab, Haryana, and UP belt were sources of nitrates and/or its pre-cursors while emissions from cattle excreta and application of nitrogenous and ammoniacal fertilizers are likely to have contributed to ammonia emissions.

Enhancement of light extraction efficiency of organic light emitting diodes using nanostructured indium tin oxide

Improved outcoupling efficiency of light is demonstrated by inserting a nanostructure film of indium tin oxide (NSITO) between ITO anode and glass. CSIR-NPL fabricated nanostructured films of ITO by using glancing angle deposition technique at an angle of 85° from that of substrate normal. Conducting ITO films were grown on the NSITO films and these films were characterized for transparency. OLEDs with the NSITO films inserted between glass and conducting ITO enhanced outcoupling efficiency in comparison to the reference OLED. Transparency was enhanced with the insertion of NSITO films between glass and conducting ITO. Electroluminescence spectrum at various viewing angles was found to be unchanged and the technique was found to be direction independent unlike the other techniques for outcoupling efficiency enhancement.

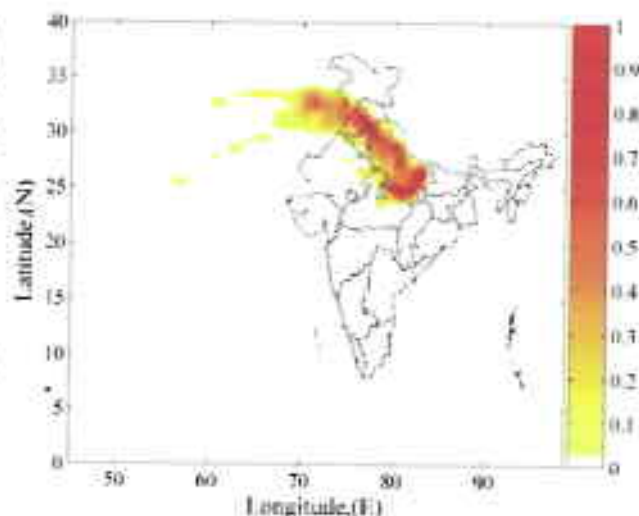


Fig. 1.100. Aerosols in the Indo-Gangetic plain

Single or double layer graphene sheet from re-exfoliation of expanded graphite

Graphene (Gr), as the fundamental 2D carbon structure with exceptionally high crystal and electronic quality, has emerged as an important material in the field of material science. It is the thinnest known and the strongest ever measured material in the universe. Both single and double layer graphene (Gr) were produced by CSIR-NPL from sonication and centrifugation of re-exfoliated expanded graphite (EG) in an organic solvent. The prepared Gr-sheets are identified by Ultraviolet-visible spectroscopy and characterized using

