

III. COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH

1. INTRODUCTION

Council of Scientific & Industrial Research, a premier autonomous R&D organization with its 38 laboratories and 47 regional centers, has completed 60 years of its existence. Nourished, fostered and supported by the successive governments, since its inception, CSIR is now recognized internationally as an institution which is moving speedily towards achieving global excellence without diluting local relevance. In India, it symbolizes a culture that links science with society through technology and industrial manufacture. Man of Vision and Values have shown path and built CSIR to its present strength, ethos and culture.

CSIR has celebrated its Diamond Jubilee Year from September 2002 to September 2003. The year-long Diamond Jubilee Celebrations were held at all the constituents of CSIR. During the year, CSIR has also taken new initiatives such as creating a CSIR Diamond Jubilee Technology Award of Rs.10 lakh; Diamond Jubilee Innovation Award for school children; CSIR Diamond Jubilee Research Intern Awards; establishing Institute of Genomic and Integrative Biology by changing the mandate of Centre for Biochemical Technology, Delhi. A series of seminars, symposia, workshops, open house meetings, scientific lectures and bringing out scientific publications, reports, articles, souvenirs etc. were organized to focus about CSIR's services to the nation and its contribution to science, society and economy. An exhibition of sixty most outstanding developments was organized and taken to 50 places all over the country.

As the nation's strongest holder of intellectual property rights, CSIR leads the way for

protecting traditional knowledge strength while adding to the new IPR capital. CSIR was ranked the first amongst major PCT applicants from developing countries. CSIR has also continued to promote excellence in science and is the only S&T organization which had nurtured and supported human tech from 16 to 65 years of age through numerous schemes on human resource for scientific research.

2. SIGNIFICANT DEVELOPMENTS

2.1 *Creating massive knowledge networks*

A key feature of CSIR's performance was the creation of major and innovative knowledge networks across and beyond CSIR laboratories. Not too long ago, most CSIR laboratories had acted as single units with several laboratory based programmes. CSIR's massive network on 'bioactive molecules' launched three years ago began the process of leveraging the benefit of networking by bringing together 20 CSIR laboratories and several other institutions. This philosophy was carried forward with vigour. Most of the programmes for the Tenth Plan now have been formulated with networking of resources and capabilities as the major component.

2.2 *Contributing to Indian industry*

CSIR continued to provide a strong support to Indian industry. The major achievements included successful commercialization of process for: conversion of Naphtha to Gas and Gasoline (NTGG); catalyst for speciality polymeric materials based on zirconium tetrachloride; lacidipine process; methane sulphonic acid process; Precipitated Calcium Carbonate (PCC) etc.

2.3 Catalyzing civil aviation industry: SARAS roll out

CSIR has been rendering yeoman service to the Indian aerospace sector. Its contributions and excellence are acknowledged not only nationally but internationally as well. The light transport aircraft programme achieved a significant milestone on February 4, 2003 when its first prototype of SARAS rolled out. The prototype was named VT-XSD - SD in honour of Dr. Satish Dhawan, a doyen of aerospace and former Chairman of National Aerospace Laboratories (NAL) Research Council at whose instance NAL's Civil Aviation activities were initiated. Major testing activities have been completed for SARAS in preparation of the first flight. It needs to be emphasized that the first journey that began with a Light Combat Research Aircraft in the National Aerospace Laboratories, was taken forward to the series of HANSA aircrafts, resulting finally into an all composite aircraft HANSA-3, that was test certified in 2001, and is productionised and taken to Indian skies already.

2.4 National Policy Setting: CSIR's inputs

CSIR had privilege to contribute to framing of two important policies during the year, namely auto fuel policy and policy on drug regulatory issues & spurious/substandard drugs. The committees for the purpose were chaired by DG,CSIR. For these two domains of national importance, the knowledgebase available in CSIR system, was of substantial help in examining highly technical and complex issues and providing need based solutions. The auto fuel policy took a holistic view of the diverse aspects of emissions, auto technologies and auto fuel quality on one hand and social costs, security of fuel supply and absorptive capacity on the other. The policy tried to provide a practical and balanced approach to meeting of these challenges. Likewise, the policy on drug regulatory issues and spurious drugs too, provided far sighted directions to bring diverse

systems in the domain up to international standards. It dealt with the regulatory issues of products of ISM, therapeutic foods and dietary supplements, medical devices, diagnostics etc. It also addressed the issues of clinical research, an emerging opportunity for India.

2.5 Traditional knowledge: efforts for protection and value addition

CSIR lead the Team India initiative for setting up the first ever Traditional Knowledge Digital Library (TKDL). The TKDL would provide a search interface to retrieval of traditional knowledge information on international patent classification (IPC) and keywords in multiple languages. At global level it would act as a bridge between 'Sanskrit Slokas' and a patent examiner.

CSIR's programme on discovery, development & commercialisation of new bioactives and traditional preparations completed its first phase. It has 52 leads under various stages of development, for diverse diseases namely cancer, ulcer, tuberculosis, immunomodulation, parkinsonism etc. The programme now has under its network 20 CSIR laboratories, 12 universities and 3 systems of Indian system of medicine i.e. Ayurveda, Siddha and Unani. The effort now is focussed towards filing new chemical entities, which will lead to entirely new and novel therapeutics.

2.6 Science & Technology for the Society

As a socially conscious organization, CSIR continued its efforts to provide the S&T needed for the masses. During the year it adopted villages to promote employment generation on one hand and developed diverse technologies to add to quality of life on the other hand. These technologies include: ceramic membrane based removal of arsenic and iron from contaminated ground water; pesticide removal unit for producing potable water free from organic pollutants; lead-free Jaipur blue pottery; setting

up of Reverse Osmosis (RO) based desalination plants in villages; marine sanitation device for “Kettuvallom” etc. In a unique endeavour, CSIR catalyzed commercial cultivation of geranium in Uttaranchal through community participation. In this end to end mission farmers have been trained not only for cultivation of geranium but also for extraction of oil and making value added products.

2.7 Renaming of Centre for Biochemical Technology (CBT)

Centre for Biochemical Technology became a full fledged research centre of CSIR on 1st April, 1993 after sixteen years of its inception in 1977 as an affiliated Centre. From 1997 onwards there was a change of direction in CBT, which raised its ambition. The center added a major network activity on “Functional genomics” realizing that human and other genome sequencing, will transform biology and medicine forever and will open up a new chapter for biochemical technology as it enters the “Genome era”. CBT charted a new path, which completely changed its trajectory. Its activities were thus directed towards multidisciplinary research in the areas of genomics, molecular medicine, bioinformatics and environmental biotechnology of high scientific impact, leading to technology development and services relevant to society. The centre has created a large network involving many clinicians from various hospitals & medicinal institutions. CBT thus rapidly got transformed from a small laboratory working in narrow areas of biochemical research to a largely networked laboratory. This was achieved by utilizing the existing scientific strength of CBT and introducing two new areas “Molecular human Genetics’ and Genome Information”.

The Performance Appraisal Board (PAB) of CBT recognized that CBT was emerging as a distinctive Institute with its new R&D

programmes viz., comparative genomics, proteome analysis, in-silico drug target discovery, and novel screens for drug target development. In view of aforesaid, PAB recommended a change in the name of the centre to reflect its new mandate closely. In view of the suggestion given by the PAB, the emerging scenario and also looking at the future of the biomedical research, an appropriate name of the CBT was recommended by the Research Council of CBT as Institute of Genomics & Integrative Biology (IGIB). The change in name was agreed to. This name would not only reflect the present position and the new content of R&D but also will give focus to diverse activities.

2.8 New Millennium Indian Technology Leadership Initiative (NMITLI)

NMITLI continued its efforts with the thrust to harness national potential in Science and Technology to realize the vision of a resurgent India by partnering with Indian industry to achieve global leadership position in select niche areas. Concerted efforts were made to synergise the best competencies of publicly funded R&D institutions, academia and private industry. In a short span of less than three years, 25 path setting technology projects have been crafted with an enviable network of industry, academia and publicly funded R&D. These involve partnership of over 50 industries and 150 R&D institutions. During the year, eleven new projects were launched. These included 5 industry initiated and 6 nationally evolved projects in which 27 research institutions and 14 industrial firms were participating.

The significant achievements include: Identification for the first time, of contrasting chemo types from over hundred accession of *Withania somnifera* collected from across the country; Launching of a next generation bioinformatics software, “Bio-Suite” which is a comprehensive, portable, modular and scalable

software having more features than any existing commercial product; a new pharmacophore is being developed towards IND filing under the project on “Latent M. tuberculosis: new targets, drug delivery system, bioenhancers and therapeutics”; identification of potential leads for ambient preservation of hide and for dehairing of goat skin - these leads are being further pursued to develop a chemical free environmental friendly technology for leather processing; development of a high performing catalyst for desulphurising diesel from 2500 ppm to <50 ppm - the catalyst is now scheduled for testing at a plant scale; designing and fabrication of a new Liquid Crystal Display device for flat Panel Display System with two orders of magnitude faster switching time, a higher contrast ratio, symmetric and wide viewing angle; and development of a novel process for (S) 3-hydroxy- γ -butyrolactone - a versatile intermediate using maltose and maltodextrin, as raw materials.

3. SCIENTIFIC & TECHNICAL ACHIEVEMENTS

Some of the scientific and technical achievements sector-wise are provided in the following paragraphs:

3.1 Aerospace Science & Technology

Separation control by bubble flow energization

The phenomenon of separation in fluid flow leads to a variety of problems including loss of performance. Hence all successful aerospace designs aim at minimizing and controlling flow separation. A novel strategy adopted by NAL involved active flow control using tangential blowing inside the separation bubble (dead air zone) to suppress flow separation. This is an unconventional technique and offers the promise of controlling separated flows in general. In this technique, inactive flow inside the bubble is energized as opposed to energizing

the boundary layer ahead of separation as in the classical boundary layer control approach. This bubble flow energization results in elimination of shear layer reattachment and improved flow characteristics. Having succeeded in this technique, NAL now plans to extend this to configurations of interest to future civil aircraft designs.

Computational Fluid Dynamics (CFD) software

The growth of CFD software at NAL has reached a state of functional utility. It has been contributing to design and development efforts in aerospace. CFD tools have been adding synergistically to wind tunnel testing and flight testing in the development of superior aerodynamic configurations. These tools have demonstrated its usefulness in the entire velocity range - from low-speed, typical of hydrodynamic flows for naval applications through the transonic and supersonic flows of relevance to aircraft configuration to the hypersonic flows of interest to space vehicles. The capabilities developed have been comparable to those elsewhere in the advanced countries.

Flosolver

NAL has achieved, as part of a NMITLI programme considerable progress in monsoon modelling. Development of the boundary layer module which incorporates the heat flux scaling of Narasimha and team has been undertaken. The thermodynamic process in the tropics is an active field of research at present and the integration of the new insights of the related mechanism into NMITLI mesoscale weather code provides international competitiveness. Computational experiments coupled with available field data have already shown significant results including identification of the fact that a large region of low wind regime exists and therefore its proper modelling is

extremely important. Major successes in hardware include two new versions of the FloSwitch, viz., Beta 1 Pentium Switch with a 32 bit data path and Beta 2 Pentium Switch with a 64 bit data path using the processor @ 50 MHz.

Wankel engine studies

Wankel engine is a rotary piston engine, which has demonstrated advantage for aeronautical applications over gas turbine (initial cost and fuel economy) and over the reciprocating engine (high specific power and smoothness of operation). NAL's initiative in Wankel technology began with solving the cooling problems and successful applications to powered hang glider. Following this, a full development activity was taken up including the development of software packages for thermodynamic cycle analysis, thermal analysis and stress estimation in various engine components, sophisticated machining procedures for side plates, trochoid, rotor & gears and vendor development for specific components. The indigenous components have been assembled and run successfully on a bought-out NR 731 engine at full load and speed. Technology is now established for the design, analysis and prototype manufacture of air-cooled Wankel engines.

Advanced flow diagnostics

Density measurements in high speed flows using Background Oriented Schlieren (BOS): Knowledge of density field is vital for understanding high-speed aerodynamic problems. BOS is a new optical technique proposed by Deutsche Luft und Raumfahrt (DLR) Germany which has the potential to provide quantitative information of density in a compressible flow medium. The density measurements using BOS in a simple flow at high speeds have been fully validated at NAL. The method has been applied to flows at Mach

2.0 over bodies having standard shapes and the results verified against those available in literature. After obtaining the integrated density field, a filtered back-projection technique (FBPT) was employed for the first time in the country to successfully obtain the density field in one plane. Comparison of density field obtained by this method with others was excellent. BOS will now be applied to capture density field in other standard high speed flows like jet flow and viscous flows. These flow configurations have strong relevance to NAL projects as well as national aerospace programmes. The use of FBPT holds promise for application to non-axisymmetric flows as well.

Development of pressure sensitive paints for wind tunnel applications: Surface pressure measurements on wind tunnel models are of fundamental importance in experimental aerodynamics. The Pressure Sensitive Paint (PSP) technique is a new experimental method for the quantitative measurement of surface pressure on wind tunnel models which has some important advantages over the conventional methods. The main advantage of PSP is that it is non-intrusive and it has a high spatial resolution. NAL has developed this technique to a level of maturity, where this can be applied to wind tunnel measurements. The PSP formulations are of proprietary nature and are prohibitively expensive. Hence NAL has also taken the initiative to develop the paint formulation and has successfully developed three formulations, NAL GI, NAL G2 and NAL G3.

Design of brittle ceramic structures by probabilistic approach

NAL has initiated a research programme on the structural design of brittle ceramics. The objective of this programme is to study various probabilistic design methodologies used for brittle ceramics and to develop a computer code for predicting the probability of failure for

ceramic components subjected to thermo-mechanical loads. Currently, two computer programmes have been developed as a part of this effort, one of which processes the material strength test data and computes the Weibull Modulus and Weibull Stress for volume and surface flaw analysis. The other programme essentially functions as a post processor for finite element analysis software. Based on the stress analysis results, this programme computes the probability of failure of a ceramic component under different conditions. The results of these programmes compare well with those obtained using software developed in the USA (NASA-CARES) which were denied to Indian Institutions due to sanctions imposed by the US Government.

Co-curing and co-bonding technique

In order to bring down the life cycle cost of the aircraft and provide an added advantage to those arising due to the fact that composites are insensitive to fatigue loads and are corrosion resistant, it is necessary to minimize the number of components and fasteners. NAL has developed indigenous co-cured and co-bonded technologies to achieve this. It is a state-of-the-art technology which was not available to the country at any cost from anywhere in the World. Using this technology, major primary structures of LCA namely fin, rudder and large number of parts of centre fuselage have been developed as also to develop the control surfaces of SARAS aircraft. This breakthrough in composite structural technology is prompting many innovative composite design concepts to emerge in aircraft industry to leverage the maximum advantage from the potential use of composite materials.

Multi-layer superlattice coatings

Multi-layer superlattice coatings of transition metal nitrides, also known as third generation hard coatings have been successfully prepared at

NAL using reactive DC magnetron sputtering process. The Cu/Ni multi-layer system gave a wealth of information regarding the science and technology of superlattice formation. The layering of two materials on nanometer scale significantly improved the mechanical properties as well as thermal and chemical stability of the coatings. Based on this work a variety of ceramic/ceramic multilayer systems are being studied. These include TiN/CrN, TiN/NbN, TiN/VN etc. These materials are expected to exhibit hardness as high as 60 GPa or more.

Helicopter technology

NAL has made significant contribution in the helicopter technology area. These contributions include a specialized technique for taper machining of hollow shafts, through chemical milling routes and design and development of hollow power transmission shafts, which would reduce the weight of the shaft considerably. Both technologies have undergone extensive testing and successfully met the acceptance criteria. In addition, NAL has been providing extensive material testing and characterization support, as well as life extension work related to the helicopter programmes of the country.

Test rig to measure roll damping on aerospace vehicle models

NAL has designed and developed a special test rig to measure the roll damping on models of spin-stabilized aerospace vehicles. This has been installed and it has fully validated the system using standard models. Subsequently, roll damping data have been generated on two sounding rocket models of interest to ISRO over a Mach number range of 0.5 to 3.8 for a range of roll rates, selected angles of attack and fin deflections. The generated data will be useful for estimating the performance of the space vehicle during flight.

Life extension of MiG 21 Bis aircraft

NAL has completed successfully the first phase of the programme on Total Technical Life Extension (TTLE) on MiG 21Bis aircraft. Based on the results of this programme (executed in association with IAF, HAL and the certification agency - CEMILAC), it was possible to recommend an extension of flight life by 1000 hours. This forms a valuable input to the IAF's military fleet.

Air traffic management and simulation

Air traffic is growing at a rapid rate in the developed countries and at a medium rate in developing countries. Traffic management is been, therefore, recognized world over as an important area of thrust. It is a thrust area of particular significance to the civil aviation sector. Hence NAL initiated R & D work in association with the Institute of Flight Guidance of DLR Germany. At NAL, preliminary work on Air Traffic Management was started using the Software 'SIMMOD PLUS'. For the first time in India, the activity of modeling and simulation to predict possible ground and airspace delay has been initiated. Predictions have been made for current and future traffic scenarios, expected to be handled by the Bangalore airport. NAL's studies suggest that air traffic control and airport authorities need to take important steps to keep the flight delays within acceptable limits, as the traffic increases.

Integrated Facility for Carbon fibre And Prepregs (IFCAP)

NAL's major initiative (jointly with DRDO) to establish an Integrated Facility for Carbon Fibre and Prepregs (IFCAP) has made rapid progress. The installation of all systems has been completed. System integration and commissioning trials are in progress. On completion, this facility will fill a critical gap in meeting the strategic material requirements of the nation.

Support to aerospace programmes

NAL provided extensive aerodynamic testing support to various national aerospace programmes during the year. This included over 1400 blowdowns in the 1.2m X 1.2m trisonic tunnel. The failure analysis group provided extensive expert services to different agencies for analysing failures related to the aerospace and industrial sectors. Acoustic Test Facilities provided crucial acoustic testing and certification inputs to the space programmes of ISRO. All the space systems launched during the year were tested and qualified by ATF. Extensive services were provided towards characterization of composite materials (hot wet and room temperature) to the National Programmes particularly LCA. Similar services were also provided to the Advanced Light Helicopter (ALH) programme of HAL. The wind energy group provided valuable advice on wind resource assessment and microsifting of wind energy system to a number of private and public sector agencies. Reaves Curing Chamber, procured by Vikram Sarabhai Space Centre (VSSC), Trivandrum had become non-functional due to the non-availability of service. NAL provided total revamping services to VSSC to make the chamber fully functional and updated a few systems as well.

3.2 Biological Sciences & Technology***Programme on discovery, development & commercialisation of new bioactives and traditional preparations***

Initiated in 2000, the CSIR coordinated programme completed its first phase in March 2003. It grew from strength to strength during the period as its genesis was based on novel thinking and strategy based on network which was rare and unknown then, not only in CSIR system but in other publicly funded National R&D agencies as well. As it grew, it involved systematically, 20 CSIR labs, 12 universities

and 3 systems of medicine i.e. Ayurveda, Siddha and Unani, which form now, a formidable delivering network. The programme gained in terms of resource collection, their processing, extraction, bioevaluation and pursuing then the lead(s) obtained in a defined mode of drug discovery leading to IND(s).

On nearing completion of the first phase, the progress under the programme was reviewed by a 'High Power Committee' under the Chairmanship of DGSIR. The membership for the committee was drawn from CSIR's Governing Body, Advisory Board and Society in addition to the well-known peers in the field. The Committee appreciated the programme endeavor in totality. It recognized that in a short span of three years, 52 leads were obtained for diverse diseases namely cancer, ulcer, tuberculosis, immunomodulation, parkinsonism and other neurological disorders etc. due to well orchestrated concerted effort. These leads, characteristically have national and international relevance. The committee also appreciated, the creation of diverse 'state of the art' facilities, namely for bioevaluation (in vitro and in vivo), for breeding and maintenance of transgenic animals for various diseases, and associated facilities for resource collection, processing and extraction as well. The members endorsed extensive approach for screening of the extracts and intensive approach for INDs as a right strategy employed for the project endeavour. CSIR efforts for joining hands with the industry for the identified leads for some diseases were applauded. Infact the network set up in the country by the programme has been termed exemplary and extraordinary. The concept has now become role model for other CSIR Tenth Five Year Plan Programmes.