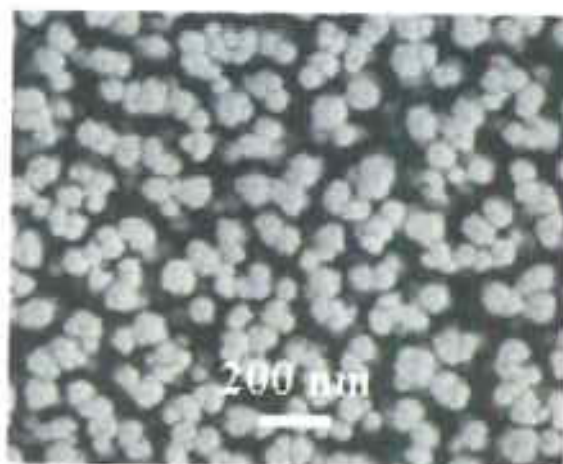


Fig. 1.101(a). SEM of ITO

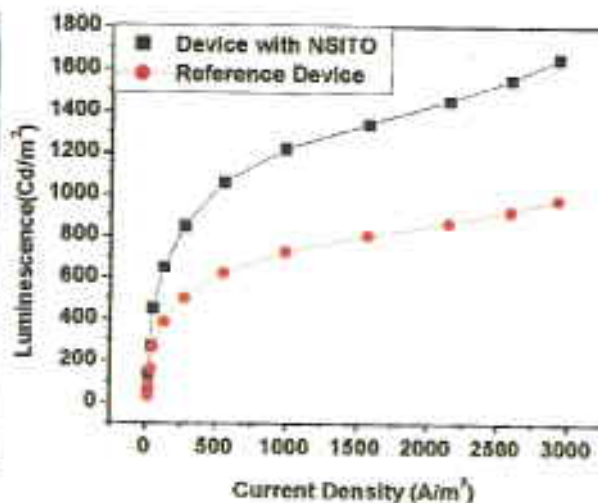


Fig. 1.101. (b) Electroluminescence spectrum

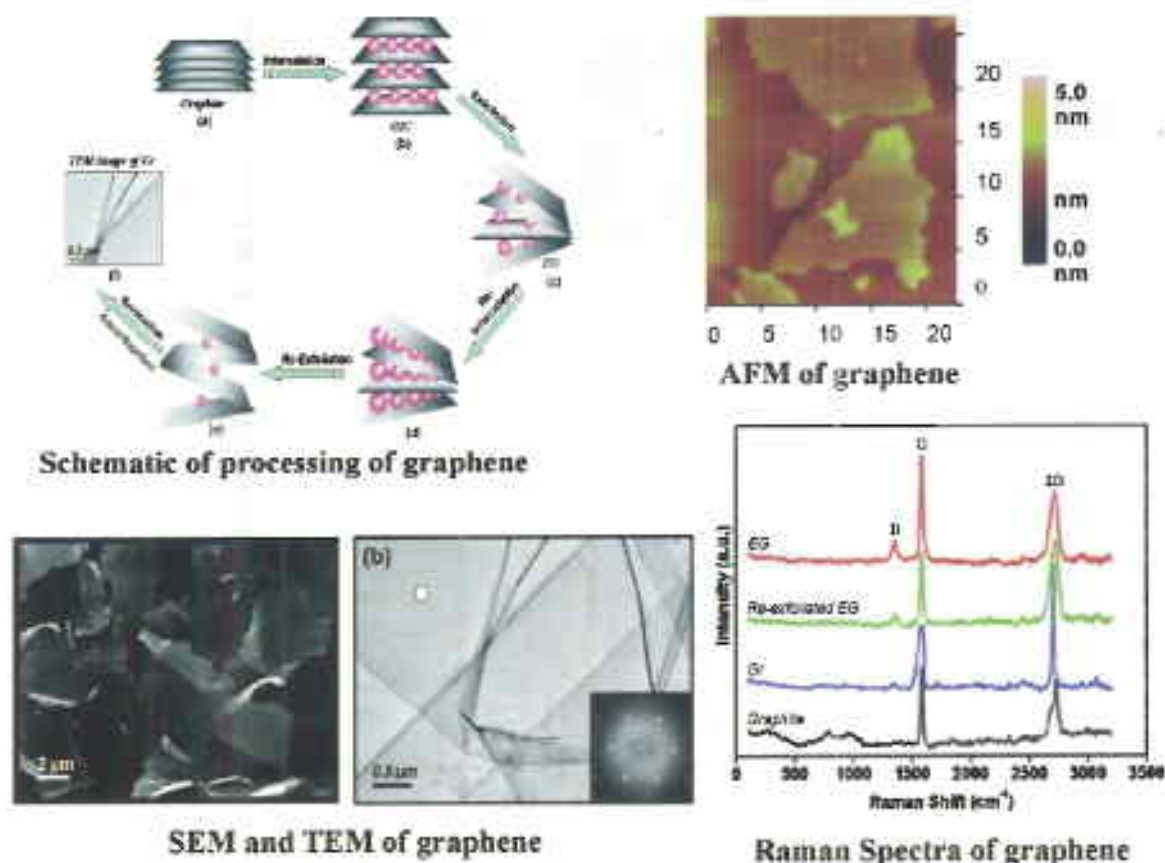


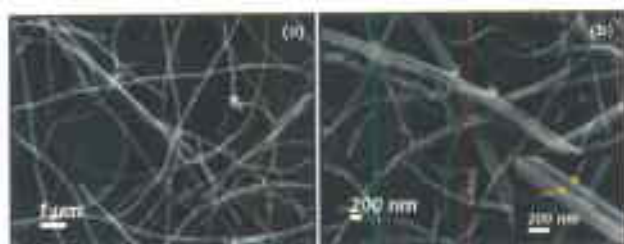
Fig. 1.102. Processing and characterization of Graphene produced by wet technique

different techniques. Transmission and scanning electron microscopy observations show that the Gr-sheets have an area of $\sim (12 \times 10) \mu\text{m}$. The selected area electron diffraction analysis and Raman spectroscopy have confirmed the presence of single layer Gr-sheet. The $I(2D)/I(G)$ ratio from Raman spectrum of Gr is found to be ~ 1.7 which suggests the presence of single and double layer Gr. Scanning Probe Microscopy studies reveals that on re-exfoliation of EG, thickness of Gr-layer decreases from 6-7 nm to 0.75-1.075 nm. This suggests that re-exfoliation overcomes the problem of insufficient oxidation or inadequate pressure buildup during heat treatment. PL spectrum of Gr depicts the emission of blue light at $\sim 390 \text{ nm}$ which indicates the presence of some functional groups. These Gr-sheets should facilitate the manipulation and processing of Gr-based material for various applications.

Multi-layer graphene nanoribbons from thermally reduced unzipped MWCNTs

An easy and scalable approach is adopted by CSIR-NPL for the production of multi-layer graphene nanoribbons (GNRs) from thermally treated unzipped multi-walled carbon nanotubes (MWCNTs) by controlled oxidation and intercalation followed by heat treatment at 1000 and 2500 °C. After oxidation and intercalation, unzipped MWCNTs thickness varies depending on the diameter of starting MWCNT and the variation in width could be due to the displacement of graphene layers during sonication. The sonication process is responsible for chemo-mechanical breaking and the separation of multi-layer nanoribbons.

On thermal treatment of unzipped MWCNTs at 1000°C, some individual GNRs are observed due to the exfoliation which might be caused by the sudden evolution of volatiles product between the



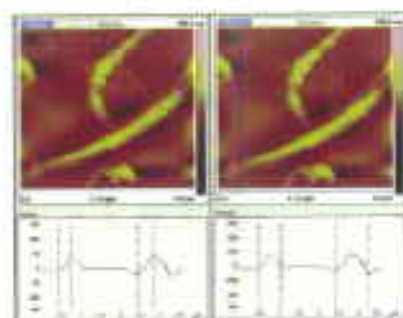
SEM of MWCNTs and Unzipped MWCNTs



TEM of unzipped MWCNT with shallow shape



Schematic of the preparation of GNRs



AFM of unzipped MWCNTs

Fig. 1.103. A process for producing Graphene sheets by unzipping of MWCNT

layer. However, after heat treatment at 2500 °C, the GNRs produced are of high purity and quality with a yield of > 70 %. The high temperature (2500°C) treatment can able to restore π -conjunction in the GNRs which can help in improving transport properties. In contrast to corresponding 3-D graphite, electrons in a multi-layer GNR may confine along one crystallographic direction can open up enormous opportunities to take advantage of the unique properties of GNRs for many technological applications.

Highly efficient luminescence from hybrid structures of ZnO/multi-walled carbon nanotubes for high performance display applications

CSIR-NPL successfully synthesized and established the strong green luminescent emission properties of ZnO/MWCNT. Recently, ZnO hybrid structures have received much attention because of the ability to tune the optical properties by hybridizing them with different materials. At nanoscale, hybridization of ZnO with other materials alters the properties of both components which may give rise to functional materials with desirable properties.

The hybrid nanostructures were synthesized via high temperature sintering method. The strong green emission at 510 nm has been attributed to surface defects of ZnO, originating from interactions between ZnO and MWCNTs surfaces.