For the period under report 4000 plant extracts and 1500 microbial extracts were processed and sent to identified laboratories for bioevaluation. Additionally 161 traditional preparations (100 Ayurveda, 36 Siddha and 25 Unani) were

received and were at various stages of screening for 19 diseases. Efforts are on to convert these leads into the commercially exploitable therapeutics.

Human genome diversity

Scientists at CCMB continued their efforts for obtaining the genetic information about various castes and tribal populations of India to construct haplotypes, which in turn will help to construct the evolutionary trees. About 1500 DNA samples of unrelated individuals (mostly male) using Y-chromosome (6 STRs and upto 20 SNPs) and mitochondrial markers (HVRI, HVRII and 9bp intergenic region) were analyzed. CCMB study on tribal populations of Andaman and Nicobar Islands had attracted International attention. It was demonstrated that the Onge and the Jarawa represent a unique subtype of haplo group D not described so far in the world population. The presence of a hitherto unidentified sub-set of the mtDNA Asian haplogroup M, and the Asian-specific Y chromosome group D, testify that the Andamanese have closer affinities to Asian than African populations and therefore are the descendants of early Paleolithic colonizers of South East Asia-the hunter gatherers and the first migrants moved out of Africa about 60,000 – 100,000 years ago. The questions remain: How then these so called Andamanese reached Andaman? and Are there any tribes in Indian mainland which show resemblance with Andamanese and therefore shed light on the root of migration? To answer these questions, studies on tribal population of Indian mainland were conducted. It was found that YAP (Y-Alu Polymorphism) insertions were present in 27 individuals out of 47 samples in Dungri Bhil from Gujarat, West coast of India, as observed in their earlier studies in Onge tribes of Andaman and Nicobar Islands. SNP analysis of the above populations was in progress. In contrast to Andamanese, the Nicobarese have genetic affinities to groups widely distributed

today throughout Asia, thus, the Nicobarese should presumably descend from 'Neolithic Agriculturists'. These studies may throw some light on the mystery of our own origins.

Genome-wide analysis of microsatellite repeats in humans

A large proportion of higher eukaryotic genome is repetitive in nature. Scientists at the CCMB are interested in finding the function of these repetitive sequences in genome. CCMB, in collaboration with Ingenovis, a division of i-labs (an IT company), Hyderabad, using the genome sequences available in public domain created a database of microsatellite repeats for human genome for easy access to such repeats for analysis and for its use in understanding their biological significance. From this analysis, they are able to identify about 2135 known or predicted genes that are associated with at least one triplet repeat type. These transcripts will be candidate genes for analysis of triplet repeat expansion and a possible association with disease phenotypes.

Genetic analysis of pancreatic disorders: detection of a novel mutation in Indian population

Pancreatitis is a complex disease with heterogeneous etiologies. Tropical calcific pancreatitis (TCP) is peculiar to India and is associated with an early age of onset and high incidence of diabetes mellitus. CCMB investigated 68 patients of tropical calcific pancreatitis comprising 44 without diabetes and 24 with diabetes (FCPD) for mutations in cationic trypsinogen (PRSS1) and pancreatic secretory trypsin inhibitor (SPINK1) genes, and also performed a genotype-phenotype correlation. In contrast to established notion, the study could not detect any mutation in the PRSS1 strongly suggesting that cationic trypsinogen gene mutations may not have a role in TCP in our population. Mutated SPINK1 was

detected in about half the patients with a founder mutation N34S in majority of the patients. A novel mutation -215G>T in compound heterozygote status with N34S was detected in 3 FCPD patients. This mutation has been included in the Human Gene Mutation database (HGMD). In contrast to a recent report, CCMB has identified SPINK1 mutations in both FCPD and TCP patients without diabetes in similar frequency. The median age of onset for TCP patients without diabetes was significantly earlier than that of FCPD patients. Comparison of parameters like the age of onset, presence or absence of diabetes mellitus and age of its onset between SPINK1 N34S heterozygous, homozygous patients did not show any significant difference. CCMB conducted studies suggested that variability in the phenotype of tropical calcific pancreatitis may be related to a different genotype. It also stresses on a common genetic basis for tropical calcific pancreatitis with additional genetic/environmental factors responsible for the variability of phenotype in FCPD and TCP patients without diabetes.

Relevance of DNA conformations in Alzheimer's disease

Alzheimer's disease is a challenging neurodegenerative disorder. It has complex neuropathology. CFTRI has observed a new neuropathological event, B to Z-DNA conformational transition in hippocampal region of Alzheimer's Disease (AD) brains. The circular dichroism spectra of severely affected AD DNA showed a typical left-handed Z-DNA conformation whereas normal, young and aged brain DNA have the usual B-DNA conformation. Moderately affected AD DNA has modified B-DNA conformation (B-Z intermediate form). The altered conformation of DNA will have tremendous implications in understanding gene expressions. Studies on DNA triplet repeats namely (CCG)₁₂, (which are involved in neurodegeneration) showed B to Z-DNA conformational transitions in the presence

of Aluminium and longer triplet repeats attaining Z-DNA conformation is the novel finding and a new mechanism has been proposed on switching off FMR 1 gene in X-Fragile syndrome. These findings have provided new insight in understanding the mechanism of cell death in brain.

Mutational analysis of tumour suppressor genes and tumour proto onco genes of primary human malignant mesotheliomas

Human malignant mesothelioma is drug resistant. ITRC, in a collaborative study with Germany, obtained samples of human malignant mesothelioma from the European Registry of Pathology and screened them for gene mutations of the tumour proto onco genes N-ras, K-ras, CDK4 and tumour suppressor gene p53, p16^{INK4a} and nf2. Screening was conducted for point mutations and microdeletions/microinsertions in exons 1-16. In the tumour suppressor gene nf2, located on chromosome 22, one tumour (7%) a 10 basepair microdeletion of exon 10 was detected by SSCP and subsequently characterized in detail by sequencing. Deletion of the second nf2 allele in laser-microdissected regions of the 10 bp mutation-harboring tumour was demonstrated by DGGE analysis. Simultaneous comparative genomic hybridization (CGH) analysis showed losses of chromosome 22 in 38% of the tumors. DGGE and CGH also revealed intra-tumour heterogeneity in the microdissected specimen. For the first time it has been indicated that disarrangement and loss of nf2 may be involved in the formation of a subset of mesotheliomas. These studies will help in understanding the disease process, treatment and development of gene therapy. The work was in progress to identify the involvement of other genes in human mesothelioma.

Molecular genetics of asthma/atopy associated genes: Identification of polymorphisms in IFN and STAT6 genes involved in asthma pathogenesis

Asthma is a multifactorial complex genetic disorder where many predisposing genes contribute towards the pathogenesis. Atopic asthma is manifested with clinical symptoms such as bronchial hyper-responsiveness, elevated serum IgE levels, wheezing, etc. A number of genetic and environmental factors have been implicated in the disease progression. Earlier studies on the pathophysiology of asthma demonstrated the central role of T cells in the initiation of the inflammatory process. In asthma, it has been shown that IFN negatively regulates the Th2 response by down regulating the IL4 cytokine. In addition, cell adhesion molecules and chemokines play key roles in the immunopathogenesis of asthma. The association of a CA repeat marker in IFN gene with asthma and total serum IgE levels in the North Indian population was investigated. The distributions of allele sizes were found to be significantly different between patients and controls. Alleles 10 and 11 were found to be over represented in individuals having asthma, whereas alleles 13 and 15 were less likely in asthmatic individuals. Research at IGIB indicated CA-repeat polymorphism in the *interferon gamma* gene was significantly associated with total serum immunoglobulin E. Twenty-six single nucleotide polymorphisms (SNPs) spanning a total of 147kb region in *STAT6* and *IL4RA* genes have been identified. Fourteen novel SNPs were found in Indian population. The encoded proteins of these two genes are part of a single signaling pathway and therefore, functional polymorphisms in these genes could potentially lead to higher risk and susceptibility to atopic disorders.

Association of a biallelic CAG repeat marker with schizophrenia and bipolar disorder

Schizophrenia (SZ) and bipolar affective disorder (BPAD) are complex genetic disorders with a worldwide prevalence of ~1%. Amongst the several chromosomal regions implicated by independent linkage studies, chromosome 22 has been the most intensely studied for both schizophrenia and BPAD. IGIB has demonstrated association of a biallelic CAG repeat marker on 22q11-13 with schizophrenia and bipolar disorder. A candidate gene *Synaptogyrin 1* (SYNGRI) within 2Mb of 22CH3 was selected. Involved in the regulation of neuronal exocytosis, SYNGRI is an attractive candidate for schizophrenia and bipolar disorder. It is a 37 kb gene with six exons. Sequencing of all the six exons and flanking splice junctions in probands from 20 densely affected SZ and BPAD families has been done at IGIB, as well as ethnically matched normal individuals. In one schizophrenic proband, a heterozygous mutation resulting in a nonsense codon (G105A, encoding Trp27Ter) was found in the second exon of this gene. This heterozygous mutation was also found in two affected and one asymptomatic sibling of this proband. The RT-PCR and Northern blot analyses revealed that the exon 2 containing transcript of *Synaptogyrin 1* gene was indeed expressed in brain.

Functional genomics approach for pathway modulation in *Mentha Sp.*

The critical step in the biosynthetic pathway of *Mentha* is from pulegone to menthone to menthol. But pulegone is also converted to isomenthone in *Mentha arvensis* and to menthofuran in *Mentha piperita*. These two components affect the price of the oil. Similarly, the Indian piperita fetches less price compared to the American type due to the compositional differences of menthol, menthone and other minor components. The pulegone reductase

activity for the synthesis of isomenthone from pulegone was found to be increasing with decrease in menthol biosynthesis during cloudy weather in *Mentha arvensis*. The differentiation in protein expression pattern of trichomes of normal and cloud/rain induced plants was confirmed through 2D electrophoresis by comparing the proteins of the trichomes isolated during normal as well as cloudy weather. The study was conducted in the variety 'Saksham' of *Mentha arvensis*. This is likely to provide molecular basis for pathway manipulation to develop designed crop of *Mentha piperita* in future.

Based on the sequence of menthofuran synthetase ID AF346833 forward and reverse primers were synthesized at CIMAP. The forward primer bears Hind III site and the reverse primer bears Sal I restriction enzyme site. The DNA samples of 'Kukrail' (a released variety of *Mentha piperita*) was amplified using the specific primers and the amplified fragment was isolated, restricted with Hind III and Sal I restriction enzymes and cloned in pBluescript II SK (+). One clone was selected having the insert fragment of approximately 1.6 Kb. The end sequence was comparable to the reported menthofuran synthetase gene. This gene from *Mentha piperita* 'Kukrail' can be used in future for modulation of the biosynthetic pathway for menthofuran synthesis.

Preparation of neurotrophic chemotherapeutic agents

In amyloid biochemistry to decode the mechanism of spontaneous formation of toxic aggregates of amyloid peptides in the physiological conditions is one of the unsolved problems. Studies at CLRI have shown that under conditions of forced molecular crowding, toxic beta sheets of prion peptides are formed with ease. It is also observed that helical turns formed in the hydrophobic sequences of another amyloid forming A β peptides acts as main

stabilizing force in the propagation of amyloid structures. For the first identified sequences with helical turn propensity in amyloid fragment has been identified and shown that they take stable helical turn conformation in monomeric and aggregated form. Based on the results, helix nucleating regions i.e. Ala-Ile-Ile-Ile-Gly-; Ala-Val-Val-Gly-; and Lys-Leu-Val-Phe-Ala- have been selected as lead molecules for the development of anti amyloid molecules. These peptides will be coupled incorporated with lysine based dendrimer. The vehicle for the delivery across the blood brain cross over is 20 residue peptide Pegylin [Pegylin-Lys dendrimer-(Boc-Ala-Ile-Ile-Gly-)_n; Pegylin-Lys dendrimer - (Boc - Ala - Val - Val - Gly)_n; and Pegylin-Lys dendrimer - (Lys - Leu - Val - Phe-Ala)]_n.

Bioavailability enhancers – from ancient wisdom to modern therapeutics

A new concept of enhancement of drug bioavailability/ bioefficacy based on clues from Ayurveda has been conceptualized at RRL Jammu. The development of plant based bioavailability/ bioefficacy enhancers is targeted for drugs which are: poorly bioavailable; given for longer period of time; and highly toxic and expensive. Based on systematic investigations on 'Trikatu' a reputed formulation (containing Piper spp and Zingiber officinale) prescribed for a number of ailments in Indian traditional medicine, piperine, a pure alkaloid molecule from Piper spp., having bioavailability/ bioenhancing activity have been isolated. Piperine was studied in detail with anti-TB drugs. The major outcome has been the development of a formulation containing 50 % reduced dose of rifampicin while retaining the therapeutic efficacy at par with standard (450 mg) dose of rifampicin. Reduced dose formulation (Rifampicin + Piperine) has gone through phased multicentric clinical trial upto Phase III. Permission has been obtained from DCG (I) to increase the size of patient

population as per RNTCP guidelines. Based on clues from Ayurveda three more plants [coded as 0200, 0194 and 0173] were taken up for detailed investigation. One fraction from a plant has shown promising bioavailability enhancing effect when combined with rifampicin. The active fraction was found to enhance the bioefficacy of rifampicin against Mtb. *In vitro* and *in vivo* studies have shown that the active bioenhancer in combination with rifampicin caused 2 log reduction in the MIC of rifampicin. A chemically characterized pure, active compound has been isolated from the active fraction having bioavailability enhancing activity.

Wildlife conservation: assisted reproduction in wild animals

Decimation of wildlife due to habitat destruction and poaching has led to fragmentation of populations of wildlife. This apparently has a very significant effect on the breeding efficiency of the animals. Scientists at the CCMB have standardized techniques for semen collection, semen cryopreservation and artificial insemination in the spotted deer as a model for the endangered deers and in the Blue Rock Pigeon as a model for birds. Using these techniques, it has been possible to achieve successful artificial inseminations in deer and pigeon which resulted in birth of young ones.

Carbohydrates, a versatile tool for combinatorial synthesis

Carbohydrates have extensive potential to generate vast library of compounds both as chemotherapeutic agents and as biological tools particularly artificial receptors because of the availability of large number of functional sites as well as chiral centers. CDRI has recently designed and synthesized libraries of glycoconjugates of the general formula X1-X2-carbohydrate having a bifunctional amino acid with or without functionality in the side chain at

position X2 and aromatic, heteroaromatic or other amino acids at X2 position. These compounds were screened for DNA topoisomerase inhibitory and antitubercular activities, providing new leads in these areas. The glycosylated amino acids were further used in the synthesis of a variety of C-nucleosides by coupling with isocyanates or isothiocyanates on a Sieber amide resin and finally with diazabicyclo undecene, a hindered organic base as catalyst, for cyclisation as well as cleavage from the resin. These nucleosides are more stable towards enzymatic degradation and associated with anticancer, antibacterial, antiviral and antileukemic activities.

Isoxazole-carboxaldehyde, a novel scaffold to study Baylis-Hillman chemistry

Isoxazole is an important heterocycle as it forms part of scores of biodynamic molecules and natural products and serves as building block for construction of new molecular systems. The Baylis-Hillman reaction, a C-C bond forming reaction has attracted the global attention of various research groups because of its immense synthetic potential to afford multifunctional products that can lead to wide spectrum of heterocycles and natural products. In the era of combinatorial chemistry, this reaction gains further significance as the densely functionalized products obtained from it can be tailored and diversified for building up of chemical libraries of privileged scaffolds in solution and on solid phase in appropriate manner. This is a reaction between an electrophile i.e. usually an aldehyde and an activated alkene in the presence of a Lewis base or Lewis acid. With the objective of developing isoxazole-based chemical libraries through solution and solid phase, for the first time CDRI found that substituted 5-isoxazolecarboxaldehyde is one of the fastest reacting substrate for Baylis-Hillman reaction. This led to some interesting observations such as formation of ether and hemiacetal during

DABCO-mediated and $TiCl_4$ -mediated Baylis-Hillman reaction, respectively. Also methodologies to obtain azides and substituted phenols from the Baylis-Hillman chemistry have been developed. These isoxazole-derivatives furnished through Baylis-Hillman chemistry have elicited good biological response in the area of antithrombotics and antihyperlipidemics.

Oenostacin: the plant based antibiotic shows activity against vancomycin resistant Staphylococcus epidermidis strains

CIMAP had earlier isolated a novel compound 'Oenostacin' from *Oenothera biennis* (Evening Primrose), which inhibited the growth of *Staphylococcus epidermidis*, the causal organism of infectious endocarditis. Amoxycillin and vancomycin are the drugs of choice for treating such infections. Vancomycin is recommended for high-risk patients and in cases where the patients are allergic to amoxycillin/penicillin antibiotics. Resistance to vancomycin is already reported in many staphylococci resulting in serious medical complications. The drugs that exhibit potency against staphylococci group of organisms, therefore, should also be active against vancomycin resistant strains. Hence, the activity of oenostacin was tested against the laboratory derived vancomycin resistant strains of *S. epidermidis*. Over 20 Van-R strains were developed by NTG induced mutagenesis and evaluated. The results showed that the resistant strains were also sensitive to Oenostacin at a level comparable to that of the wild type. A US patent has been granted for an antibacterial composition comprising oenostacin from *Oenothera biennis*.

Anti-cancer activity of lignans isolated from the heartwood of Himalayan yew

The Himalayan yew (*Taxus wallichiana* Zucc.) is a tree growing on both sides of Himalayas. In

contrast to the European yew (*Taxus baccata* L), it has a remarkable history of medicinal use. In continuation to CIMAP's studies on the isolation of anticancer compounds from *T. wallichiana*, anticancer activity has been detected for three lignans isolated from the heartwood of the plant. These three lignans, characterized as taxiresinol, isotaxiresinol and (-) secoisolariciresinol on the basis of their spectral characteristics, were active against colon adenocarcinoma cell lines in MTT assay. Isotaxiresinol and secoisolariciresinol were most active against Caco-2 cell line with an IC₅₀ value of 0.08 µg/ml in MTT assay and 0.056 and 0.251 µg/ml respectively in clonogenic assay. However, these two lignans were inactive against other cell lines. Isotaxiresinol was equal to or even better than standard reference compounds such as taxol and doxorubicin against colon adenocarcinoma (Caco-2) in both the assay systems. Taxiresinol was active against ovary teratocarcinoma and breast adenocarcinoma cell lines albeit at higher concentration. The anthracycline derivative doxorubicin and microtubule depolymerization inhibitor Paclitaxel (Taxol[®]) (Sigma Chem. Co., St. Louis, USA), both established anticancer agents, were included as standard reference drugs.

Commercialisation of natural streptokinase

Streptokinase is a vital, life-saver injectable protein drug that saves upto 40% of human lives after heart attacks if given within a few hours of the onset of chest pain. The Indian sub-continent has been recognized by the WHO as a highly vulnerable population pool for cardiac problems, with nearly 20 million patients in India alone that are suffering from heart-related maladies. Till now, streptokinase has been wholly imported at high prices in India from MNCs of the West. The technology for its production was developed at IMT and transferred in the year 2000-2001 to M/s Cadila Pharmaceuticals Ltd., Ahmedabad. The drug is now being indigenously produced for the first

time. As a result, the price of even the MNC-produced brands have been 'forced' to be reduced by about 30%, resulting in a major saving to the Indian consumer. IMT's process is high-yielding (approx. 70% yields) and delivers drug of exceptionally pure quality (> 99% SK protein) that is safe toxicologically and stable for extended periods of time.