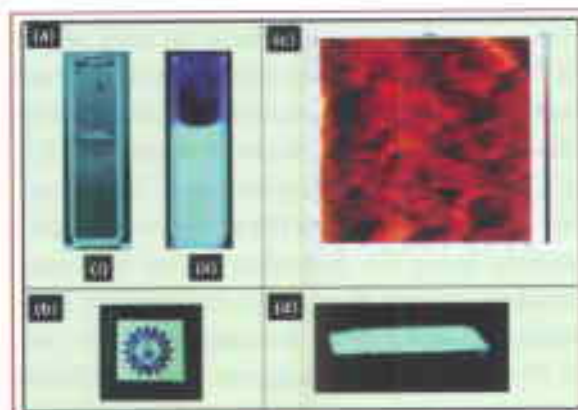


Fig. 1.104. Typical photograph of quartz-cuvette containing ZnO/MWCNTs hybrid material dispersed in SHMP(sodium hexameta-phosphate ; (a)-(i) depicting the transparency of the colloid under room light, (a)-(ii) showing strong green-emission at 510 nm under UV 370 nm light, (b) transparent layer showing 82% transparency, (c) AFM image shows uniformity of the film formed from ZnO/MWCNTs hybrid material, (d) when the transparent layer is exposed to 370 nm light it shows strong green emission.

These hybrid structures can be useful for various types of applications.

Cesium Fountain

CSIR-NPL has been developing a cesium atomic fountain primary frequency standard. The Physics package of the fountain is completely assembled and the overall vacuum in the flight region is better than 10^{-9} Torr. The developed optical set-up delivers six cooling and two detection beams via single mode polarization maintaining fibers to the physics package. At the output end of the fibers, the beams are collimated with home-made beam expanders and give out the desired beam size and polarization. Scientists of CSIR-NPL succeeded in trapping Cs atoms in the magneto-optical trap (MOT) and characterized them to measure the number of atoms, temperature and size of the cloud. They are able to trap about 10^7 atoms and cool them to about 6 μ K by both MOT and polarization gradient cooling (PGC) and launch them up by moving molasses method. The fountain action has been demonstrated by launching the atoms up to 1.1 m up and detection of the return signal by measuring the fluorescence.



Fig.1.105. Cs-Fountain

Optical radiation standards

CSIR-NPL using correlated photon metrology experimental setup carried out fundamental studies on sub-wavelength interference with pseudo

thermal light. This becomes the basis of establishing quantum base for the classical standards of optical radiation. The phenomena of interference and polarization were also studied in both space-time domain and space-frequency domain. Basic research on optical coherence for its application on encoding and information processing was pursued further. Three different compounds namely 5- fluorouracil, Indinavir sulfate and Nelfinavir were chosen for this study. Thermal stability, photo stability and chemical stability were studied as per ICH guidelines. The results suggest that vibrational spectroscopy can be used as a simple, rapid and reliable stability indicating technique to assess the stress stability of pharmaceutical compounds.

Low-cost portable ECG device

A high quality, low cost and portable ECG device, HEARTRACE, has been invented at CSIR-NPL which can be plugged into a laptop/PC for operation. The device, showcased at the CSIR Technofest, International Trade Fair held in November 2010, utilizes concepts of virtual instrumentation and off the shelf easily available components as opposed to proprietary ones. It is perfect for taking high quality ECG recording free from power line noise and base line drifts. It is a self-calibrating device with the facility to retrieve, store and print patient records, which can in turn be sent to doctor via email from the laptop/PC. Analysis of various ECG parameters is also built in the software. Wireless transmission of data has also been made possible over Bluetooth. While a highly affordable version has been designed for use at home and in small private clinics, higher versions with fast throughput are for the OPDs at hospitals and ICUs. Indian and international patents are pending for this device.



Fig. 1.106. Low-cost ECG machine

X-ray imaging based mango sorting machine

CSIR-CEERI developed a soft X-ray imaging and computerised image processing based machine for detection of internal defects in mangoes. The machine identifies and segregates mangoes with seed weevil (the fruit fly that grows inside the mango stone and then breaks out of the stone and spoils the flesh) and spongy tissue (an internal physiological disorder). The machine is very valuable for alphonso mango exporters for whom the non-detection of seed weevil and spongy tissue has so far been a big handicap in expanding their exports. Evaluation and Field trials of the machine was carried out at Dr. BS Konkan, Krishi Vidyapeth, Maharashtra. Technology of the machine has been transferred to M/s Proteck Circuits & Systems Private Limited, Chennai for commercial exploitation.