Local contraceptive cream

Reetha saponins developed by CDRI for use as spermicide has been granted marketing permission by DCGI and negotiations for licensing to industry are in progress. The product named Consap by CDRI can be used safely as a local (intravaginal) contraceptive. The spermicidal constituent of the Consap cream are the total saponins of *Sapindus mukorossi* incorporated in a cream with appropriate excipients. Repeated intravaginal application of Consap cream in rabbits and rhesus monkeys does not cause any local irritation/pathological lesions and no saponins could be detected in the blood of rhesus monkeys even after application of 25% cream for 90 days indicating no systemic absorption and safe profile of the contraceptive cream. Its contraceptive efficacy has been confirmed through clinical trials.

Improved process for production of vasicine: A bronchodilator from *Adhatoda vasica*

Adhatoda vasica (family Acanthaceae) is commonly known as "Arusa", "Vasaka" or "Malabar nut". It is an evergreen perennial shrub and is a well known drug in Ayurveda for the treatment of respiratory complaints and diseases like, cough, asthma and cold. The most studied chemical component from the plant is vasicine. It shows bronchodilatory activity both *in vitro* and *in vivo*, comparable to theophylline. CIMAP has developed a simple, economic and quick process suitable for commercial production of vasicine.

Development and delivery of therapeutic agents through novel drug delivery systems for non healing ulcers

CLRI has developed a drug-impregnated scaffold by impregnating drug loaded microspheres into known concentration of solution of collagen *in situ* and subsequently initiating fibril formation. The average particle size of the drug loaded microspheres were of 300-370 μm with 3% total drug entrapment. Release characteristics were observed for 96 hours and controlled release of SSD was achieved. The results of *in vitro* drug release studies and *in vitro* antibacterial susceptibility studies indicated that SSD was released from the microspheres impregnated collagen scaffold in a controlled fashion. It is thus capable of controlling infection for extended time period.

Gene prediction software for prokaryotes

Genedecoder is envisaged as a peptide library based gene prediction software for prokaryotes. The effort is based on the hypothesis that nature has utilized a restricted number of peptides during evolution. This is apparent from the fact that the difference between theoretically possible peptides and that are actually observed grow exponentially as the length of the peptide increases. The software developed by IGIB is designed to "predict protein coding regions" in the given nucleotide file. It is written in C language and is far more optimized than the previously written PERL code. The programme is tested to identify genes in *E.coli* without using *E.coli* peptide library. Genes specific to *E.coli* as well as highly conserved genes of the microbe have been identified.

Leishmania donovani antigens encapsulated in liposomes

Studies at IICB on leishmania donovani promastigote membrane antigens (Iag) encapsulated in positively charged liposomes

have shown to induce very significant levels of protection against experimental visceral leishmaniasis. The protectively immunized animals exhibited profound delayed type hypersensitivity and antibody responses. The extent of protection induced by the same antigens, however, varied depending on the charge of the vesicles. Investigations included human vaccine trials with killed promastigotes and immunization of mice with attenuated, killed crude parasite fractions as well as purified recombinant antigens and their DNA. While presently there is no effective form of immunoprophylaxis against this disease, the impressive recent advances in this area may soon result in the development of a safe and effective vaccine.

Infectivity and virulence of Leishmania donovani promastigotes

Infectivity studies in hamsters and BALB/C mice showed that promastigotes isolated in B-M199 were several folds more infective than those obtained from M199. Comparison of the infectivity and virulence of promastigotes of AG83, with a recent isolate of kala-azar, SL94, harvested under similar conditions, revealed greater infectivity of SL94 for both macrophages and animal models.

O-acetyl sialic acid specific IgM in childhood acute lymphoblastic leukaemia

Studies at IICB have revealed an enhanced surface expression of O-acetylated sialoglycoconjugates (O-AcSGs) on lymphoblasts concomitant with high titres of IgG in childhood Acute Lymphoblastic Leukaemia (ALL). Antibody specificity towards O-AcSGs was confirmed by selective binding to erythrocytes bearing surface O-AcSGs, decreased binding with de-O-acetylated BSM and following pretreatment with O-acetyl esterase. Competitive inhibition ELISA demonstrated a higher avidity of IgM for O-

AcSA than IgG. Flow cytometry demonstrated the diagnostic potential of purified O-AcSA IgM as binding was specific with ALL patients and minimal with other haematological disorders and normal individuals. It therefore may be adopted as a non-invasive approach for detection of childhood ALL. It has been concluded that carbohydrate epitopes having terminal O-AcSA a2@6 GalNAc determinants induce disease specific IgG and IgM, potentially useful molecular markers for childhood ALL.

Biocontrol combination against lepidopteran insects

A synergistic biocontrol composition comprising of alcohol extract from the parts of plant *Albizia lebbek* and *Bacillus thuringiensis* □ - endotoxin acetone powder killing the lepidopteran insects was developed with the objective to prevent the emergence of resistant insects due to sole application of the insecticidal compounds. The dose requirements of the plant extract and □ - endotoxin acetone powder were significantly low compared to the individual application of the components to achieve the same level of killing of the insects. Further, it was observed that application of □ - endotoxin first followed by ethanolic extract reduces the pupation percentage compared to application of extract followed by □ - endotoxin. This is in addition to the finding of synergistic combination for simultaneous application. The effect of reduced pupation may be due to the weakening of digestive system by initial □ - endotoxin application. The synergistic composition has an edge over individual sole application of either □ - endotoxin or the ethanolic extract as the killing percentage increases tremendously. Considering the low cost nature, easy availability, preparation, application and non-persistent biological nature, the composition and the process of application will definitely have an edge over other biological formulations.

Mycoparasite tolerant *Claviceps purpurea* variants identified

Ergot is the sclerotial form of the parasitic fungus *Claviceps purpurea* growing on rye plants and optimum production of ergot on rye can be achieved through best combinations of host-parasite interaction. Ergot alkaloids (ergotamine, ergometrine, ergotoxin, etc.) are important alkaloids used by pharmaceutical industry worldwide. These and their derivatives have extensive uses in gynaecology, migraine, orthostatic circulatory disturbances, hypertension, Parkinsonism, etc. The attack of mycoparasites like *Cerebella andropogonis* (Ca), *Fusarium palidoroseum* (Fp), *Fusarium avenaceum*, *Fusarium graminearum* and *Cladosporium cladosporioides* threatens the developing ergot sclerotia, causing more than 50% damage to ergot yield and alkaloid content. Mycoparasite tolerant variants have been identified at CIMAP through the DBT sponsored *Jai Vigyan* National Science & Technology Mission Programme. This would help increasing the production of ergot alkaloids needed for import substitution.

A novel source of dwarfing gene identified in opium poppy

Damage due to lodging caused by high velocity winds and irrigation at maturity is a long standing problem in shallow rooted - long stature opium poppy plants. Dwarf genetic stocks evolved through induced mutation breeding and interspecific hybridization could not offer desirable latex yield. Efforts to reduce plant height in the existing long stature cultivars, resorting to their cross breeding programme with the dwarf genotypes, has not yet been successful primarily due to unbreakable linkage of dwarfing gene(s) with undesirable genes in the dwarf genotypes. During the course of genetic improvement through induced mutagenesis, an extremely dwarf mutant (Accession VE-01) having much

brevity in its dwarfing gene transfer to high yielding genotypes (Vivek and SG35-II) of the same species (*Papaver somniferum*) as well as of other species (*P. setigerum*) was recovered in true bred forms in M₃ generation of variety Vivek treated with 0.4% EMS. Observations indicated that the dwarfing trait did not transmit from the parent to the hybrid contrary to the intermediate inheritance mechanism of quantitative genetics. This unusual result (in F₁) obtained at CIMAP gives an indication for the cumulative role of certain factors in reducing plant height. The major interest with the dwarf mutant VE-01 is that it allows dwarfing gene transfer in a cross hybridization programme to reduce plant height of the hybrid to a desirable extent without entailing reduction in its capsule size.

A new approach for in vitro selection of menthol rich genotypes

In *Mentha in vitro* selection clones for tolerance to menthol, which is the end product of the biosynthetic pathway, has been carried out at CIMAP to generate menthol rich cultivars. It has been done with the rationale of lifting the feedback toxicity of metabolic end product. The clones developed were found to tolerate 80 µg/ml menthol (tertiary level screening) and were found to contain the highest amount of menthol per g leaf biomass. Using this method the relationship between the primer OPT 04, menthol tolerance and high menthol content character of the genotype was established. Stemming out from this, the cultivar 'Saksham' was developed for release by CIMAP for superior performance.

Rashtrapati Bhawan adopts medicinal and aromatic plants

CIMAP developed a herbal garden, stretching over 4000 square meter at the Rashtrapati Bhawan. H.E. Hon'ble President of India, Dr. A.P.J. Abdul Kalam, inaugurated the garden by planting the first sapling of Sandalwood

(*Santalum album*). Dr. R.A. Mashelkar, Director General CSIR, on the occasion, planted a sapling of Sarpagandha (*Rauvolfia serpentina*). Dr S.P.S. Khanuja, Director, CIMAP and the scientists and technical staff involved in the development of the garden were also present during the ceremony. About 40 species of medicinal and aromatic plants including commercially and industrially important, rare and endangered species have been planted in the first phase. The project, conceived by the president himself, aims to conserve important medicinal and aromatic plant species and educate children and visitors as well about the huge potential of such plants for india.

Chromium induced apoptosis

The ability of Cr (III), Cr (V) and Cr (VI) to induce apoptosis of lymphocytes has been demonstrated at CLRI. Involvement of signaling messengers such as reactive oxygen species (ROS) and Src-family tyrosine kinases leading to apoptosis is being investigated. The modulation of p53 levels and cyclin-dependent kinases (CDKs) during various stages of exposure to chromium is an important area, which may hold clues about the change from apoptotic to transformed state of the cells. Gaps in knowledge with relevance to Src-family tyrosine kinases in apoptosis due to a number of physiological stimuli such as H₂O₂, HOCL, NO, Fas, CD-3 antigen as well as other metals have been identified and are being investigated.

Identification of new hydrogen producers through computational genomics

Screening of 92 microbes reported in KEGG was conducted at IGIB for these two principal enzymes. The organisms reported have the ability to utilize a wide range of industrial wastewaters and leach insoluble metal sulfides. They also have magnetotactic ability and could dehalogenate and degrade environmental pollutants. The anaerobic treatment of wastes yields biogas and hydrogen. It has the dual

advantage of energy generation as well as stabilization of waste.

Alkaneutre process

The capability of certain bacterial isolate to neutralize the alkalinity has been exploited at IGIB for treating beverage industry effluents. The developed process completely eliminates the use of chemicals and brings down the pH from 12.0 to 7.0. It is highly economical and safe over the existing process which is based on chemical consumption. This will replace the existing use of chemicals which otherwise incurs a huge amount of money. The Alkaneutre is being upscaled.

A new natural source of high valued rose oxides

Rose oxides along with high content of citronellol were identified for the first time by IHBT in the essential oil of *Dracocephalum heterophyllum* – a high altitude cold desert plant. Citronellol and rose oxides are being used extensively in the perfumery industry and these two essential oil isolates are the alternative sources of base materials to the perfumery industry. The plantation of *D. heterophyllum* is presently under trial cultivation and its agrotechnologies practices are being worked out for large-scale cultivation.

Improved seed germination in Podophyllum hexandrum Royle

In nature, the germination of *Podophyllum* is highly restricted. IHBT has developed a protocol for promoting germination of *Podophyllum* seeds under *in vitro* conditions. Germination rate of over 80% has been obtained through this method and a nursery has been established for raising quality planting material. The rhizomes of *Podophyllum hexandrum* are rich in podophyllotoxins and have anticancer and antitumor properties. The podophyllotoxins

are lignans whose semi-synthetic derivatives- etoposide (VP-16-213) and teniposide (VM-26) are approved drugs for the treatment of testicular and lung cancer. The present technology is likely to ensure its large scale plantation both *in situ* and *ex situ*.

Development of diagnostics for viruses infecting carnations

IHBT has developed and standardized detection strategies for viruses from carnation. The method involves antibody based detection and RT-PCR techniques. Adopting this strategy, the carnation viruses namely carnation *etched ring virus*, *carnation mottle virus*, *carnation ring spot virus*, *carnation vein mottle virus*, *carnation necrotic fleck virus* and *carnation Italian ring spot virus* were detected for the first time in India. The information generated will help in raising disease free material for production of quality flowers. This is also important from the quarantine point of view. Presently, efforts are being made to characterize and clone these viral genes.

Microwave induced process for the preparation of substituted 4-vinyl phenols

A new microwave induced process has been developed by IHBT for the synthesis of substituted 4-vinyl phenols. 4-vinyl phenols (No.3739) and 4-vinyl guacos (no. 2675) are FEMA approved flavoring agent which are known for spicy, apple, rum roasted and clove like flavors. Synthetic preparation methods are tedious. Microwave assisted method is a rapid and economical process and results in development of a highly purified product in large quantities.

Microbial association in cold desert

Situated at a strategic location, IHBT has access to rarely ventured land of cold desert- Lahul and Spiti. Studies carried out to assess the lesser

known microbial diversity of the region revealed a vast array of microbial populations associated with plants like *Hippophae rhamnoides*, *H. tibetana*, *Dactylorhiza hatageria*, *Ephedra gerardiana*, *Rosa webbiana* and *Arnebia euchroma*. The microbes identified included: Arbuscular Mycorrhizal Fungi, viz. *Aculospora sorbiculata*, *Glomus mossae*, *G. globiferum*, *G. clarum*; fifty-eight isolates of bacteria; and hundred and sixty six isolates of fungi belonging to *Acremonium*, *Aspergillus*, *Aureobasidium*, *Chrysosporium*, *Colletotrichum*, *Geotrichum*, *Gliocladium*, *Paecilomyces*, *Papulospora*, *Penicillium*, *Torula*, *Trichoderma*, *Tricothecium*, *Mucor*, and *Fusarium* spp. The information generated will help in understanding the fundamental functioning of the ecosystems at degraded sites under cold desiccating and stressful milieu of Spiti valley.

Enhancing production of high valued essential oils

Characterized planting materials of geranium and lavender were given to the farmers along with the standard cultural practices. The two distillation units designed and installed by IHBT at Fatehpur and Salooni are being extensively used by the farmers as a central processing facility for distillation of geranium and lavender oil respectively. Several progressive entrepreneurs have undertaken the cultivation of aromatic crops and have set up distillation units with IHBT technology and expertise. Also the farmer of the region are showing interest in adopting agro and processing technology of high value aromatic crops like Damask rose, wild marigold, geranium and lavender. Quality planting materials of these crops are supplied to farmers and training programmes are organized from time to time for their benefit. As a result of the efforts of the Institute, 10 kg damask rose oil worth Rs. 20 lakh, 3000 kg wild marigold worth Rs 6 lakh, 15 kg of geranium oil worth Rs 60 thousand and 3 kg lavender oil worth Rs 75 thousand were produced only from North India.

Geographic Information System

IHBT has set up Geographic Information System (GIS). The facility is useful for environment impact assessments; land use planning; management of bio-resources; agricultural development; monitoring ecological changes; and enhancement in measuring environmental parameters and mapping topographic features, monitoring changes in space and time and modeling environmental features and deriving alternatives of actions and processes. This information will be used to prioritize future research and development endeavours.

Synthesis of carbohydrate dendrimers

Dendrimer chemistry is one of the frontier areas of research due to its importance in biological, material and other branches of science. Carbohydrate dendrimers have special significance by virtue of their biochemical behavior such as lectin binding properties. Dendrimers having such complexity are rare. This work at IICB describes an expedient approach to internally functionalised chiral dendrimers incorporating furanoside skeletons. A dendrimer incorporating pentose units in the interior and hexose units in the periphery is built up on a 1, 3, 5-trisubstituted aromatic core by using 1,2,5,6-di-isopropylidene glucose as the carbohydrate precursor and a 3, 5-disubstituted aromatic unit as the branching block. The carbohydrate moiety also provides internal functionalities in the form of hemiacetal moiety of the furanoside ring. The contribution will make possible the synthesis of carbohydrate dendrimers, which could be functionalised and coupled through conjugation to biologically important molecules such as peptides leading to the development of materials with novel biological properties.

Sanguinarine - Triplex DNA structures

Triplex DNA structures are known to play a role in the gene expression and recombination and also have potential application as antisense inhibitor of gene expression. The instability of triplex structure under normal physiological condition is a critical limitation that restricts their uses *in vivo*. The present strategy is to aim at enhancing triplex stability using various intercalating agents. IICB reported for the first time that sanguinarine binds more tightly to triplex structures than to duplex. IICB has reported for the first time the thermodynamic aspects of sanguinarine-triplex DNA complexation. It reveals that the process of binding of sanguinarine to C.GxC⁺ triplex is exothermic and enthalpy driven while that to T.AxT triplex is endothermic and enthalpy driven. The present work on thermodynamics of sanguinarine-triplex stabilization has further supported the scope for the use of this plant alkaloid for purpose of gene regulation and gene therapy.

Stabilization and improvement of catalytic activity of a lower molar mass cellobiase by cellobiase-sucrase aggregation in the culture filtrate of *T. clypeatus*

Protein protein interaction is an important arena in proteomic research. IICB has identified a new mode of such interaction where extracellular enzymes of a fungus *T.clypeatus* improved its catalytic activities and stabilities by forming aggregates with other enzymes co-produced by the fungus. The biological significance of such heterologous protein-protein interaction observed for a long time was first reported by IICB.

Strain for the production of recombinant Staphylokinase

Staphylokinase, a fibrinolytic protein, secreted from *Staphylococcus aureus*, has recently been

established as a potent fibrin-specific clot buster. A recombinant system for the high level production of SAK has been developed for the production of this potent thrombolytic protein and its analogs exhibiting better functional properties. In order to understand molecular basis of plasminogen activation function, the functional relevance of its charged loop structure has been studied. It provided insight into the interaction of SAK plasmin activator complex with the substrate plasminogen during plasminogen activation. A recombinant system for the high level production of this clot-buster has been developed. It may provide a recombinant system that may be commercially viable if upgraded at higher scale/fermentation level.

Role of CD80 and CD86 in the activation of B cell and B cell lymphoma

Studies at IMT have led to proposing of a novel concept of bi-directional costimulation. It has been demonstrated that costimulation through CD80 molecule specifically inhibits the proliferation and IgG secretion by LPS-stimulated B cells and B cell lymphoma through up-regulating the expression of pro-apoptotic molecules caspase-3, caspase-8, Fas, FasL, Bak, and Bax and down-regulating the levels of anti-apoptotic molecule Bcl-xL. The study established the role of costimulatory molecules in understanding the regression of lymphomas and in the development of a strategy for controlling the growth of cancer cells.

Bioremediation of pesticide

With the ban on several organochlorine pesticides worldwide, there has been increased emphasis on organophosphate pesticides. IMT has been able to effectively demonstrate removal/bioremediation of PNP to the extent of ~90% from contaminated soil by adding a PNP-degrading bacterium *Arthrobacter protophormiae* RKJ100 to the contaminated soil

in microcosm experiments in the laboratory. Besides, the complete pathways for the degradation of PNP, 4-nitrocatechol and *o*-nitrobenzoate have also been elucidated which have been included at the University of Minnesota biocatalysis/biodegradation database. Efforts were underway to provide understanding of the above pathways at a molecular level.

Immunosensor system for environmental pollutants

IMT has developed an ultra-sensitive immunosensor system for specific and sensitive detection of environmental pollutants. It measures the biomolecular interactions on transducer surface and is capable of detecting analyte concentrations upto nano-molar range. The immunosensor system utilizes piezoelectric crystals (10 MHz, AT-cut) as a sensor transducer, and combines a specific biological recognition component to detect and identify the target molecules in solution. The process is based on the measurement of small change of mass, resulting from formation of antibody-antigen complex on piezoelectric crystal surface. The piezo-immunosensor enables detection of concentrations and also monitors interactions between molecules in real time without using any labels such as enzyme, fluorophores, radio-isotopes etc. This sensor can detect the interactions between biomolecules such as protein-protein, antibody-antigen, enzyme-substrate, protein-nucleic acid etc. The surface of the crystal is chemically modified for covalent binding of the ligand to give higher stability and reproducibility.

Microbial degradation of endosulfan

Endosulfan (CAS No. 115-29-7) is a broad-spectrum chlorinated-cyclodiene insecticide which is extremely toxic to fish and aquatic invertebrates, moderately to bird species, and has been shown to be mutagenic to bacteria, yeast, and mammalian cells. It is listed as a hazardous substance because of its abundant

use, migration in the environment, persistence, and toxicity and the disposal of its wastes is controlled by Federal Regulations (Toxicological profile of endosulfan, U.S. Department of Health, 2000). ITRC has studied the degradation of endosulfan by a bacterial co-culture, consisting of two different strains of *Bacillus* sp that have been deposited in the Microbial Type Culture Collection & Gene Bank (MTCC). The degradation of both the isomers of endosulfan was accompanied by the formation of the metabolites, endosulfan diol and endosulfan lactone, as seen by TLC, GC, and GC-mass spectroscopy. ITRC studies for the first time demonstrated microbial degradation of endosulfan isomers accompanied by a decrease in its toxicity to the test organism *Tubifex tubifex* Müller. The isolated microorganisms offer significant potential for the bioremediation of contaminated soils and waters, and safe disposal of endosulfan-wastes.

Association of lead with prostate cancer

ITRC conducted studies to evaluate the possible association of environmental exposure with lead as a risk factor for prostate pathology. Blood lead level was determined in patients suffering from prostate cancer (PCA) and benign hyperplasia (BPH) and compared with those in a control group living in the similar socioeconomic environment. The blood lead levels were significantly higher in PCA and BPH cases in comparison to normal ($P < 0.05$). Blood levels of zinc and copper were significantly lower in PCA and BPH cases when compared with controls ($P < 0.05$). In all the three groups, a statistically significant positive correlation between lead and thiobarbituric acid reactive substances (TBARS) measured as malondialdehyde and negative correlation between blood lead and antioxidants GSH level, indicative of possible generation of reactive oxygen species, were also observed after adjusting for age as a possible confounders. However, positive association between blood

lead and TBARS was relatively higher in PCA patients than in BPH and normal. The study conducted seem to suggest that environmental exposure of aging males to lead may be a risk factor for prostate cancer and/or benign prostate hyperplasia possibly through generation of reactive oxygen species and/ or reducing the level of zinc which acts as a cellular growth protector. It provides for the first time, a new insight into understanding the phenomenon of environmental exposure of aging males to lead. Further studies in this regard were in progress.

Removal of Vinca alkaloid induced P-glycoprotein mediated multidrug resistance by Indole-3-carbinol

The over expression of *mdr-1* gene transcript P-glycoprotein (P-gp), responsible for multiple drug resistance (MDR), is a major obstacle in cancer chemotherapy. P-gp acts as an energy dependent drug efflux pump, reducing the intracellular concentration of structurally unrelated drugs. Modulators of P-gp function are reported to restore the sensitivity of MDR to such drugs. In a study conducted by ITRC the P-gp modulatory potential of Indole-3-Carbinol (I3C) using *in vitro* and *in vivo* models was evaluated. I3C is a well known chemo preventive agent present in cruciferous vegetables, reported to possess many medicinal properties including antimutagenic and anticarcinogenic activities. For *in vitro* studies, K562 leukemic cells were made resistant (K562/R) towards the cytotoxicity of vinblastine (VBL) by progressive adoption of the parental sensitive K562 cell to VBL. Cross-resistance of K562/R was found between Vincristine (VCR), Doxorubicin and other antineoplastic agents. A non-toxic concentration of I3C enhanced the cytotoxic effects of VBL and another vinca alkaloid. The results showed that I3C decreased the induced levels of P-gp in resistant cells back to the normal levels as analysed both qualitatively and quantitatively by western

blotting and immunocytochemistry. Furthermore, *in vivo* combination studies showed that I3C effectively inhibited the vinca alkaloid induced P-gp over expression in mouse hepatocytes. Quantitation of immunostained tissue sections with image analysis showed a reduction in P-gp levels was up to the extent of ~80% for both VBL and VCR included drug resistance. I3C can serve as a novel, non-toxic modulator of P-gp expression and can be used as a dietary adjuvant for the reversal of MDR. Studies to delineate the mechanism were in progress.

Novel Ni(II) mixed ligand complex modified electrode: catalytic effect on anodic oxidation of phenol

ITRC has synthesized and characterized Ni(II) – cyclame thiocyanate complex and for using it as a carbon paste electrode modifier for oxidative detection of phenol. The electroactive mixed ligand complex behaves as a fast electron mediator and exhibits reversible redox peaks. The mixed ligand complex of nickel, when incorporated in the graphite paste electrode, is sensitive to detect phenol as low as 10 ppb in solution. The technique has the potential for sensing/monitoring of phenol released in the ecosystem from polluting industries. This knowledge can be applied for developing technology for detection of other phenolic compounds.

Multi enzyme based potentiometric sensor for estimation of creatinine

A process for the estimation of creatinine, with the help of two enzymes immobilized in creatinine reactor followed by potentiometric estimation of urea with a urea bio-sensor has been developed at ITRC. Creatinine has become an important clinical analyte that is used for the determination of renal glomerular filtration rate and kidney dysfunction and muscle disorder. The reference ranges for serum/plasma

creatinine and urine creatinine are 35 – 140 μM and during disorder or disease conditions, the creatinine level may rise to $> 1000 \mu\text{M}$. The device developed is cost effective and non-hazardous. Quantification of creatinine is possible by using it without any interference of other chemicals or ions in biological samples. It can detect upto 0.1mM in the aqueous samples. A patent has been filed for the development.

Phytochemical and genomic diversity in *Withania somnifera*

Withania somnifera (Ashwagandha) is a medicinal plant, used commonly in Indian traditional healthcare system. A large number of withanolides have been identified in its roots and leaves and attributed several bioactive properties. In collaboration with RRL, Jammu and CIMAP, NBRI undertook studies supported under the NMITLI programme of CSIR and revealed important aspects related to chemotypic and genomic diversity. More than 100 accessions collected from different native geographical zones in India were analysed. Several contrasting chemotypes were identified as promising for developing cultivars and designer plants for specific applications. Studies on the genes involved in the synthesis of withaferin A (an anti inflammatory and immunosuppressive molecule), sitoindosides (antistress activity) and withanolide D (antitumour activity) have revealed interesting results in *Withania*.

Chemical evaluation of biodiversity in neem

NBRI evaluated neem germplasm in the country. More than 40 provenances and nearly 1000 individuals from different states were collected and evaluated for phenotypic and major active metabolites of neem (azadirachtins, solanin, nimbin). The azadirachtins were quantified. There were wide variation in oil and azadirachtin content among different provenances. Azadirachtin A ranged from 556.9 to 3030.8 mg kg^{-1} kernel whereas azadirachtin B

was in the range between 43.1 to 590.6 mg kg^{-1} kernel among the provenances investigated. Analysis of variance among various neem provenances showed significant difference in oil content, azadirachtin A, total azadirachtin (A+B) and A:B ratio. There were individuals with high and low azadirachtins within a single provenance; and this trend was observed in all the provenances selected from five afro-climatic regions of the country.

Development and release of new chrysanthemum varieties

Four new varieties of chrysanthemum developed by NBRI through open pollinated seedling selection have been released for commercial exploitation. These new varieties are:

NBRI Indiana: is yellow pompon type, small flowered, suitable for mini and pot culture. It has profuse branching, long, erect stem, lush green leaves, uniform bloom, opening in late November, easy to multiply by suckers and cuttings.

NBRI Kusum: is yellow open disc, small flowered, single Korean type chrysanthemum, good for pot culture.

NBRI Little Darling: is terracotta pompon type, small flowered, mini chrysanthemum. It is a unique genetic strain with dwarf, bushy, compact round shape, profuse blooming habit in early December. The plant habit and shape is most attractive for 'mini culture'.

NBRI Mini Jessie: is cineraria type mini chrysanthemum. It is a unique genetic strain with dwarf bushy, compact round shape and profuse blooming habit. The plant habit and shape is most attractive for 'mini culture'.

Biological control agents as growth enhancer

A technique for the management of collar rot

disease of betelvine (causal organism: *Sclerotium rolfsii*) has been developed at NBRI by using formulations of *Trichoderma* spp. and *Pseudomonas fluorescens*. The field application of the formulations of these BCAs not only reduced the disease incidence significantly but also enhanced the crop yield under *in vivo* conditions. Corm rot and yellows disease of gladiolus caused by *Fusarium oxysporum* f. sp. *gladioli* is an important disease of gladiolus resulting in heavy losses. An integrated approach for the management of this disease has been developed by NBRI using *Trichoderma harzianum* and Chlorothalonil in combination. The application of this synergistic technique reduced the disease significantly.

Biologically derived HIV-1 protease inhibitors

First biologically derived molecule that inhibits HIV-1 protease has been isolated at NCL. The mechanism by which this inhibitor acts makes it especially robust to mutations of HIV. The inhibitor isolated has an amino acid sequence that shows no similarity to existing inhibitors, and represents an exciting new class of inhibitors with important implications for AIDS therapy. HIV requires an enzyme called HIV-1 protease in order to multiply. Thus, this enzyme is an excellent target for developing drugs against the virus. Studies indicate that drugs that inhibit HIV-1 protease (protease inhibitors), in combination with another group of drugs called reverse transcriptase inhibitors, dramatically reduce the levels of HIV in blood. While a large number of synthetic inhibitory compounds targeting the HIV-1 protease have been reported, not much is currently known about biomolecule-inhibitors from microorganisms. It has been demonstrated at NCL that an aspartic protease inhibitor, ATBI isolated from a bacterium, the alkalothermophilic *Bacillus* sp. that thrives in adverse environments, shows inhibition against recombinant HIV-1 protease. The sequence homology of ATBI exhibited no similarity with

the reported peptidic inhibitors of HIV-1 protease. ATBI exhibits a unique, non-competitive mode of inhibition that distinguishes it from other inhibitor molecules. Detailed studies of the mechanism by which ATBI acts suggest that the binding of ATBI impairs the flexibility of the flaps on the HIV-1 protease. The proposed binding interaction with the backbone of the flaps of HIV-1 protease eliminates the probability of drug resistance by single mutation. Thus, spontaneous single-point mutations in the active site of HIV-1 that drastically deteriorate the performance of other inhibitors might not affect the potency of ATBI. Another significant advantage offered by ATBI over the majority of existing peptidic inhibitors is its increased bioavailability due to its water-loving or hydrophilic nature.

Vegetation protocol for reclamation of crude oil contaminated soil

In oil fields, during drilling, gathering, transporting etc. some quantity of crude oil always gets spilled over the neighbouring land. The spilled crude oil causes serious threat to the flora and fauna at the drill site. The soil once contaminated takes years together to have the natural plant succession initiated. RRL, Jorhat has developed a protocol for regeneration of vegetation neighbouring the drill sites. Emphasis was laid on the growth and development of neem plant in such soils. The ONGCL-ERBC (SEM), Sivasagar, was provided the protocol, to be used at one of their drilling sites. The growth of vegetation was made possible with the application of RRL protocol in crude oil contaminated soil.

3.3 Chemical Sciences & Technology

Removing noise from data signals

NCL has devised new algorithms to filter and de-noise data. The algorithm takes data and extracts underlying patterns that might be

obscured by noise. For example, temperature, pressure, velocity data obtained while monitoring a chemical reactor are typically very noisy and therefore, it is difficult to meaningfully interpret the signals in the form that they are obtained. However, application of NCL's noise removal algorithms reveal hidden features even in such data and provide insight into process and reactor behaviour. This algorithm is broadly applicable and the NCL team has demonstrated its use for a wide variety of phenomena from classical chemical engineering reactors such as the stirred-tank, fluidized bed and bubble column reactors, to data from flow experiments on polymer solutions and conductivity measurements on surfactant solutions. A US patent has been granted for the development. The power of this analytical tool has excited researchers worldwide and the development has been cited in a variety of research papers. It offers significant advantages over conventional methods to remove noise from data. Conventional methods of filtering data are unable to capture sudden changes in data, such as pressure fluctuations or sudden changes in temperature. The NCL de-noising algorithm could be automated.

Novel route to Ibuprofen

NCL has developed the first heterogeneous catalysts for preparation of aryl propanoic acids. These acids are important intermediates in the synthesis of blockbuster nonsteroidal anti-inflammatory drugs such as Ibuprofen and Naproxen. Aryl propanoic acids are prepared by the hydrocarboxylation of aryl olefins or alcohols. The current Hoechst-Celanese process for the synthesis of Ibuprofen uses a palladium (Pd) catalyst in solution, (viz. a homogeneous catalyst). This process requires a highly corrosive acid promoter and works at high pressures (16-35 MPa). Earlier efforts at NCL had led to significantly improving this process by developing a novel homogeneous palladium

complex catalyst that worked at lower pressures (around 3 MPa) and yet showed significant enhancement over the Hoechst-Celanese catalyst in the catalytic activity and regioselectivity for Ibuprofen. However, all homogeneous catalysts suffer from difficulties in separation and reuse. To overcome this limitation, NCL combined their catalyst with solid silicate supports, (viz. a heterogeneous support) to produce the first heterogeneous hydrocarboxylation catalyst. It has been shown that a Pd complex (Pd-Pyca) anchored to mesoporous silicates like MCM-41 and MCM-48 exhibits high conversions and selectivities for a variety of aryl olefins and alcohols. The catalytic efficiency of the heterogeneous catalysts in terms of activity and selectivity is very high compared to previously reported heterogeneous catalysts by conventional methods. With TOF (turn over frequency) values of these anchored heterogeneous catalysts in the range of 415 - 465 h⁻¹ and high regioselectivity of >98%, these catalysts have immense potential for use in industrial carbonylation reactions.

Trifunctional catalyst

IICT has developed new immobilized catalysts stabilized in nanoclays and nanozeolites for organic transformations. A unique trifunctional catalyst anchored to silica/clay/polymer matrix has been developed to execute Heck reaction followed by asymmetric dihydroxylation (AD) and in situ oxidation of N-methyl morpholine to generate the oxidant NMO for AD in one-pot. A highly efficient "tight fit" immobilization of a-chymotrypsin in mesoporous MCM-41, with a loading of protein (w/w) wherein the effective enzyme activity 6.5% (w/w), has been achieved for the first time.

Biotransformations

Chemo-enzymatic methodologies have been developed at IICT for the preparation of 3-

aryloxy-3-phenylpropyl amine, a key intermediate for antidepressant drugs and 5-(1-aminoethyl)-2-(cyclohexyl methoxy) benzamide, an important intermediate for Src-SH2 inhibitor. A one-pot lipase catalysed synthesis of enantiomerically pure secondary alcohols from carbonyl compounds and a new protocol for lipase-mediated resolution have also been developed. Efficient methods have also been developed to use lipases and phospholipases for the preparation of hydroxy and saturated fatty acid rich phospholipids from vegetable oils.

Non-glycerol based cationic transfection lipids

Several new structural analogues of non-glycerol based cationic transfection lipids containing two 2-hydroxyethyl head-group functionalities have been designed and synthesized. Two cationic lipids in these new series were found to be more efficient in transfecting cells than DMRIE, one of the most extensively used commercially available cationic transfection lipids. IICT's results do indicate that too-strong lipid-DNA interactions might result in weaker transfection efficiency for non-glycerol based cationic lipids. In addition, novel cationic lipids based on lactic acid were also synthesized and evaluated for gene transfection.

New Centres for Bioactives - Safety and Functional Evaluation (BIOSAFE) & Health of Pharmaceuticals - Evaluation (HOPE)

IICT has established the "BIOSAFE" Centre for functional evaluation of bioactives and the "HOPE" Centre for evaluation of health of pharmaceutical preparations as per Indian Drugs and Cosmetics Act. The "BIOSAFE" Centre will cater to need of in-house as well as industry sponsored programmes associated with the development of new bioactive molecules of commercial importance and will be used for the generation of animal pharmacology and

toxicology data as required by schedule 'Y' of Drugs and Cosmetics Act 1940 and Rules 1945. The "HOPE" Centre is recognized by the Andhra Pradesh State Drugs Control Administration. It will assess the quality of drugs and cosmetics employing state-of-art testing facilities. A wide range of tests in accordance with IP, BP, USP and various regulatory standards can be conducted at this centre.

Synthesis and characterization of novel metal complexes

A new chromium (III) complex $[\text{Cr}(5\text{-chlorosalprn})(\text{H}_2\text{O})_2]\text{ClO}_4$ has been prepared and characterized at CLRI by electrospray ionization mass spectrometric (ESIMS) analysis and other spectroscopic techniques. Single crystal XRD reveal that the complex assumes a *trans* diaquo structure $[\text{Cr}(\text{C}_{17}\text{H}_{18}\text{Cl}_2\text{N}_2\text{O}_4)]\text{ClO}_4 \cdot \text{H}_2\text{O}$. The effect of phenyl ring substituent on the rate of formation of $[\text{O}=\text{Cr}^{\text{V}}]^+$ has been investigated. The bimolecular rate constant for the formation of $\text{O}=\text{Cr}^{\text{V}}$ species by the $[\text{Cr}(\text{Schiff base})(\text{H}_2\text{O})_2]\text{ClO}_4$ where Schiff-base = salprn (1) and 5-chlorosalprn (2) with PhOI was compared. In case of 2, the rate was found to be faster by an order of magnitude at pH – 4 compared to 1. The introduction of chloro substituent on the phenyl ring not only influences the rate of redox reactivity but also the pKa values of aquo ligands of the complexes.

Novel synthesis of mono- and bis(2,3-fused perhydrooxazol-4-one) systems

The unstable isomünchnones generated from the α -diazoidimides have efficiently been trapped using oxygen nucleophiles in the presence of rhodium(II) acetate catalyst. This forms a facile tandem cyclization-nucleophilic addition method to 2,3-fused perhydrooxazol-4-one 1 and bis(2,3-fused perhydrooxazol-4-one) 2

skeletons with the option to vary its substituents and ring sizes in good to excellent yields and the formation of upto two cyclic rings, four C–O bonds are achieved in a single step. This synthetic process developed at CSMCRI forms a facile entry into the new family of 2,3-fused perhydrooxazol-4-one 1 and bis(2,3-fused perhydrooxazol-4-one) 2 systems with the atom economy. It will be applied to synthesize dendrimers with this multiple bonds formation technique.

Aerobic oxidation of tertiary nitrogen compounds to N-oxides

IIP has achieved for the first time oxidization of a variety of tertiary nitrogen compounds to their corresponding N-oxides in excellent yields using molecular oxygen as the sole oxidant in presence of catalyst. Oxidation of tertiary nitrogen compounds is an important synthetic transformation, as N-oxides find wide application as oxidants and offer functional group manipulation and structural modification possibilities, which are not accessible by other methods. Aerobic oxidation of other substrates is being studied to develop new oxidative synthetic methodologies.

Catalyst for deep catalytic cracking

IIP has developed a catalyst of deep catalytic cracking. It would be used for cracking of residues to maximize the production of light olefins such as propylene and isobutylene. Highly dealuminated zeolite with strong acid sites, low unit cell size has been used as one of the ingredient in catalyst recipe. Catalyst has been found suitable for high severity FCC operation for olefins maximization. The yield of gaseous hydrocarbon was found as high as 40% with higher content of C₃/ C₄ olefins, from heavy feedstocks. The development work was undertaken in collaboration with Centre for High Technology (CHT).

Making plastics biodegradable

An ingenious technique to convert high-volume, commonly used plastics into biodegradable materials, has been developed at NCL. It is demonstrated that bacteria could be induced to degrade commodity plastics such as polyethylene, polypropylene and polystyrene. Each year the global polymer industry produces around 100 million tons of polyethylene, polypropylene and polystyrene. These low-cost, durable materials are used in a variety of applications ranging from plastic shopping bags to bottles, sheets and styrofoam cups. After use, these polymeric objects are typically discarded and they enter the waste stream. Here, the durability of the polymers poses a grave problem as they do not degrade and remain in the environment. The increasing volumes of polymer production and consumption make this resistance to degradation a serious ecological hazard. The problem is addressed by chemically attaching a small number of sugar molecules to polystyrene. Bacteria readily attack the sugar molecules (sucrose, glucose, or lactose) and, in the process, they seem to break up the otherwise-resistant polystyrene. As little as a few percent of sugar incorporated onto the polystyrene chain dramatically increases the rates of polymer degradation, while leaving other desirable properties of the polymer substantially unchanged. This novel method represents a significant improvement over previous attempts where chemicals (additives) were added to the polymer to enhance degradation. These additives were toxic in nature, leached out of the waste and adversely affected the performance of other additives added to improve the properties of the polymer. Further work in this regard was in progress.