Fig. 1.107. Mango Sorting Machine

1.6 CSIR 800

An ambitious and socially relevant programme, "CSIR 800" aims at providing innovative and affordable R&D based products and processes for the common masses. Through this initiative, CSIR has adopted unique mechanisms and methodologies for not only removing drudgery but also add to economic upliftment of the needy people. CSIR actions in the field were through kisan melas, training camps, workshops and technology demonstrations. Face to face discussions and training of over 25,000 farmers by CSIR scientists was accomplished. Women workers and tribal farmers were especially focused

during these training programs. CSIR were able to bring nearly 200,000 ha under cultivation for a range of CSIR technologies relating to khus, sisal, ashwangandha, mentha, citronella, lemon-grass, seaweed, varieties of tea, curcuma, bamboo, medicinal and aromatic plants, sericulture and cut flower. CSIR scientists travelled to guide coastal seaweed farming in Tamilnadu to tea gardens in Assam and Mizoram, from sodic waste lands to mountainous terrains. CSIR distributed seedlings, slips and spawn packets in the tens of lakhs.

CSIR technologies were able to create nearly 50 million man-days of employment, the overwhelming 'winner' being the cultivation of *Mentha arvensis* farmed over 150,000 ha and created 40 million man-days of employment, followed by the 1 million man-days of employment in cut flower. Cut flowers generated ₹ 50 lakhs in the Delhi flower market. The incomes of over 100,000 farmers were raised from 10 to 25% and more than 1,300 self-help groups benefitted from the trainings. Most impressive were the gains that the salt small scale manufacturers saw, in some cases adding about ₹ 1 to 1.5 lakhs to their annual income.

CSIR instituted structures to ensure sustainability of its actions in form of centers for sisal, post-harvesting in the NE region, mushroom spawning, and distillation units. The SAMADHAN KENDRA, inaugurated by the President of India, promises to be an important resource of current information on site-specific agro-issues. This area will be further supported in the 12th Plan by a CSIR-800 Information Portal that will allow the full spectrum of stake-holders to transparently exchange and learn of progress of their projects.

Sisal Buffing Wheels

CSIR-AMPRI has prepared prototype Buffing wheel using sisal fiber for creating employment in rural areas. Approximately one million pieces of 2-10 inch diameter cotton wheels are used in practice. The prototype Sisal fibre buffing wheel developed by CSIR-AMPRI buffs metallic



Fig. 1.108. Sisal Buffing Wheel

surfaces faster, saves time and energy and offers better cutting/buffing action as compared to stripper cotton buffs.

Computer based Instrumentation System for Maintaining the Quality of Stored Potatoes

CSIR-CSIO developed an instrumentation technique and subsequent implementation to maintain the quality of the stored potatoes. This was achieved by the on-line monitoring and control of storage environmental conditions, through the use of modern electronic sensing and computational based system. Optimum environmental storage conditions are being established through various experiments on different varieties of potatoes jointly with Central Potato Research Institute (CPRI), Shimla.



Fig.1.109. Environmentally controlled Chambers for potato storage

Tea Farm mechanization

- A protocol on "Tea Farm Mechanization Culture" has been developed for the benefit of local tea planter. Comparative techno-

economic details on manual and mechanized farm operations in tea plantation have been worked out.

- 755 workers engaged in tea plantations have been trained and benefitted through 44 trainings and demonstration programs on tea mechanized operations of Dharamshala, Palampur, Bir and Baijnath regions in Himachal Pradesh. Moreover, 2 self help groups were formed to manage their tea gardens through cooperative system by machines.
- Self Help Group Zhikar, Dharamshala, Self Help Group Bir, Kangra, tea planters of Kangra and adjoining district Mandi of Himachal Pradesh and Tea Board of India Palampur branch Tea are ready for adoption of Tea Farm Mechanization. Tea Board of India Palampur (HP) unit and Tea Co-operative Factory Palampur (HP) have prepared a project for funding by Tea Board of India, Kolkata for total farm mechanization of 500 hectare tea gardens in Palampur region with the technical assistance of CSIR-IHBT.