Biomimetic approach to nano-particles for diagnostics and therapeutic use

The utility of monodispersed superparamagnetic

(SPM) iron oxide particles in biopolymeric matrices for a range of biomedical applications has been highlighted. Conventionally, sub-micron (100-300nm) ferrimagnetic iron oxide particles precipitated from non-solvent or from supersaturated solution are dispersed into different synthetic media to form a composite film; role of macromolecules remains limited as a dispersant. Interfacing an external magnetic field during its synthesis is also known to bring about a dramatic modulation in the size, shape and assembly of nanoparticles. However, the processes fail to yield expected results when dealt with SPM particles in the size range that is below a single domain (1-10nm). Biomimetic synthesis has helped solve some existing synthesis problems, like the synthesis and self-assembly of several nanocrystalline inorganic systems in pre-organized synthetic and biopolymer matrices. Studies at NML have demonstrated the self-assembly of highly oriented array of SPM iron oxide particles that are biomimetically precipitated in protein and synthetic polymeric matrices under the influence of an external magnetic field. The role of biomimetic synthesis in synthesizing mono-disperse hydroxy-apatite particles as well as polymer hydroxyapatite composites for various applications in orthopaedic treatment was demonstrated. The contribution is based on the understanding of the nature's way of synthesizing functional materials and their translation to materials engineering for synthetic systems to be used as advanced materials. The work contributes towards the understanding of macromolecular interactions with selective cations leading not only to controlled nucleation and growth but also their self-assembly to form long range structures with and without an external stimuli like magnetic field. The studies also demonstrate that how an external field leads to the selective nucleation of a specific polymorph as a result of reduced entropy of the

system. Based on the above results it is planned to go for the clinical trials with superparamagnetic iron oxide and hydroxyapatite particles. This will be carried out in collaboration with other agencies like Atomic Energy and Department of Biotechnology.

Three-component reactions under thermal and microwave irradiation

The indolizines and dihydropyrimidinones are synthesized in a one-pot reaction via three component reactions (3-CR) in excellent yields. The synthesis of biologically active indolizines continue to attract the attention of organic chemists. However, these strategies in general involved multi-step synthesis employing two component reactions and do not represent the goal of an ideal synthesis. On the other hand the dihydropyrimidinones have emerged as backbone of several calcium channel blockers (nifedipine), anti-hypertensive agents and marine derived alkaloids having HIV inhibitor activities. A fast solid phase synthesis of 1,5-diketones via Michael addition was achieved and employed at RRL, Jorhat for synthesis of a novel class of 1',2'-diazepino[17,16-d'] steroids. The contribution made in these studies have established the viability of a three component reaction (3-CR) involving a 1,3-dipolar cycloaddition reaction between an in situ generated dipole using microwave energy and a Biginelli condensation using metal catalyst. The strategies provide the first successful example of the application of this approach and an access to fast one-pot synthesis of indolizines and dihydropyrimidinones which otherwise are accessible only through multi-step synthesis. The methodologies denote a new class of 3-CR and an advancement of Biginelli condensation reaction, which are expected to be general routes for the facile, one-pot combinatorial synthesis of a wide range of indolizines and dihydropyrimidinones.

Conductive hydrogel

CECRI has developed a conductive hydrogel. It is a component of disposable ECG electrode and provides ready adhesion for measurements in diagnostic tools. This biologically acceptable polymer is cost effective and is resourced from a cheaper source. It is unique as the conductive gel could be converted into a laminate, sheet or film meeting the device configuration. The cross-linking chemistry of the gel has been fine-tuned with a new set of reactions. This product provides longer shelf life when appropriately protected and is free from the spontaneous drying and other problems associated with the conventional gel. The process for conductive hydrogel production has been licensed for commercial exploitation.

Gold plating on aluminium alloy components

The cover plates of momentum Wheel Assembly and Reaction Wheel Assembly used in INSAT and IRS satellites are made of AA 6351 Aluminium alloy. These components are to be plated with gold as per ISRO specifications. A plating facility for carrying out this work was set up at CECRI and gold plating of IISU components was in progress. Feasibility study regarding gold plating on AA 6351 and AA 2024 alloys was taken up initially for IISU, Thiruvananthapuram. After successful development of plating procedure, the components were plated and sent to IISU for testing. The quality of plating was found to be satisfactory for space applications as per ISRO specifications. Based on this a gold plating facility was set up at CECRI to carry out plating to the requirements of IISU.

Scratch resistant coating on plastic by sol-gel processing

A process has been developed at CGCRI for making abrasion resistant coatings on polycarbonate sheets and ophthalmic lenses based on

UV curable inorganic – organic hybrids (epoxy methacrylate – silica) loaded with boehmite nanoparticles. The method has also been used for depositing inorganic-organic hybrid coatings doped with gold and silver nanoclusters respectively on polycarbonate substrates for application as abrasion-resistant coloured coatings and nonlinear optical materials. The composite sols were prepared from GLYMO, TEOS, MEMO and the corresponding metal salts (HAuCl₄ and AgNO₃ for AuAg). Dual organic functionality i.e. heat sensitive epoxy and photosensitive methacrylate ester groups were used. The hydrolysis-condensation of alkoxy groups and polymerization of epoxy and methacrylate groups formed the composite matrix. The coatings became hard and reddish-purple in the case of Au and yellow in the case of Ag after UV irradiation followed by heat-treatment at 100°C. The polymerization of epoxy groups occurred at the sol stage in presence of an epoxy polymerization initiator, methyl imidazole, while UV irradiation simultaneously helps to polymerize methacrylates, strengthen the silica network and generates metal nanoclusters in the film. UV-VIS spectra of the coated films showed clear peaks at 530 nm and 445nm due to the surface plasmon resonance of Au and Ag nanoclusters respectively. A TEM also confirmed the presence of spherical metal nanoclusters in the films. TEM micrograph of the Au-nanocluster doped film showed the presence of spherical (about 9-10 nm diameter) Au nanoclusters in the inorganic-organic film. The coated polycarbonates show high abrasion resistant property compared to that of the uncoated substrates.

Novel heterocyclic compounds

CLRI has synthesized novel heterocyclic compounds viz. 4-aryl-8-(4-(aryl)-3a,4,5,9b-tetrahydrochlopenta [c] quinolin – 8 - ylmethyl)-3a,4,5,9b-tetrahydro-3^h cyclo penta [c] quinolines. This is the first report for the imino diels alder reaction of Schiff's bases derived

from 4,4'-diaminodiphenylmethane. A simple and facile route for the synthesis of pyrazolodihydroquinoline derivatives from tetrahydroquinolonehydroazones has been developed.

Synthesis, characterization and reactivity ratio studies on new sulfide copolymers containing ethylbenzene units

Polysulfide polymers possess excellent thermal stability, weatherability, solvent resistance, and oil resistance, etc. They are used as coatings, adhesives, sealants, insulators and as coating agents. These polymers are commercially synthesized by condensing an organic dihalide with sodium polysulfide. Efforts at CLRI have led to enhance the solubility of monosulfide polymers in common organic solvents by introducing kink structure in the form of ethyl benzene unit. The phenyl substituents restricted the close packing of the polymer chain resulting in increasing in the amorphous content of the copolymers. New copolysulfide polymers based on ethylene dibromide (EDB) with styrene dibromide (SDB) and Na₂S in the presence of phase transfer catalyst such as tetrabutylammonium bromide (TBAB) has been synthesized. The copolymers have been characterized.

Redox switchable NIR dye derived from ruthenium-dioxolene-porphyrin systems

CSMCRI has synthesized Ru(bpy)₂(sq)-derivatives, covalently linked to porphyrin-core. They show very high ϵ values ($>59000 \text{ dm}^3 \text{ mol}^{-1} \text{ cm}^{-1}$) in the NIR region which exhibit fast switching between on/off-states depending on the redox state of the coordinated dioxolene functionality. The fast response property in picosecond time scale for switching between on/off-states imparts a novel molecular function in these complexes. These derivatives are ideally suited for probable use in redox switchable NIR dyes and sensors for optoelectronic devices.

Novel adsorbent for oxygen, nitrogen and argon separation from air

A novel zeolite based adsorbent for separation of oxygen, nitrogen and argon from air has been developed at CSMCRI. Some of the commercially significant features of the adsorbent are: high adsorption capacity for N₂ almost 1.5 times compared to the best capacity values reported for similar zeolites; and high selectivity for nitrogen from its mixture with oxygen compared to reported selectivity of 3-4 for similar zeolite. It is the first zeolite based adsorbent showing selectivity for N₂ as well as Ar over O₂. A PCT application has been filed for the development which offers a new technique of developing adsorbent by cluster formation inside zeolite cavities.

Biopigment: production C-Phycocyanin

CSMCRI has developed a process for production of high value fluorescent pigment, C-Phycocyanin (C-PC), from a strain of *Spirulina platensis*. Important innovations in the protocol for cultivation, harvesting, extraction and purification have yielded high purity C-PC with 10% yield on dry weight basis. The absorption spectral data show, that the CSMCRI product has similar absorbance at 620 nm as the product from Sigma, when both spectra are recorded with similar concentrations of C-PC (0.14 mg/ml). The ratio of absorbances at 620nm & 280nm, which indicated the extent to which protein impurities are present, is also comparable for the two products. A key factor behind the high purity of product obtained is membrane processing of crude extract. The membrane of appropriate molecular weight (M.W.) cut off developed for this purpose in the Institute enabled the undesirable low M.W. proteins and other impurities to be eliminated. C-Phycocyanin, is a high value product and has possible applications in areas like food, pharmaceutical, cosmetics, immunodiagnostics, flow cytometry, etc.

Precipitated Calcium Carbonate (PCC)

CSMCRI has developed a process for production of Precipitated Calcium Carbonate (PCC) from calcium carbonate rich by-product of nitrophosphate plant. The product obtained is rubber, PVC, paint and toothpaste grade. The unique features of the process are that it produces calcium carbonate from inorganic powder having average particle size of 50 micron, and an alternate raw material to natural lime stone for producing PCC is established. The knowhow has been transferred to a fertilizer industry. The industry is generating around 300 tpd of calcium carbonate rich inorganic by-product out of which around 200 tpd is presently not finding any use. In addition to production of about 30,000 tpa of PCC for various applications, the process developed will allow the company to recover a valuable chemical worth Rs.1 crore per year from this by-product (presently unused). Two PCT applications have been filed covering the innovation. The development will be useful to all the fertilizer industries having nitrophosphate plants where the problem of disposal of inorganic byproduct is faced.

Low sodium salt from bitterns

The in take of low sodium salt in place of pure sodium chloride is being recommended to patients suffering from hypertension. Presently no technology exists for the production of low sodium salt directly from brines. CSMCRI has developed a process for the recovery of low sodium salt (a mixture of sodium chloride and potassium chloride) from bitterns, byproduct of salt industry. A PCT application has been filed for the development. The present innovation thus contributes greatly towards development of an entirely new technology. Hitherto, low sodium salt is produced by mixing sea salt with potassium chloride. Against this the present invention provides a simple route for the recovery of low sodium salt directly from

bitterns, which obviates the drawbacks of the known processes.

Photochemistry for materials and new molecular entities

Several 9-anthraceneacrylic esters were synthesized at IICT in order to study photochemical E(trans)-Z(cis) isomerization. This E-Z isomerization phenomenon has application in molecular electronics and also as opto-mechanical and opto-electrical switching storage devices. Several 3-arylallyl acetates and E-3-(1-naphthyl)-2-propene-1-ol were synthesized for studying ionic photo-dissociation. This photo-dissociation has application in polymers & electronics viz. cationic polymerization; cross linking depolymerization; surface imaging by acting as photo acid generator; depolymerization; and surface imaging by acting as photo acid generator.

Chirally-pure anti-hypertensive drug: (S)-Amlodipine

Asomex-2.5, the first chirally pure anti-hypertensive drug launched on the Indian market has been manufactured by using a patented technology developed at NCL. Amlodipine, the molecule on which Asomex-2.5 is based is chiral, viz. it has "handed-ness". The NCL process uses a cheap and naturally occurring resolving agent to separate out (S)-Amlodipine with a chemical and optical purity exceeding 99.5%. This is a significant improvement over the Pfizer process that uses costly and unnatural D-tartaric acid for resolution. Asomex-2.5 has been used in clinical trials. The chirally pure (S)-Amlodipine does not lead to any of the adverse side effects observed for treatment with the racemic mixture. In addition, Asomex-2.5 has been observed to lower the patient's LDL cholesterol level.

Process development/demonstration at IICT

IICT developed and demonstrated successfully several processes during the year which included:

- ☞ Catalyst for speciality polymeric materials based on zirconium tetrachloride was demonstrated and released on 100 g/batch size (3 consecutive batches) to NFC, Hyderabad;
- ☞ Hydroxy Ethyl Cellulose (HEC) process with a viscosity in the range of 200-300 Cp at 5% concentration (Grade-I) on scale of 20 g/batch demonstrated and released to M/s Pidilite Industries, Mumbai;
- ☞ Lacidipine process on a scale of 50 g/batch (3 consecutive batches) was demonstrated and released to M/s Cadila Pharmaceuticals Ltd., Ahmedabad;
- ☞ Lamda cyhalothrin process was demonstrated on a pilot plant scale of 3 kg/batch (3 consecutive batches) to M/s Isagro (Asia) Agrochemicals, Mumbai;
- ☞ 3-Furaldehyde process was demonstrated and released on 50 g/batch scale to M/s Standard Products Manufacturing Company, Hyderabad to upgrade and modernize the bulk drug industry; and
- ☞ Methane sulphonic acid process for the conversion of methyl mercaptan- a bad smelling pollutant effluent gas into a value added product (methane sulphonic acid) was demonstrated to M/s SMS Pharmaceuticals Ltd., Medak, A.P. in their commercial Ranitidine drug manufacturing plant.

NTGG process – a commercial success

IIP has developed a process for conversion of Naphtha to Gas and Gasoline (NTGG) The

process is based on a novel zeolite catalyst, which selectively converts the C5-C6 rich feed stocks to LPG and high octane and low benzene gasoline with very low dry gas yield. The catalyst and the process were developed with Gas Authority of India Ltd. (GAIL). IIP prepared the basic engineering package, based on which GAIL started the detailed engineering and construction activities in June 2000 for setting up demonstration unit at Vaghodia, Gujarat. The plant has been successfully commissioned this year. On-spec LPG and gasoline was produced in the first run itself in a record time of under four hours. The Vaghodia unit has demonstrated the technology successfully and valuable data is being collected for its further scale up and development. A US patent has been granted and four patents are filed in India on NTGG and related processes by IIP.

Catalytic aerobic oxidation of secondary alcohols to ketones and 2-naphthols to binaphthols

Oxidation of secondary alcohols to carbonyl compounds is conventionally carried out by Chromium and Manganese based reagents producing copious amount of heavy metal wastes. In the recent years aerobic oxidation of secondary alcohols to ketones by using metal catalysts such as hydrated RuCl_3 , $\text{RuO}_2 \cdot \text{H}_2\text{O}$ has been described in the literature. However, these procedures suffer from drawbacks like use of expensive metal catalysts and oxidation of only activated alcohols. IIP has developed a new methodology for the aerobic oxidation of secondary alcohols to ketones using cobalt phthalocyanine as catalyst and methyltrioxorhenium catalyzed oxidative coupling of 2-naphthols to 1,1'-bi-2-naphthols.

Oxidative coupling of 2-naphthols is an important synthetic transformation as 1,1'-bi-2-naphthols are widely used as chiral inducers in synthetic organic chemistry. The methodology developed could oxidize a variety of activated

and non activated secondary alcohols to corresponding ketones with molecular oxygen using cobalt phthalocyanine as the catalyst.

Aziridination of alkenes

Metal catalyzed reactions of in-situ generated nitrenes with olefins is an efficient and practical method for the preparation of aziridines and has received increasing attention in the recent years. In this context Ph I = N TS has been widely used as a nitrene processor for aziridination of alkenes, in the presence of several transition metal based catalysts. However, Ph I = NTS is expensive and yields iodobenzene in equimolar amounts. Efforts at IIP have lead to aziridination of alkenes using N-iodo--N-potassio-p-toluene sulphonamide (TsNKI) as a cheap and convenient nitrene precursor. It is an important synthetic transformation as azeridines find broad utility as electrophils and as synthetic intermediates in the preparation of pharmaceuticals and agrochemicals.

Improved soaker visbreaking technology

IIP developed soaker visbreaking technology in use for the reduction of viscosity and pour point of fuel oils. The process is also used for upgrading of residual fraction. Six commercial units based on the technology are under operation. Efforts at IIP in collaboration with EIL and UDCT have lead to further improvement in the technology, which would provide following benefits: increased conversions due to uniformity in temperature and flow profile; decrease in coke deposition in soaker and furnace coils and hence reduction in frequent shutdowns; and increase in selectivity towards middle distillates. The process is energy conserving, the benefits to the user will thus be of the order of Rs. 50 lakh per annum for the plant of 1MMT capacity in saving of fuel oil. In

addition, overall throughput will also increase, as the run length will increase, enhancing the productivity.

Pressure Swing Adsorption (PSA) process for helium

IIP has developed a process for the recovery of Helium from low helium bearing gas mixtures such as natural gas. In India helium requirements presently are being met through imports, notably from the United States, which is currently the world's largest supplier. It is essential to develop technology for extraction of helium from indigenous sources in view of its strategic importance. Helium is present in small amounts in some of the natural gases, found in Rajasthan area, in gas emanations from thermal springs in West Bengal and in off gases from monazite sands processing operations in Kerala. The PSA technology developed is a step towards indigenous capability development for extraction of this strategically important material. The process involves a two stage PSA operating at ambient temperatures and uses commercially available adsorbents. The process is able to enrich helium from concentration levels of around 4 mol% to around 85 mol% with a recovery of 75%. The two stage PSA uses different cycles in each stage designed to maximize helium purity and recovery. The process is being scaled up.

Shear stability test rig for hydraulic oil

The hydraulic oils are widely used to transmit power and motion in the hydraulic systems used in the earth moving equipment. These oils are subjected to very high pressures and velocities in these hydraulic circuits causing very high shear of the oil molecules. The shearing of oil causes deterioration of equipment performance due to lowering down of oil quality. The shearing of hydraulic oil is dependent on nature of oil. For studying the shear stability performance of hydraulic oil, IIP has installed a test facility. In this equipment the oil is subjected to very high shear. The degradation

of oil is measured through change in the oil quality. At present this is the only facility available in South-East Asia.

Biosynthesis of nanoparticles using fungi

The controlled synthesis of nanoparticles over a range of sizes and chemical compositions has emerged as an extremely important area of nanotechnology. Inspired by the exquisite inorganic nano-scale structures generated by micro-organisms of NCL has demonstrated the synthesis of silver and gold nanoparticles of good monodispersity within the cells of a fungus, *Verticillium*. It is found that treatment of the fungal biomass with aqueous ions of gold chloride (AuCl_4^-) resulted in reduction of the metal ions and intra-cellular formation of gold nanoparticles. The formation of gold nanoparticles is visible to the eye in terms of the biomass turning purple in color. Thin section TEM analysis of the *Verticillium* cells showed that the particles were fairly monodisperse and bound to both the cell wall and the cytoplasmic membrane. It is believed that reduction of the metal ions is due to reductases present on the fungal cell wall/on the cytoplasmic membrane.

Green route to antidepressants

Manufacture of drugs with complex chemical structures typically involves complicated multi-step reactions. These reactions use hazardous reagents and eco-unfriendly solvents and, have very low yields, viz. only a small amount of the final purified product is recovered despite using large quantities of starting materials. NCL has developed a high-yield route to a new generation antidepressant, Venlafaxine. The novel process uses mild reaction conditions; substitutes hazardous reagents with cheap, relatively non-hazardous chemicals and; the key step is performed in water rather than in an eco-unfriendly organic solvent. The NCL process is a four-step reaction that employs two novel patented schemes. This process introduces

significant improvements in the first two steps over what is currently practiced. The process gives high yield and it is anticipated that ongoing research will further improve the yield.

2-Methallyl sulfonic acid sodium salt and 2-acrylamido-2-methyl-1-propane sulfonic acid

These are speciality monomers that find applications in the acrylic fiber industry for imparting dye-affinity to the fiber. Polymers prepared by using later monomer (ATBS) are also extensively used in the Enhanced Oil Recovery (EOR). Similarly it is used in water treatment chemical and in preparation of specialty polymers. M/s Vinati Organics Limited (VOL), Mumbai, sponsored the project to NCL for development and transfer of the technology for these two monomers. NCL successfully developed the process for both the monomers. It was successfully demonstrated to VOL on the bench scale as well as on the pilot scale. Special equipments were identified for some of the steps also and trials for these were conducted at vendor's site. Basic Engineering Package for 750 TPA SMAS and 1000 TPA ATBS was also delivered and comprehensive assistance to the detailed engineering firm was provided during engineering, procurement and construction phases of the project. The plant was commissioned with the assistance of NCL at the identified site.

Preparation of alumina membrane for micro and ultra - filtration

NML has designed and prepared a very thin disc type ceramic membrane (0.3-0.8 mm thickness, 25-30 mm diameter) made of pure alumina. It is suitable for micro-filtration applications. A sol coating was applied to the disc to form an ultra-filtration membrane. The pore size of the membrane vary in the range of 0.1-0.7 μm and porosity in the range 25-55% by optimising the experimental parameters. The most important factor for determining the pore size of the

membrane was found to be the initial particle size distribution of the ceramic powder. Firing temperature and soaking time are other crucial parameters affecting volumetric porosity. Water permeability through the membrane under suction and under positive pressure is comparable with that of ceramic membranes prepared by conventional methods. A very sharp drop in the pore size distribution pattern around 0.4 μm indicates that no pores larger than this exist. This implies that all particles with radius $> 0.4 \mu\text{m}$ are trapped in the membrane, providing excellent separation efficiency. Results of microbial separation tests confirmed the possibility of micro-organism separation through these membranes.

Fabrication of in-situ dense $\text{Al}_2\text{O}_3\text{-ZrB}_2$ and $\text{Al}_2\text{O}_3\text{-ZrB}_2\text{-TiB}_2$ composite

Incorporation of high temperature boride particulates to improve the properties of ceramic matrix composite is of recent interest. Amongst the various borides, zirconian diboride (ZrB_2) is an important material and the addition of zirconian diboride to alumina is expected to demonstrate high mechanical strength, hardness, fracture toughness and impact resistance. The alumina matrix dispersed with Zr diboride becomes electrically conducting, which makes the composite machinable by EDM. The investigation at NML emphasised the fabrication of in-situ $\text{Al}_2\text{O}_3\text{-ZrB}_2$ and $\text{Al}_2\text{O}_3\text{-ZrB}_2\text{-TiB}_2$ composite by SHS dynamic compaction technique. The process developed for making such in-situ composite using cheaper raw materials such as oxides of the components and one of the constituent as metal powder. A range of composites based on alumina with zirconium diboride and titanium diboride at different volume percent could be manufactured through the process. The high-density composites in the range of 93% to 98% of that of theoretical density could be obtained with controlled grain growth. The grain growth could be controlled to very fine size of the order of 1-5

μm to submicron level, which is required for obtaining high strength composites. The process is fast; in-situ reaction and densification takes only few seconds to get a good dense composite.

Determination of micromechanical parameters of primary heat transport system piping material of Indian PHWR (SA333 Gr.6 Carbon Steel)

The nucleation of voids, their growth and coalescence followed by fracture are important manifestations of various stages of ductile fracture in metallic engineering materials. Exogenous inclusions and endogenous second phase particles are mainly responsible for void initiation. These phenomena are dependent on the state of stress and plastic strain. Studies on these phenomena are important to understand damage mechanisms and fracture toughness parameters such as J_{ic} and J-R curve. Different damage mechanisms have been used at NML for numerical analysis of the ductile fracture process. One such model is due to Gurson, popularly known as Gurson-Tvevergaard-Needleman's model. This model makes use of a number of parameters related to void nucleation, growth and coalescence during large-scale plastic deformation. For useful application of this model for a particular grade of steel, it is needed to have elaborate and painstaking experiments to monitor the progression of various void related phenomena in specimens, which have been subjected to tensile loading to various levels. Gurson model are generated for steel of SA333 Gr. 6 (base metal and weld metal), which is a pressure vessel steel for the Indian Pressurised Heavy Water Reactors. Following are the parameters: (a) Initial condition without loading-void vol. fraction (f_n), (b) Saturated nucleation conditions – void vol. fraction (f_n), means strain (e_n) and standard deviation of mean strain (S_n), (c) Void coalescence condition – void vol. fraction (f_c) and (d) Rupture condition – void vol. fraction

(f_F). The generation of parameters of micro-mechanical model for numerical simulation of ductile tearing of PHT piping material of Indian Pressurised Heavy Water Reactor and the studies on these phenomena are significant and important contributions to understand damage mechanism and fracture toughness parameters such as J_{ic} and J-R curve. Further studies on different materials (SS304/HSLA-100/SA-515) to understand the micro-mechanism of fracture and development of model for damage mechanism was under progress.

Beneficiation and zinc extraction studies on Ganesh-Himal zinc-lead ore from Nepal

A rich mineralisation of zinc and lead is located in the Ganesh-Himal region of Nepal. M/s Nepal Metal Company Ltd. (NMCL), Kathmandu has been interested in exploitation of the deposit. At the instance of NMCL, earlier bench scale beneficiation and zinc extraction studies were carried out using NML's patented process. Encouraged with the results it was proposed to undertake beneficiation and large batch zinc extraction studies on Ganesh-Himal lead-zinc ore sample, in order to study the feasibility of the process. The scope of the investigation includes characterisation, bench/pilot scale beneficiation, preparation of zinc sulphide concentrate and large batch hydrometallurgical extraction of zinc. About 5 tonnes of lead-zinc ore sample (low & high grade) was received for the proposed studies. Bench scale flotation studies were carried on the blended sample, assaying 13.45 % Zn and 3.53 % Pb. The zinc rougher float assayed 49.31 Zn with over 80 % recovery. Cleaning of the rougher flotation product resulted in cleaner zinc sulphide concentrate assaying 55.68 % Zn, considered suitable for hydrometallurgical extraction of zinc. Pilot scale trials were also conducted and sufficient quantity of zinc sulphide concentrate was produced for the subsequent hydrometallurgical extraction of zinc. Based on the process know-how and the data provided by NML techno-economic

feasibility of the process is being carried by M/s Metallurgical and Engineering Consultants (India) Ltd., Ranchi for the commercial exploitation of the lead-zinc ore deposit. The project is sponsored by South Asian Development Fund, Kathmandu, Nepal.

Improved process for fabrication of in-situ synthesis and consolidation of Al₂O₃-ZrB₂-TiB₂ composites

NML has developed a process for the in-situ synthesis and consolidation of Al₂O₃-ZrB₂-TiB₂ composites of approximate 93-97% density. It uses cheaper raw materials compared to conventionally used metal powders and high temperature furnaces are not required. The product obtained is electrically conducting with resistivity in the range of 300-800 micro ohm centimetre. The composite target for nano and hard coatings of Ti-Zr-Al-B-O system by sputtering can be fabricated by this process. The manufacturers of cutting tools, wear resistant components, and high temperature components will be benefited with this development.

Metallurgical study of broken rail pieces and other items from accident site at Sarai Banjara

The Inquiry Commission headed by Justice Saghir Ahmad, Northern Railway has commissioned NML to carry out metallurgical and chemical tests on selected (by the railways) pieces of components collected at the site of accident that took place at Sarai Banjara, Punjab in December 2000. The requirement on NML, as suggested by the commission, has been to find out the possible cause of material/component failure(s) that might have contributed to the occurrence of the accident. NML received a total of 31 samples consisting of 45 pieces (41 rail fragments, 2 coupler body fragments, 1 brake block fragment and 1 unbroken knuckle) for the purpose of the investigation. The investigation was carried out and the final report has been sent to the Inquiry Commission.

A novel bio-physico technology for the treatment of industrial effluents

A novel electro-flotation process has been developed by NML for the treatment of effluents. The innovative feature of this process is the controlled generation of micron-sized bubbles used for flotation of suspended particle matter through electrolytic dissociation of water. An additional feature of this process for the treatment of effluents is the *in situ* generation of oxygen that results in a substantial decrease of the biological and chemical oxygen demands of the effluent. A pilot scale electro-flotation cell to treat 0.7 to 1 m³/hr tannery effluent was designed, fabricated and commissioned in the common effluent treatment plant at Chennai. Above 95% reduction in suspended solids, 60-75% COD and 60-73% BOD could be achieved at pilot scale. This process has shown superiority over conventional chemical treatment presently adopted. The technology has been demonstrated to the tanners. Several of them have expressed keen interest in adopting the technology. Pilot scale trials were in progress in various tanneries.

Polymetallic nodule

RRL, Bhubaneswar has developed a flow sheet for processing the ocean nodules through hydrometallurgical route. A pilot plant for testing the entire flow sheet has been put up by EIL-HZL at C.R.D.L of HZL, Debari, Udaipur with the assistance of the laboratory. The process would be further scaled up on the basis of the data generated through trial runs at the plant.

Improving the performance of graphite beneficiation plant

Tamil Nadu Minerals (TAMIN) have in operation a graphite beneficiation plant of 200 tpd capacity. The plant since inception could not achieve the target grade of 96% F.C. and 92% recovery from a feed of around 14% F.C. The

grade and recoveries are reported to vary between 90-92% and 65-70% respectively.

RRL, Bhubaneswar is assisting TAMIN in improving the grade of graphite and its recovery. A detailed exercise was carried out based on which RRL has suggested certain modifications in the plant and methodology as a first step. TAMIN followed them and as a result the recovery could be substantially improved to around 80% at 96% F.C. Although recovery could be augmented substantially there is still inconsistency in the plant performance. RRL is now making necessary efforts to achieve the desired consistency in grade and recovery by imparting the training on column flotation and other unit operations to the plant staff.

Advanced centre for iron ore processing

The requirement for uniform quality of pig iron and sponge iron demands meticulous efforts for iron ore processing. The ores and agglomerates prepared from iron ore fines should meet the stringent quality standard for both physical and metallurgical properties. RRL, Bhubaneswar has set up an iron ore processing centre which is equipped with modern sophisticated equipments for determination of important physical and metallurgical properties. This Centre will be of immense help to many iron and steel industries of Orissa and neighbouring states to evaluate the quality of raw materials and ore samples.

A broad spectrum antibiotic from soil Streptomyces

RRL, Jorhat has isolated a bioactive microbial metabolite 2-methylheptylisonicotinate, a broad spectrum antibiotic from a soil *Streptomyces* sp. The novel molecule endowed with both antifungal and antibacterial activity was structure elucidated as a natural analogue of antituberculous drug isoniazid. The molecule was found active while bioassayed *in-vitro* against wide range of pathogens at RRL Jorhat

and CDRI against *Mycobacterium tuberculosis* H37Rv. (in-vitro), the causal organism of second most killer disease TB. Agriculture application of the antibiotic as biocontrol agent was proved by its effectiveness against dominant fungal diseases of some economically important plants such as Cabbage, Mustard, Brassica and Radish. The isolated novel molecule was found to be three times more potential compared to standard isoniazid. The natural antibiotic may prove to be most effective potential drug not only to check the alarming rate of TB occurrence due to HIV epidemic but also to control subsequent secondary fungal infection in TB patient which aggravates the situation.

Application of soil microorganism in biotransformation reaction

RRL, Jorhat has employed soil micro-organism *Pseudomonas fluorescens* RRLJ 134 for a facile 1,5-rearrangement of N-acetyl group of steroidal and non-steroidal formyl enamides as well as for efficient cleavage acetates to alcohols. Fluorescent pseudomonads are the most extensively studied bacterial biocontrol agents for a diverse range of soil-borne diseases, their potential in biotransformation reactions has received little attention. On the other hand, an acyl group is a frequently used protective group for alcohols and there has been continued search for mild and efficient methods for the cleavage of esters employing enzymes and Lewis acid catalysts. Attempts made in the laboratory to utilize soil microorganisms in bio-organic transformations led to a facile 1,5-rearrangement of the N-acetyl group of b-formyl enamides as well as cleavage of the esters catalysed by *P.fluorescens* strain RRLJ 134.

Extraction of natural dyes from the plant sources

RRL, Jorhat has isolated pigments from *Morinda angustifolia* and established its

chemical structure. It is amorindone type of compound containing an anthraquinone group. The dyeing properties of the pigment have been evaluated. Silk and cotton fabrics can be dyed with this colour component with and without using different mordants to obtain a wide range of colours with fair to good wash and light fastness. Thus, the dye so extracted may be an alternative to synthetic dye for dyeing of silk and cotton. The yield of colour component varies from 10% to 20.9% depending on duration of extraction (30-240 min). Fair to good fastness properties are obtained on fabrics when dyed with 3% of colour component at 2% concentration of mordants.

3.4 Engineering Sciences & Technology

Analytical studies on fracture behaviour of metallic structural components considering corrosion

Metallic corrosion has been identified as one of the issues of major concern as it affects the overall strength, safety, integrity and performance of structures. In India, the loss due to corrosion is estimated to be around Rs.20,000 crores per year. It is therefore essential to contribute towards methodologies that can reduce such losses and predict the rate of corrosion on a scientific basis for reliable and economic designs of structures. At the state-of-the-art level, R&D is focused towards not only in understanding the nature and behaviour of structure under corrosive environment but also provides estimates of rate of corrosion for cost effective design of structures. Internationally, the practice has been based on thumb rules, past experiences and empirical corrosion rate prediction models. At SERC, after conducting number of studies, a linear damage function model has been developed to predict the rate of corrosion under atmospheric and seawater environments. The model developed considers a number of corrosive agents like temperature, humidity, percentage of SO₂, etc. and their

variations. The proposed model is simple to use and is flexible. It can be extended for application to additional metals and corrosive environments. The proposed model has a scientific basis to evaluate the corrosion rate and is among the very few such models available internationally. When used along with fracture mechanics principles, this will facilitate in arriving at reliable estimate of the remaining life of the structure.

Attenuation relationships for Indian region

The attenuation relationships are considered to be applicable for earthquake range between magnitude range 5.0 to 7.0 with hypocentral distances ranging 10 to 300 km. The relationships give good prediction PGA values for above magnitude range, a larger data set is required for accurate prediction of PGA values for further use for earthquake resistant design and seismic hazard estimation.

CBRI is actively involved to study natural hazards such as earthquakes, cyclones and landslides such kind of for their mitigation. Seismic microzonation involves the combination of geological features, ground conditions and seismic activity for the division of a region into sub-regions. The earthquake database is one of the most important factors for such studies. CBRI has established first and only Digital Strong Motion Accelerograph (DSMA) Network in seismically active and strategically important national capital region to record ground motion in real time. The site-specific studies provide basic inputs for the town planners and city managers.

Out of several waste materials produced in India, phosphogypsum is an important by-product of phosphoric acid industry which is currently available to the extent of about 6.0 million tonnes per annum. It has a serious problem of disposal and health hazards. Presently, it is being used not more than 10.0

percent annually in India. in the manufacture of ammonium sulphate fertilizer, cement and soil reclamation. It contains impurities of P_2O_5 , F, organic matter and alkalies which hamper the normal setting and strength development of cements and plasters produced from it. It is, therefore, essential to beneficiate phosphogypsum to get gypsum of acceptable properties for use in plaster and value added products.

Based on wet sieving of phosphogypsum, a pilot plant of capacity one tonne per shift (3 tonnes per day) has been designed and installed at CBRI for the beneficiation of phosphogypsum.

Investigations on cyclic tearing and crack growth in straight pipes

Earthquake load, which is cyclic in nature and of short duration, is the main design basis accident load for designing the Primary Heat Transport (PHT) piping components of Indian Nuclear Power Plants. Adequate protection of piping components from the effects of earthquake requires detailed knowledge of strength and deformation characteristics of the components and assemblies making up the piping system. SERC conducted investigations to understand the fracture behaviour of pipes under cyclic loading. Fracture tests were conducted on carbon steel (SA333 Grade 6) pipes of 219 mm OD and stainless steel (AISI Type 304LN) pipes of 168 mm OD with through-wall circumferential crack. The influence of various parameters, such as cyclic load ratio, range, amplitude and initial crack size on crack growth and number of cycles for failure was investigated. The studies showed significant reduction in the fracture resistance under cyclic loading conditions. The results would be useful in formulating appropriate guidelines for pipe design under earthquake type loads.

Habitable reclamation of abandoned flyash ponds

CBRI was entrusted the responsibility of exploring technical feasibility of habitable reclamation of ash ponds. Keeping in view the exigency of the problem, study was undertaken to develop and demonstrate the techniques of local stabilization of abandoned ash pond for ground improvements to sustain loads of at least four storey buildings. Under the current programme, abandoned ash pond at National Fertilisers Ltd., Panipat and Badarpur Thermal Power Station (BTPS), Badarpur were selected for the exploration and construction purposes. Exhaustive laboratory and field studies were carried out to determine the physico – chemical, mineralogical and engineering properties. In addition evaluation of ambient air quality and under ground water quality in the vicinity of both the sites was also carried out. Demonstration dwelling units were constructed at NFL, Panipat ash pond site on the improved / virgin deposit of ash. Dwelling units were instrumented for monitoring long term behaviour with respect to settlement, crack development on the super structure and the pore pressure development and its dissipation during seasonal variations. At BTPS ash pond site four full scale foundations were constructed and loaded upto $16t/m^2$ which is equivalent to 4 storey building load.

Image codec simulation

Study and simulation work on Digital Image Codec for both the Encoder and Decoder paths consisting of signals scaling, quantization, zig-zag scanning, huffmann and entropy coding and 1-D to 2-D sequencing in its Forward (Encoder) and Reverse (Decoder) paths were carried out at CEERI. Approximately 600 lines of Visual C++ Version 6.0 and C Codes were developed in Windows and RedHat Linux O.S. to simulate the JPEG Codec behaviours for input pixel block patterns, minimum five times data

compression were achieved with in the desired S/N ratio which is $\sim\pm 5\%$. Some of the Codec modules were simulated after developing 320 lines of VHDL. This work can be propagated for the modeling of vision chip and design for the components of vision chip starting from the sensor to signal processing which incorporates various algorithms and control modules.

Studies on design aspects for couplers, multistage depressed collectors, magnets and backward wave oscillation for high efficiency space TWT

TWT is one of the most complex and expensive components of any communication system either being used in space or ground. There has been a growing demand for high power, high efficiency C-band and Ku-band space TWTs to meet the new emerging requirements of the satellite communication systems. CEERI designed different components of the space TWTs using in-house developed software packages. The input and output couplers are also important parts of TWTs for efficiently coupling the microwave power in and out from the helical SWS of a TWT. Input and output coaxial couplers have been designed for Ku-band 140 Watts space TWT. Impedance transformation approach was used for design of the input/output couplers with return loss better than -20dB (VSWR<1.20:1) over the desired frequency band from 10.9 to 11.7GHz. The design was refined using 3-D electromagnetic field simulator ANSOFT HFSS that can simulate the coupler along with the helix slow wave structure (SWS). Multistage depressed collector is one of the major components of a space TWT that enhances the overall efficiency of the tube and reduces the amount of heat generated. A 3-D simulator including the secondary electron emission model was developed for the simulation of multistage depressed collectors. This package included an automatic optimization technique that uses the

genetic algorithm during the studies on design aspects. Critical packages namely, SUN_CKT (for magnetic field simulation in the GUN region) and SUN-BWO (for backward wave analysis) were also developed.