Virus free Apple, Plum and Cherry

- The 37 varieties and 9 rootstocks of apple, 3 varieties of cherry and 3 varieties of Plum has been maintained virus free at CSIR-IHBT germplasm field, collected from different parts of Kashmir, Solan and Palampur.
- In order to propagate the same, awareness generation programs had been arranged for growers and nurserymen to plant/produce virus free plants through popular articles, programs on national TV network and on campus training.
- Through tissue culture industries, quality planting materials (90,000 plants) have been distributed to farmers covering an area of about 90 ha. Its impact will be realized in future.

Curcuma and Hedychium cultivation in agro-forestry system

- About 25 ha area has been brought under cultivation of medicinal crops *Curcuma aromatica* and *Hedychium spicatum*, which would provide additional income to farmer. About 500 persons have been trained and provided quality planting material of the characterized target crops.
- CSIR-IHBT has established an Arboretium, Fernery and Bamboo museum as part of dissemination activities. Societal developmental activities were carried out in the area of field production and value addition of tea and bamboos plantation, commercial floriculture, horticulture, medicinal and aromatic plants based on exclusive technologies developed at the institute. Extension activities helped increase in area under cultivation of commercial flower crops from 30 ha (1993-94) to 813 ha with an estimated turnover of 77.26 crores in a year.
- Bamboo treatment plant has been installed at CSIR-IHBT. Institute has designed and tested charcoal kiln for converting bamboo into charcoal. Bamboo candies as a new product out of edible bamboo shoots are being tested. These developments will be impacting rural economy in years to come.

Samadhan Kendra - A rural Information Technology Center for farmers

Samadhan Kendra is integral part of the India Development Gateway (InDG) Portal, launched by her Excellency the President of India Smt. Pratibha Devisingh Patil on 4th July 2008 at Vigyan Bhavan, New Delhi.

- CSIR established 4 Samadhan Kendra at East and West Godavari districts with the help of local NGOs. The Samadhan Kendras provide useful information on pest disease management, seed management, and optimum fertilizer doses. For benefit of

farmers, this portal also contains information about relevant govt. schemes, subsidies/ loans, public health centers, colleges and schools.

- Each Samadhan Kendra is catering to the needs of about 20 villages in and around its location. It is estimated that a total population of one lakh will be benefitted by each centre.
- 70,000 mango farmers have benefited in Chittoor District by the effective role played by Samadhan Kendra in disseminating the day to day price for the mango crop without the intervention of the middle men or the commission agents. Samadhan also helped the vegetables and fruits farming community (Horticulture crops).
- During the year 2010-11, 43042 visitors have visited the four Samadhan centers of west Godavari district of Andhra Pradesh with different queries pertaining to agriculture, horticulture, bank loans, educational details and other information.

Better recovery and utilization of fallen animal carcasses

- A new mechanical device has been developed by CSIR-CLRI for lifting and flaying the carcasses which prevents any damage to hides. Additionally an improved and efficient meat cooker has also been developed and provided for demonstration.
- The timely recovery and utilization of carcasses utilizing CSIR-CLRI technology would not only result in cleaner environment, recovery of more number of hides with better quality but also enable higher value addition to carcass by-product.
- The three workshops organised in Gujarat and one organized in Uttar Pradesh, extended technical help to NGO's and co-operative societies and would help them in not only improving their quality of life but also help in augmenting their income.

Improved Rural Tanning

- Developed the technologies like improved rural Bag Tanning (Eastern India Tanning), conversion of wet blue to finest leather and improved method for sole leather. These technologies would help in improvement of working conditions of the artisans, leather colour and yield and thus ultimate help in improving economic returns. The technologies have been transferred to the rural artisan in Rajasthan and leather Co-operative societies in Gujarat and trained 200 artisans in Gujarat and Rajasthan.
- CSIR-CLRI got the “Bharat Jyothy Award” by Indian international friendship society New Delhi on 07.01.2011 for contributions to the improvement of rural tanning.