Silicon load cell

Load cells are force sensors, which are used for weighing bridges, lorries, cars and trailers. Piezoresistive property of polycrystalline silicon thin film is used at CEERI to realize load cell capable of measuring loads in the range of 100s of kilogram. Using standard lithography and reactive ion etching (RIE) based etching of (100) orientation silicon a meander type of silicon piezoresistor is realized on SiO₂ covered silicon surface. Proper control of the grain size, residual stress and doping in the polysilicon, high sensitive strain gauge performance is achieved. Silicon load cell chip of 10 mm x 11 mm was designed. It is basically a force sensor, where force is measured by compressing meander shaped poly silicon strain gauge. Another strain gauge, which does not come into contact with load, is used for reference and temperature compensation, generated due to bending and stretching stresses in the chip. The specifications of the chip are: input load range - 0 - 200 Kg.; resistor value (Meander) -100 K Ω 15%; chip size -10 mm x 11 mm; and chip thickness - 0.50 mm.

On-line freeness tester for pulp and paper industry

CEERI has developed an on-line freeness system for the pulp & paper industry. The technique is based on intermittent timed level measurement. It consists mainly of an optical detector, transparent measuring column, a fine mesh screen, etc., and is assembled and mounted directly on a bye-pass line. The development is built around a RISC based micro-controller which controls the cycle of operations as well as computes freeness value

after due linearisation added with suitable correction for consistency and temperature. The on-line freeness tester has been tested at M/s. Seshasayee Paper & Boards Ltd. The system had performed very well and the results matched well with standard set. The development of such an instrument will be of great use to the pulp & paper industry especially during the refining stages of the paper making process.

Development of investment cast aluminium components from wax impregnated polystyrene RP patterns

In this competitive age, engineering and consumer product companies are continuously seeking ways to compress the lead-time from concept to market. Despite the rising interest in computer simulations of 3-dimensional objects and virtual reality, physical models and prototypes remain fundamental to superior product development. CMERI initiated this project recently and successfully concluded it in an effort to establish the process technology for conversion of selective laser sintering (SLS) based polystyrene patterns to functional metallic parts. This technology converts wax-impregnated polystyrene patterns to Al- based metallic part through investment casting process. This will help to suitably utilize RP process for development of metallic component and benefits the clients by reducing the chances of rejection to make convertible polystyrene RP-patterns to metallic part. In CMERI, wax patterns of different automobile components like crank case, covers, cylinder heads, etc. and other engineering components from CAD model and RP&M process followed by silicone rubber mould are used in investment casting. Expendable polystyrene and wax impregnated polystyrene patterns, however, need considerable research in order to establish the process parameters. CMERI has carried out the manufacturing run of high quality functional metallic parts by Rapid Prototype Soft Tooling (RPST) and quick cast process.

Neuro-fuzzy controller

A neuro-fuzzy control system is relevant and effective in an unpredictable nature of system. CMERI has derived an approach for the neuro-fuzzy control methodology for any system of uncertain and unpredictable nature through the development of a control mechanism for a centrally airconditioned floor area comprising several rooms with different degrees of occupancy and different articulated requirements for the comfort level.

Management Information System (MIS) for highways

CRRRI has developed an intelligent road map and the database which is useful for designing, planning and maintenance of rural roads. The database is useful for socioeconomic and transport development of a given region and could be easily updated. CRRRI has also developed a GIS based MIS for a section of National Highway-2 between Varanasi and Aurangabad.

Environmental aspects in corridor management of a major highway

In recent decades the demand for both urban and regional travel has increased manifolds due to higher economic growth in the country. This has manifested in the form of much higher traffic and consequent environmental implications along the major highways. One of the important highway corridor is the section of National Highway-2 between Delhi and Agra. Due to the weak land use control in India, the complexion of the developments along the highway is fast changing and it is likely to cause serious problems in terms of environmental pollution. Thus, all corridor management projects should account for environmental parameters also as part of the performance criteria.

NH-2 corridor of 201 km length where

measurements of primary air pollutants and meteorological data have been made by CRRRI in six locations representing the varying traffic and land use conditions along the corridor. These six sections are then divided into eighteen subsections for the purpose of modeling the pollutants dispersions based on CALINE 4 model. This spread of primary pollutants, when modeled longitudinally and laterally in the form of profile showed its present correlation with the land use development status. However, both the traffic along the corridor and the land use are expected to grow exponentially due to the NCR (National Capital Region) development strategy as well as other provisions. For example, the National Highways Authority of India (NHAI) has given this corridor to a franchisee for all types of management (in term of maintenance /management of road pavement, traffic control including development of ITS, and other land use developments) with authorization for collection of toll. By adoption of new technology in vehicles, it has been found that the level of pollution (CO) is decreasing over a period of time along the corridor, provided the land use pattern remains same. The result clearly shows that corridor management contracts cannot be left only to cover the road and traffic management, but also must include the environmental parameters. It also suggests how the development controls can help in arresting the environmental degradation.

Use of marble slurry dust (MSD) in roads and mass concrete work

Marble slurry dust (MSD) is generated as a waste product during the cutting and polishing of marble. The hazardous dumping practices of this waste material has posed a severe environmental threat in Rajasthan. CRRRI has carried out extensive R&D for the bulk utilization of MSD in roads, embankments and mass concrete work and a technology for the purpose has been developed. A road stretch based on the technology was under construction

in Rajasthan using MSD. The same was done through a joint project of CRRI and Udaipur Chamber of Commerce & Industry, with the financial support of DSIR.

Development and implementation of Pradhan Mantri Gram Sadak Yojana (PMGSY programme)

CRRI is the Principle Technical Agency for GOI launched nation wide programme called Pradhan Mantri Gram Sadak Yojana (PMGSY). The programme aims at providing connectivity through good all-weather road to all rural habitations with population more than 500 by the year 2007. A wholistic approach for rural road development including planning, design, construction and quality control, project preparation, execution, monitoring and as well as human resources development was adopted to execute the programme. Rural road plan at district level was developed, based on prioritized links of a core network to provide most cost effective connectivity to education, health and market facilities. Detailed projects were prepared for the prioritized links taken in a year under the programme. The road structure including pavement and cross-drainage structures were designed based on the local conditions. A manual covering all the technical details has also been prepared for the use of state implementing agencies. The entire programme has changed the concept of rural roads into an engineering structure. The effort has not only optimized the utilization of available resources but also provided transparency in implementing the programme.

Long-term performance monitoring of Lok Nayak Setu (New Yamuna Bridge) in Delhi

Scientific monitoring of the health of major bridges helps in the creation of a reliable database which will be useful in the efficient management of the bridges. The Lok Nayak Setu, across river Yamuna at I.T.O., New Delhi

is the first four-lane single cell box girder bridge built in the country. The long-term monitoring of this bridge presented a unique opportunity to instrument it and observe its performance since inception. It is clear from the site data collected of the bridge through instrumentation that there are progressive changes in performance parameters due to shrinkage, creep etc. for a period of four to five years after its construction. The stabilized values of performance parameters provide the base-line data for future performance monitoring of the bridge. These base values may change within the limits of diurnal and seasonal variations. The changes in structural performance parameters beyond the boundaries of normal changes due to environmental effect is required to be analyzed critically in the course of bridge management. The performance monitoring on long-term basis will provide information in terms of structural parameters regarding the effects of any distress, in the bridge during its service life. The data collected during monitoring would help in identifying the causes of such a distress and facilitate adoption of timely and appropriate remedial measures to avoid aggravation of distress in bridges thus extending the life of structures. It will also reveal the unknown long-term behavior of bridges which will result into useful guidelines for the design of new bridges.

Road safety audit of engineering design for construction packages on NH-2

On the sponsorship of NHAI, Govt. of India, CRRI carried out the road safety audit of the detailed engineering designs of the 15 construction packages of 897 km of NH-2 from Agra to Dhanbad. Detailed engineering drawings (existing and new proposals) of the given 15 stretches as well as traffic volume and accident data for the last five years were examined. Safety audit checklists, and the best international practices suited to Indian conditions were applied on all the stretches to cover aspects like alignment cross-sections,

sight distances, shoulders, footpaths, pedestrian crossings, road marking signs, road lighting, junction layout, lay byes, access adjacent development, road side furniture, etc. Appropriate recommendations were provided for each parameter. Also one-day awareness-cum-training programme on "Road Safety Audit" was organised for training the practicing engineers and concerned personnel. The draft final report has been submitted to NHAI.

Vehicular pollution study in Dhaka

NEERI provided expertise on fuel quality issues for Asian Development Bank funded project entitled "Urban Transport and Environment Improvement Study" in Dhaka, Bangladesh. The study resulted in first ever action plan suggested to Government of Bangladesh for Vehicular Pollution Control.

Wind tunnel investigations on a 220 m tall building

A dynamic pressure measurement study was conducted by SERC on a model of a 56-storeyed tall building, which has different plan shapes at four different levels. The height of model was about 95 cm based on a geometric scale of 1:250. As much as 240 pressure taps were used and average pressures were recorded based on pneumatically pressure averaging technique. The acrylic model was fabricated in-house and it was tested for various angles of wind attack. The model was tested in simulated open terrain conditions. The values of mean drag and rms lift coefficients were evaluated experimentally. Thus, for a structure, where no direct aerodynamic loading information is available in code of practice, such wind tunnel experiments are necessary and useful.

Wind turbine support towers

Green power production structures, specially the wind turbine support towers are designed for

static, dynamic and operational fatigue loads (service loads). SERC experimentally evaluated the Fractional Fatigue Damage (FFD) of a tower at given site during various operating conditions adopting a novel methodology. A table of hourly fatigue damage rate evaluated from measurements could be used to assess the possible residual life of the support tower.

Adequacy & efficacy and up-gradation of the common effluent treatment plant at Ankleshwar, Gujarat

Large number of small-scale chemical industries are located at industrial estate of Ankleshwar, on Mumbai-Ahmedabad National Highway No.8 around 90 km from Baroda in the state of Gujarat. These units do not have their own treatment facilities due to lack of space, expertise, inadequate capital, and operation & maintenance problems. The estate houses large number of medium and small scale industrial units manufacturing chemicals, pharmaceutical products, textiles, pigments, dye & dye intermediates and pesticides. M/s Enviro Technology Limited (ETL) is authorised by the small-scale industrial units for environmental management arising from the activities of the industries in the estate. Hence, M/s ETL proposed treatment of combined process effluent from various small-scale industries through implementation of a Common Effluent Treatment Plant (CETP) at a centralized place. M/s ETL approached NEERI to carry out a detailed assessment of the adequacy and efficacy of the CETP. NEERI designed the cost-effective CETP to treat the coloured combined effluent. Also various treatment options were suggested to achieve the quality of treated effluent for recycle/reuse in the industries as process water. The quality of treated effluent complied with the standards prescribed by Gujarat Pollution Control Board (GPCB) for discharge of effluent into inland surface water.

Upgradation of the effluent treatment plant for PAP

The industrial complex of M/s Sterlite Industries (India) Ltd at Thoothukkudi (Tuticorin) has a phosphoric acid plant (PAP), which produces 350 tonnes per day of 100% phosphorus pentoxide (P_2O_5) and 7.5 tonnes per day of hydrofluorosilicic acid (H_2SiF_6). In the manufacturing process of P_2O_5 and H_2SiF_6 , highly acidic wastewater is generated and requires prudent management, which is environmentally, ecologically and economically sustainable. An effluent treatment plant has been provided for PAP effluents. M/s Sterlite approached NEERI, to conduct treatability studies, and optimize the operating parameters to enable upgradation of the existing treatment facility.

NEERI designed the cost-effective ETP for the treatment of phosphoric acid wastewater and provided an appropriate wastewater management option for treatment of effluent generated from PAP. The unit processes/ unit operations were recommended for effective treatment of phosphoric wastewater included: plant wash collection sump; filter wash collection cum equalization tank; flash mixer (stage I); clariflocculator (stage I); flash mixer (stage II); clariflocculator (stage II); treated effluent collection tank; sludge collection tank; and sludge drying beds or sludge centrifugation. The knowledge based on this project can be utilized for the treatment of wastewater of similar nature, mitigate environmental pollution leading to sustainable development.

Process for cold drawing of the key bar profiles

RRL, Bhopal has developed a process for cold drawing of the key bar profiles. The process parameters have been standardized to fabricate defect free dove tail stud and stator key bar having improved performance. Conventionally these are fabricated by milling/machining of the

cylindrical rods to the required shape and size. The product so fabricated generally suffered from inadequate mechanical properties. The developed process involves the final shaping of the components by cold drawing in different steps associated with intermediate heat treatment. This led to improvement in mechanical properties and surface finish of the components. Stress analysis, using FEM technique at different regions of the components, has been carried out. It shows that the fabricated product is strong enough to withstand different levels of stress.

Veneers from banana leaf

A method of preparation of veneers from banana leaf sheath and a process for fabrication of composite sheet materials using the veneers has been scaled up by RRL, Tvm. The major advantages of the process are high production rate, lower energy consumption and tailorability of the composite to suit a wide range of applications in building industry. The process is designed in such a way that it can be easily adopted by the existing plywood manufacturing industries. Commercial level trials are being carried out in collaboration with Indian Ply Wood Industries Research And Training Institute, Bangalore.

3.5 Food Science & Technology

Identification of new allergens

CFTRI has identified the allergens in pomegranate (*Punica granatum*), and cultivated mushroom (*Agaricus bisporus*), as mannitol, the sugar alcohol of D-mannose. It is the first report of IgE-mediated allergy to mannitol which is described as a new low molecular weight allergen in foods. The study has provided new insight into the mechanism of allergenicity of low molecular weight sugar alcohols. This contribution has also resulted in

the development of mannitol-specific antibodies which has applicability in the development of immunoassays for mannitol.

Novel method for measurement of texture of cooked grains

Grains are consumed generally after processing and cooking and it is always a difficult task to properly assess the cooking quality of grains especially in the routine laboratory analysis. The methods available currently for measurement of cooking quality are either subjective or based on sophisticated instrumental analysis. CFTRI has developed a simple device and a method for direct measurement of cookability of grains based on the measurement of 'spread area' of cooked grains. It is a new concept for measurement of textural softness of cooked grains particularly that of cooked dhals and rice. This method also eliminates the subjectivity in testing the textural softness, which is a problem in other methods. Being a simple device, it can be adopted for assessing the cookability of grains for routine laboratory evaluation. The development has been patented. Efforts are underway for the development of a full-fledged equipment for measurement of textural softness of cooked grain. The equipment will be useful for the quality testing laboratories and agricultural scientists involved in breeding newer varieties.

Dehulled finger millet

Finger millet (*Eleusine coracana*) or *ragi* is an important nutri-cereal. Its utilization however is confined to flour based foods, that too to the traditional consumers. This is because of the dark unappealing color and characteristic odour of the millet foods, mainly caused by the seed coat content in the meal. The millet cannot be cooked in grain form, as it has tough and fibrous seed coat which inhibits swelling and softening of the endosperm. The millet is at disadvantage for its decortication due to its smaller size and

the floury texture of its endosperm attached rigidly with the seed coat. These disadvantages have been overcome, by the process of decortication of the millet developed at CFTRI, wherein the texture of the endosperm of the millet is hardened by hydrothermal treatment and the grains are decorticated in a cereal milling machinery. The decorticated grains, with appealing light cream color resemble native grains in shape and size, cook to a soft edible texture within 5-7 min as discrete grains and contain nutrients such as protein, carbohydrates, lipids, dietary fibre, calcium and polyphenols. It can be consumed as a substitute to rice and bulgur wheat in conventional products or can be used to prepare millet foods such as *roti* and *mudde*. It is amenable to secondary processing to prepare expanded millet, flakes, semolina and bakery products. The decorticated millet would not only thus diversify its utilization but also could provide health benefits to the non-traditional millet consumers.

Bioactive compounds from Garcinia species

The importance of bioactive compounds is very well established. Studies at CFTRI on the fruit rind extracts of certain indigenous species of *Garcinia pedunculata* and *Garcinia cowa* established their antioxidant, antimicrobial and antimutagenic activities. These bioactive principles have a potential for application as food biopreservatives. The spray dried powder of hydroxy citric acid obtained from the rinds of *G. pedunculata* had a purity of 60-65% (w/w) which can find commercial application. The structural and functional characterization of the bioactive components was in progress; it will provide newer insight into the mechanism of activity.

Continuous bio-plate casting machine

CFTRI has developed a continuous bio-plate casting machine. It is an attempt towards

mechanizing the preparation of bio-plates and cups. The unit is based on a unique concept of circular rotating die sets, with adjustable arrangement to accommodate different thickness of leaves. The application of load/pressure in the machine are done by a geared motor through a cam. The machine has a capacity of producing 750 nos./h and has connected electric load of 9.0 kW. The engineering material in contact with the bio-plate is of food grade. The bio-plates can be an alternative for the plastic and paper products. Work is also in progress for obtaining sterilized plates and cups in large volumes. The machine has a societal application for mass production of plates and cups for serving of food in places like industrial canteens, hostels, hotels, and other mass feeding centers.

Technology for phycocyanin

CFTRI has developed a technology for production of phycocyanin from *Spirulina*. *Spirulina* is cultivated in clean water system using CFTRI protocol. *Spirulina* biomass is processed for obtaining a phycocyanin rich aqueous fraction which is later subjected to aqueous two phase extraction method to separate the contaminant such as chlorophyll. Stabilization of phycocyanin is achieved using permitted preservative. The crystalline phycocyanin is separated from the extracts through drying and cell debris is separated as another fraction which is a bioproduct of utility for animal feed. Novelty of the process lies in separation of the pigment from other cell constituents in three step process to obtain over 90% phycocyanin. This methodology is simpler and easily adoptable compared to that available elsewhere in the world. The product is superior and highly stable compared to international samples. Since all bioproducts are utilized and the cultivation medium is recycled, this is an eco-friendly technology, free from pollutants. The technology has been licensed to M/s. Indoleena Biotech Company, Madurai for commercial exploitation. CFTRI's efforts have

thus led to establishment of first plant for the production of phycocyanin in India.

Hybrid heating system for food processing

A hybrid system with provision for both convective and infrared (IR) heating of food materials has been developed at CFTRI for various food processing operations. The system can be used for different heating modes such as convective, infrared and, combined infrared and convective. It could be conveniently used for drying of vegetables (such as Carrot, Potato, Cabbage), and dry blanching of vegetables. This has a unique design; consists of a continuous SS perforated wire mesh conveyor on either side of which the infrared heat sources are provided for uniform heating. The combination of hot air and infrared heating reduces the overall processing time and there by increases the organoleptic quality of the product. As there is a greater demand for better quality products in the market, the development could be a good alternative to the conventional dehydration process.

Machine vision system for on-line sorting and grading of fruits like apples

CEERI has developed an on-line fruit sorting system for sorting and grading of fruits, apples in particular. Various studies on the problem of sorting and grading of apples using machine vision technology were conducted. New algorithms were developed that applied on the fruit images collected dynamically on-line to sort them based on color, size and shape. The system developed consists of conveyor assembly, diffused uniform illumination system, CCD camera and image processing software. It can perform complex color, size and shape based classification, comparable with human vision but with far greater speed, repeatability and reliability. This development will help the farming community to increase value addition to their produce and it will help separate the bad agricultural produce from the good.

Convection driers

Natural convection driers have been designed and developed by RRL, Thiruvananthapuram. These have been licensed to fabricators for commercial manufacturing. The driers are being used by farmers, artisans, cottage scale industrial units and household sector for drying of variety of materials. The laboratory has participated in demonstration and training programmes organized in collaboration with various panchayats and NGOs. Trials have been carried out for drying of apricots in Jammu for the benefit of defence personnel.

S&T Services

CFTRI rendered diverse S&T services which were of value to the economy, environment, society etc. These included:

Technical reports: Techno-economic feasibility reports were prepared on fruits and vegetable preservation and export in SAARC countries, utilization of fruit and vegetables in Chotanagpur and poultry dressing plant. Detailed project reports were prepared on centralized facility for the manufacture of milled ragi flour/husk free milled cereal flour of capacity 5 tones/day, dehydration plant for fruits and vegetables and processing of jack fruit.