Innovative Materials for Kolhapuri Footwear

- Alternate newer materials in place of Bag tanned leathers have been developed. The advantageous features of newer materials for the development of Kolhapuri footwear are; higher degree of comfort parameters, availability of materials in abundance, ease to handle, fashion oriented and bio-friendly, ecologically compatible.
- While the uniqueness of Kolhapuri footwear has been preserved particularly in the process such as braiding, woven of fibres, etc., the bottom preparation of Kolhapuri footwear has been engineered with the blending of mechanization for enhanced productivity.
- The specialty of improved technology imparted in rural folk is primarily on the conversion of waste into wealth. The leather scraps being discarded as wastes from shoe industries have been utilized as the basic materials for the fabrication of upper components of footwear. This technology would help upgrade the quality parameters of product, upgrade the productivity gains and finally backup for increased income generation for the artisan families.

Environmentally safe Natural dyes for rural handloom sectors

- Design, fabrication and installation of prototype for extraction of natural dye from plant resources (*Terminalia catappa*, *Tectona grandis*, *Artocarpus heterophyllus* & root bark of *Morinda citrifolia*) @ 10 Kg/day capacity, using solvents has been completed as per laboratory studies carried out. The prototype plant is yet to operate with different materials to study its performance.

Bus-mounted RO plant

CSMCRI has developed mobile RO plant i.e. a RO plant for water filtration mounted on a bus. It can deliver drinking water maximum at the rate of 60000 litres per day. The bus was pressed into service in the devastating flood hit areas in the state of Bihar. It had delivered drinking water to the flood affected people through army camps who were monitoring the rehabilitation programme. The bus also helped Aila-affected people in West Bengal.



Fig. 1.110. RO-mounted Bus

Air ferry system for societal applications

Continuing the development of system for societal applications, by making use of an inexpensive base vessel made up of bamboo material, a six-seat air



Fig. 1.111. AAM RATH (a) LAL HAMSA

ferry system was developed by CSIR-NAL and tested at the MEG Centre, Bangalore. Christened as 'Aam Rath', it is powered by a 33hp aero engine; the air ferry has been observed to perform well in water with respect to speed, turning ability, and, above all, with good stability characteristics. In addition, a three-seat air ferry system, 'Lal Hamsa', with an FRP base vessel and a seventeen hp aero engine, was also developed and tested. Both the systems employ deflection vanes downstream of the propellers for aerodynamic control to effect side turns. These transport vehicles have potential for development in rural areas as river crossings and simple water transport facilities for short distances.

Post harvest technology centres

CSIR-CMERI in collaboration with NGOs has set up High Efficiency Post Harvest Drying & Processing Centres in the states of Mizoram and Arunachal Pradesh for post harvest processing of Ginger, Big Cardamom, Turmeric, Chillies etc. More than 10,000 farmers of North East would be able to sell their produce at 20-25% higher price to the processing center. These centers would generate direct employment to about 300 people. Thus, through this initiative, CSIR is playing a key role in the developmental roadmap of the Indian North East area and has made a rapid tread in augmenting the local economy and providing livelihood to a large population of the area.

Demonstration of bulk use of pond ash/fly ash from thermal power Plants in fields

The fly-ash-soil-amendment-technology (FASAT) developed by CSIR-CIMFR was successfully demonstrated in farmers fields (>100 fields) in the vicinity of Koradi, Khaparkheda and Chandrapur TPSs (Maharashtra) during various cropping seasons (2005-2010). The crops grown include cereals, oil seeds, sugarcane, cotton, and seasonal vegetables. Important findings arising out from the ash amended fields are:

- Better germination and growth in terms of height, tiller, general health, vigor, etc.
- Overall increase in the crop yield in the range 10.0 - 30.0% over control.
- Considerable improvement in the nutrient status of crop produce together with insignificant uptake of trace elements and radionuclides from ash.
- Substantial improvement in the physicochemical properties including texture of red lateritic and black cotton field soil.
- Kisan Gosthis were organized periodically involving the officials of TPPs, FAU representatives, local/District Agriculture Officers, Village Sarpanch, and local farmers at the demonstration sites of farmer's fields. Being fully convinced with increase in crop yield, many more farmers have shown keen interest for using ash in their fields.



Fig. 1.112. Paddy and Cotton crops in PA amended fields

Overall, the technology is employment generation oriented and an important step for solving the problems of bulk utilization of fly ash/pond ash in an eco-friendly manner.

Iron making process developed: being used by tribals of India

CSIR-NML demonstrated the scaled-up process of ancient iron making with heat recovery system at two tribal sites namely Tribal Cultural Society, Jamshedpur and Technical Training Institute, Bahanaga, Balasore, Orissa. The product of the process is the value added wrought iron, extremely suitable for making decorative items, which has got good export market. The adaptation of this scaled-up process with heat recovery system will raise the income and living standards of tribal and rural artisans of our country and preserve the age old technology of iron making. In order to improve the efficiency, of age old furnace, heat recovery system was designed and incorporated to recover the thermal energy of the exit gases. For the ease of operation and increasing the processes efficiency, the semi-mechanized air blowing system was designed instead of skin made bellows or hand operated blower. The tribal Iron making furnace was scaled-up [5-6 times] to which the heat recovery system was fitted. As a result, the temperature of air blast increased to more than 120°C which brought about significant improvement in the productivity.

Natural water and purifiers

A comprehensive and dynamic open access database (<http://www.safewater.in>) on naturally occurring minerals as water purifiers has been developed by CSIR-NML. Presently 46 different minerals covering a wide range including iron ore, bauxite, limestone, coal etc. have been incorporated in the database. Each mineral has been characterized for its chemical composition (major, minor, trace and ultratrace), surface properties (surface area, isoelectric point, surface charge) and adsorption property (cations and anions).

To get an insight of inter-compound effect in plant cycle accumulation from water, four inorganics (Pb, As, Sb, and Hg), four pesticides (water soluble) and three metallo-organics (with known hazardous behavior) have been studied by CSIR-NML. Analytical protocol for specification of arsenic and selenium is in progress in environmental samples.

Biovillage Programme

CSIR-CIMAP efforts towards popularization of cultivation, processing, value addition and marketing of medicinal and aromatic plants through hand-holding awareness camps and field demonstrations of crops like lemongrass, vetiver, ashwagandha, mints (both menthol mint and peppermint), citronella, patchouli, geranium, satavar, rosemary and rose in the states of AP, Karnataka, Uttarakhand, Jharkhand, Bihar and

Uttar Pradesh have helped benefit farmers and entrepreneurs through additional income estimated around ₹ 40,000/- per annum.

Demonstration of technologies suitable for rural women like raising nursery, agarbatti making, gulab jal, vermicompost production from farm waste were made and more than 1000 women were trained in these areas. A novel initiative on technology dissemination for re-use of temple flowers for agarbatti making to help rural poor women generate income (₹ 2500-3000/-per month) and for protection of the environment has been undertaken by the laboratory at Chandrika Devi Temple, near Lucknow and second at Dewa Sharif Dargah in district Barabanki of Uttar Pradesh. A Women Entrepreneurial Training Facility (WETF) near Chandrika Devi Temple, and two self help groups (SHGs) near Chandrika

Devi Temple and Dewa Sharief Dargah have also been set up.

As part of CSIR-CIMAP's initiative to extend ICT based services for timely alerts, a SMS based agro-advisory was launched in January 2011 Kisan Mela for farmers cultivating medicinal and aromatic crops. More than 700 farmers have been registered so far and the number is increasing with every training and awareness program.

Industrially-important Oleochemicals from Sal-Fat

Sal trees grow mostly grown in forest areas and these seeds are being collected by tribals for their livelihood and in recent times the demand for sal fat is coming down. CSIR-IICT, has developed hydrogenated fat, surfactants and biolubricants from sal fat to enhance the value to this fat and also to uplift the tribal economy.