Process demonstration: Twenty one processes were demonstrated to various entrepreneurs. Notable among these were: ready to use idli batter in retail packs, dehydration of bitter gourd, malted ragi flour, tamarind juice concentrate, ginger powder, bulk preservation of mango pulp, minimally processed vegetables, and fixation of green colour in cardamom.

Awareness programmes: Several EDP and technology awareness programmes were organized in different parts of the country on aspects such as, investment opportunities in the food processing sector, food processing, rural

technologies, leaf cup making, technologies and facilities that CFTRI can offer among others.

Analytical testing: A number of samples of food commodities and packaging materials received from private and public sector food industry, port health authorities and legal samples from judiciary were tested and analyzed for their adherence to set food standards such as PFA, FPO and codex alimentations. Sensitive methods were developed for detection and determination of contaminants and pesticide residue in foods.

3.6 Information Science & Technology

Traditional Knowledge Digital Library (TKDL)

TKDL is a collaborative project between NISCAIR and Department of Indian Systems of Medicine and Homeopathy (ISM&H). TKDL was created with the objective of preventing the grant of patents on non-patentable traditional knowledge. Traditional knowledge documented in regional languages is neither easily accessible nor easily understood by the patent examiners. Traditional knowledge needs to be made accessible to patent examiners by overcoming the language barrier in a format that is easily understood by the patent examiners. Therefore, the project on TKDL was initiated to create more easily accessible non-patent literature databases that deal with traditional knowledge. TKDL software with its associated classification system, i.e., Traditional Knowledge Research Classification (TKRC) converts Sanskrit *Slokas* into English, French, German, Spanish and Japanese. The software does not do transliteration rather it does smart translation, where data abstracted once are converted into several languages by using Unicode and Metadata methodology. Software also converts traditional terminology into modern terminology, for example *Kumari* to *Aloe vera*, *Mussorika* to smallpox, etc. TKDL includes a search interface providing full text search and

retrieval of traditional knowledge information on International Patent Classification (IPC) and keywords in multiple languages. Traditional Knowledge Classification shall be integral to TKDL database along with background on Ayurveda concepts, definition and scientific basis of Indian Systems of Medicine, details of practitioners, hospitals and dispensaries.

From the Ayurvedic texts so far 35,000 *Slokas* have been identified for inclusion in the database. About 32,800 formulations have been entered and decodified. Transcription of the rest of the 2,200 formulations is being carried out. About 13,200 *Slokas* have been scanned for establishing the prior art. Besides, 11,750 formulations have been verified and validated by eminent Ayurveda experts. Four thousand formulations have been frozen for publishing the first CD to be sent to patent examiners. A concordance table has been prepared to correlate existing subgroups of TKRC with corresponding group of IPC. A software programme has also been developed for incorporation of appropriate IPC codes into the database. The translation of TKRC in Hindi, Spanish, German, French and Japanese has been completed.

TKDL database shall act as a bridge between ancient Sanskrit *Slokas* and a patent examiner at a global level, since the database will provide information on modern as well as local names in a language and format understandable to patent examiners. It is expected that the gap on lack of prior art knowledge shall be minimized. The database shall have sufficient details on definitions, principles, and concepts to minimize the possibility of minor/insignificant modifications.

Indo-Russian collaboration in S&T: An analysis through co-authored publications, 1995-99

NISTADS conducted a study to analyse the

Indo-Russian collaboration in S&T through the co-authored publications during the period of 1995-99. The study revealed that there were two streams of collaboration; the first was bilateral in which only Indian and Russian institutions/scientists were involved and in the second, scientists/institutions from other countries like USA, UK, Japan, etc. also participated, besides Indian and Russian. It is astonishing to find that out of 355 jointly authored papers in S&T, a majority of 294 papers had multilateral collaboration, and only 61 were under bilateral collaboration. The study included an analysis of co-authored papers by main fields and sub-fields and the impact of such collaboration in different fields, and identification of major participating institutions involved in collaborative research, and also provided a few suggestions for improving further collaboration between the two countries. It has been found that under the bilateral category (involving at least one Indian and one Russian institution), there were 61 co-authored papers, which accounted for only 18% of the total output during 1995-1999. The remaining 294 were multilateral papers and involved the participation of India, Russia and 40 other countries. In order to make collaboration between India and Russia more effective, there is a need to understand the shortcomings in the mechanism of participatory research by Indian institutions. This mechanism needs to be modified in the light of the changing priorities of the two countries in S&T. For promoting collaborative research, both Russian and Indian institutions may offer more fellowships, travel grants, etc. to researchers. There is also a need to extend the scope of cooperation to frontier areas of S&T, particularly to those areas where Russia has a strong base.

Unit for Research & Development of Information Products

CSIR's Unit for Research & Development of Information Products (URDIP) continued its

endeavour to put in place value added IT products covering diverse S&T domains for the benefit of professionals, academicians and industry. It consolidated its resources during the year and successfully developed following:

Patestate is a full text database of Indian and Foreign patents that have been granted to CSIR. Four volumes in this series covering the period 1981 to 1985 (Vol.I), 1986 to 1990 (Vol.II), 1991 to 1995 (Vol.III) were brought out earlier. A fourth volume covering the period 1996 to 2000 (Vol. IV) has been brought out during the year. In addition, a fifth volume containing the abstracts of all the patents granted to CSIR from 1940 to 2002 was also brought out. All the above five volumes are available in the form of CD-ROMs. A separate website for CSIR patents has been created (www.patestate.com). Abstracts of all the patents granted to CSIR from 1981 till date have been put on this site. This site is being developed as an online marketplace for CSIR Intellectual Property.

Health Heritage is an archival, interactive, multimedia CD incorporating both traditional knowledge from Sanskrit Classics referred to by practitioners of Indian systems of medicine and the modern information made available through systematic research during the past forty years on medicinal plants used in Ayurveda. The modern chemistry literature from 1960 to 2000 was completely scanned for the purpose. The CD summarizes the chemical studies of plants and biological evaluation of total extracts and fractions thereof. It also lists all the pharmacological, biological and clinical work done on pure constituents obtained from plants and gives the complete structures of new substances isolated. Abstracts of patents currently granted by US and Indian Patent Offices on traditional medicinal plants have also been included. The two volumes covering 100 widely used plants have been brought out. The third volume covering additional 50 plants is under preparation.

Ayuta Index is a digital version of Ayurvediah Triskandha-Kosha based on the basic four texts of Ayurveda i.e. Charakasamhita, Sushrutasamhita, Ashtangasangraha and Ashtangahridaya. The first volume in this series representing the Lakshana - Kosha that contains each and every reference related to symptoms of various diseases as well as health conditions from above texts has been brought out in the form of a CD-ROM.

CSIR Technology Advisory Point (TAP) is a web based technical service, prototype for which has been put on the web and is being tested. It will bring the knowledge of CSIR's 6000 scientists to desktop of customers. This service will be particularly useful for small and medium scale enterprises.

In collaboration with C-DAC a one year Diploma in Database and Web Technologies was launched to upgrade the skills of URDIP and NCL staff. Training Programmes were also organized on "Online Searching of Science and Technology Databases" and "Patent Information for Drug Research".

Collaboration in material science research in India

NISTADS undertook a study of collaborative aspects of material science research in India based on papers published by Indian scientists in collaboration with foreign researchers. The study based on SCI journals, covered a period of five years (1995-1999). The results indicate that materials science in India is broad based and covers most of the important sub-areas, and is based on inherent strengths. Most of the work involved bilateral rather than multilateral collaboration. The top collaborating countries were the US, Germany, France, UK and Japan. Collaborative linkages with developing countries accounted for only about 10% of the total papers. Ten top Indian institutions contributed nearly 50% of the collaborated

papers. The major areas of collaboration were theoretical studies, metals and alloys, electronic materials and superconducting materials.

EU-India cross cultural innovation network project

NISTADS carried out an EU-India cultural innovation network project. The main objective was to set up a management framework for effective academic-entrepreneurial networking involving universities and entrepreneurs in the EU and India and to build upon and promote existing models and paradigms of innovation for sustainable transfer of cross cultural knowledge and know how. The project revolved around the models of enterprise innovations in cross cultural context in three settings: model of entrepreneurial innovations - a cross-cultural model of research: action research in the dairy sector; model of entrepreneurial innovations – small and medium enterprises; and model of entrepreneurial innovations – traditional technologies (Dhokra artifacts from Bankura). The main reports which emerged from the effort under the project, depicted a unique model of innovation in each setting in the Indian context. These were also compared in Cross-cultural context with the EU-India project partners from UK, Germany, Denmark, Italy, Gujarat and Ludhiana.

Techno-economic study on artisans in unorganised sector

Techno-economic study on artisans in unorganised sector was carried out by NISTADS under sponsorship of ICAR. The study included collection of data regarding the clusters of various artisans in the country; organization of demonstration-cum-extension programmes in these clusters; upgradation of the technological skill of the rural artisans; development of curriculum in ITI's as per the

needs of the artisans of the area; quality improvement in the products of these artisans by providing the necessary infrastructural facilities; development of an information network on these artisans' products, exploitation of market potential of these products so that the socio-economic condition of the artisans may improve. The report has been adopted by the scientific panel on agricultural engineering, ICAR. It was suggested that R&D groups should consider these artisans as manufacturers of simple equipment and they may be used in the fabrication of research prototypes for multi-location trials. It was suggested by the Panel that PC (FIM) should bring these clusters to the knowledge of the concerned R&D Centres located in Northern India so that they could use these for the fabrication of their prototypes.

National Science Digital Library (NSDL)

CSIR has envisaged setting up of the National Science Digital Library (NSDL). It will be a national information facility designed to provide internet access of digital resources to universities and college education system through out the country, in particular the student community in remote areas facilitating similar level of access to information as is available in metro cities. NSDL is being developed on the concept where digital repository is created not by acquiring the contents, but with the content providers who would pay for storing their intellectual property and access to users.

Research Journals

NISCAIR's contribution to Indian Science is through publication of as many as nineteen journals covering all the major disciplines of science. The *Indian Journal of Traditional Knowledge* was launched during 2002-03. These journals are of international repute and provide communication links among members of the scientific community engaged in research in India and abroad. The papers published in the

journals are indexed and abstracted in most of the international indexing and abstracting journals and thus provide international exposure to Indian R&D workers. The contents and abstracts of all the periodicals are regularly updated on the NISCAIR's website www.niscair.res.in. A programme was launched to widen the visibility and reach of NISCAIR journals and enhance the subscription base. Efforts have been made to reach out to the new potential subscribers at the national and international level. The impact of journal outreach programme is evident from the increased total subscription to a record Rs. 1 crore (54.8% increase).

CSIR electronic journals consortium

The CSIR E-Journals Consortium aims at providing electronic access to nearly 4,500 worldwide S&T periodicals. CSIR has entered into an agreement with *M/s. Elsevier Science*, one of the largest publishers of S&T e-journals for having access to its 1,700 S&T journals among all the laboratories/units/centres of CSIR. NISCAIR (erstwhile INSDOC) has been designated the implementing agency for CSIR E-Journals Consortia.

Science popularisation

Popularization of science among the masses is a major programme of NISCAIR. For the purpose of spreading awareness about scientific developments and creating a scientific temper among youth, the Institute published three well-circulated popular science journals, *Science Reporter* (English monthly), *Vigyan Pragati* (Hindi monthly), and *Science ki Duniya* (Urdu quarterly) apart from a number of popular science books.

Science Reporter a monthly science magazine enjoys a wide readership throughout the country. *Science Reporter* continued with its objective of providing to its readers topical

coverage of issues in various fields such as information technology, wildlife, environment, space, nuclear technology, health, and biotechnology as well as light reading material such as humour, amazing scientific facts, profiles of scientists, science projects, inventions and discoveries and much more. Efforts were made to give a contemporary look to the magazine by inviting special articles from experts.

Vigyan Pragati is a monthly popular science magazine in Hindi that reaches far and wide in the country. It endeavours to introduce readers with important current events/issues in an easy to understand manner. The major issues covered during the year were: medicinal plants, diamonds, alpha space station; plant hormones/human hormones (April 2002); syndrome X, edible vaccines, research institutions of India, vermiculture, seabuckthorn (May 2002); biodiversity, air pollution, pollution & human role, noise pollution, pollution from organic chemicals (June 2002, special issue on *Environment & Biodiversity*); geoscientific monuments, the world of spiders, antarctica, internet telephony, minerals (July 2002); A.P.J. Abdul Kalam, Honorable President of India, wireless application protocol (August 2002); vultures, *Withania somnifera & Ocimum sanctum* (September 2002); world food day (October 2002, special issue); children's day (November 2002, special issue); metro rail project, bats, Stephen Hawking (December 2002); traditional knowledge (January 2003, special issue); special issue on national science day (February 2003); and the latest on Columbia Space Shuttle Tragedy (March 2003).

Science ki Duniya, the quarterly popular science magazine in Urdu, reaches far and wide across the country. One of the most widely read Urdu magazines in the country, it has now entered into its 30th year. During 2002-2003 *Science ki Duniya* continued to disseminate information on current scientific topics in easy

and attractive manner. The cover stories brought out during this year were: *Biodiversity – ek jaeza* (April-June 2002), *A.P.J. Abdul Kalam – laboratory se rashtrapati bhawan tak ka safar* (July-September 2002), *Indian railways ke ek sau pachas sal ka ek jaeza* and *Delhi metro rail* (October-December 2002). The October-December issue was also a special issue on children containing a number of articles for children, like *Duniya ka azeem darya Amazon, nap taul ke maiyaron ki ahmiyat, parindoon se hum nae kya seekha* (science fiction), *machchar bhi kuch kam nahin*, and *main protein hoon*. On the occasion of international year of mountain *Himalaya pahar aur mahuliya* and other major articles covering the Diamond Jubilee of CSIR have been published in the January-March 2003 issue.

CSIR News, the fortnightly newsletter serves as a useful link among the various CSIR establishments and communicates activities/accomplishments of the Council to other R&D organizations, universities, S&T agencies/departments, industry and other users, mass media, etc. It also disseminates information on CSIR to other countries through Indian missions abroad and foreign missions in India. Twenty-four issues brought out during the year covered news pertaining to R&D accomplishments, technology transfers, marketing, commercialization / utilization, sponsorships, collaborations, IPR, etc. A special issue was brought out on Traditional Knowledge Digital Library. The October issue was a special issue on CSIR Diamond Jubilee, and February 2003 issue was special issue on Dr. R. A. Mashelkar, Director General, CSIR.

CSIR Samachar launched in 1984, is now in its 20th year. It is a monthly news bulletin in Hindi, which covers the R & D activities of all the laboratories of CSIR and consequently serves as a useful link. It also disseminates information on various activities of CSIR. November-December issue of CSIR Samachar exclusively

covered the CSIR Diamond Jubilee function held at Vigyan Bhavan on 26th September 2002. It also included the awards instituted by CSIR, especially Shanti Swarup Bhatnagar award; Technology award; Young Scientist award etc. NISCAIR also brought out popular science books during the year. CBSE has launched the Biotechnology course in schools for the first time in India, a *Textbook of Biotechnology* was brought out for the purpose. A revised updated version of the much appreciated and highly sold *Golden Treasury of Science & Technology* was brought out on the occasion of the Diamond Jubilee celebration of CSIR. The volume contained about 400 new scientific entries keeping in view current concerns and contemporary topics. And a hindi version of the Golden Jubilee series book Curable Cancer, '*Cancer par roktham*', was brought out during February 2003.

NISTADS Dhokra Museum

NISTADS Dhokra Museum was inaugurated, which presents a collection of brass and bronze artefacts made in the Dhokra belt over an extended period of time. NISTADS Dhokra museum will not only demonstrate the phases of evolution of the lost-wax technique but also highlight an unbroken tradition starting from the Mohenjodaro days when a craftsman cast the bronze figurine of a dancing girl. The museum, which will serve as an educational resource for children and others, now has a repository of artefacts created over a period of time.

3.7 Leather Science & Technology

Studies on the potential uses of plant poly-phenols as raw material for industrial chemicals

Considering the value addition by converting vegetable tannins and other plant poly-phenolics into dyes/pigments, studies have been carried out at CLRI. The preliminary studies reveal that

reagents like vanillin-HCl, paradimethylamino benzaldehyde develop coloured species with vegetable tanning constituents and other associated phenol carboxylic acids. Characterization of the colourants formed by spectral data is under progress. Studies have also been carried out for the process development of iron-hydrolysable type of vegetable tannin complexes as tanning cum dyeing agent for the production of eco friendly black leathers.

Evaluation of a new source of natural oil for possible use as a fat liquor

Jatropha oil is an indigenously available forest product from Madhya Pradesh and Andhra Pradesh. It is toxic and used, in a limited way, in native medicines and fungicides. It has a relatively high Iodine value (95-105) with Oleic and Linolic acid as major components (about 78%). CLRI has developed a novel method for complexing the oil with a polymer composition. It has proved to be successful. Pickled pelts treated with the product show tanning effect giving white and soft leather.

Enzymes in leather processing

Under CLRI-NCL collaborative programme on "Alkaline protease" supported by DBT, a fungal lipase from *Conidiobolus coronatus* has been found to be very good for dehairing and soaking of goat skins. Initially, an enzyme assisted process has been standardized using alkaline protease for dehairing of goat skins and cow / buffalo hides. The enzyme assisted process has been demonstrated in tanneries in and around Dindigul. Recent experiments show that enzyme only process could be standardized using alkaline protease without sodium sulphide for dehairing of sheep skins and cow / buffalo hides.

Utilization of chrome shavings for product development

Chromium containing wastes in various forms in leather processing is under review. The high protein content of chrome shavings has been utilized for reduction of chromium (VI) in the preparation of chrome tanning agent at CLRI. This approach has been exploited in the development of two products one with chrome shavings alone as reducing agent and other with equal proportion of chrome shavings and molasses. The developed products exhibit more masking due to the formation of intermediate organic oligo-peptides. Hence, the developed products find use as chrome tanning agents for leather processing, thus providing means for better utilization of chrome shaving wastes.

Technology package for synthetic tanning agents

New generation syntans namely formaldehyde-free chrome syntan and polymeric syntan have been developed by CLRI and patented for eco-benign chrome tanning in leather processing. The technology package has been licensed to M/s Balmer Lawrie & Co. These syntans are free from formaldehyde and also help in the reduction of pollution loads such as chromium and Total Dissolved Solids (TDS).

Alternative source for water in leather processing

CLRI has carried out a study for using seawater and common chemicals for pre treatment of leather. The method developed has basically addressed the hardness of seawater. The leathers processed using treated seawater were comparable to the leather processed using conventional water. Studies at pilot tannery level were underway.

Fashion design and development of leather products through ethnic skills

In the North Eastern region ethnic products based on bamboo and textiles are widely in use. CLRI undertook a systematic study on these products and collected samples of these products. The knowledge so generated through this organized effort has been utilized for developing innovative leather products with a view to enhance the market base and value addition to the product. Dissemination through training programmes is being carried out for a range of these products.

Cost effective therapeutic material

CLRI has developed a material based on starch / oil cake using water/vegetable oil as binder. It could be an alternative for existing methods of taking foot impressions of patients needing therapeutic and orthotic shoes. This new material provides additional advantages, such as forming the impression of foot in standing position, producing accurate negative impression of patient's insole and reusability. The clinical trials using the same were in progress.

Resolving the total dissolved solids problem

The tanning sector in India has been able to comply with Pollution Control Norms except for Total Dissolved Solids (TDS). Viable solutions for TDS have formed an area of priority. Pickle free chrome tanning based on use of combination of masking salts and polymeric syntan free from formaldehyde has been standardized at CLRI and field tested. Salt free short term curing methods have been developed and tested in goat upper leathers.

Ecofriendly processing

Hexavalent chromium formation poses serious problems in leather production. Post tanning

chemicals/auxiliaries have been screened at CLRI for their tendency to convert Cr(III) to Cr(IV) in chrome tanned leathers. Suitable treatment methodologies have been developed using reducing agents to avoid formation of Cr(VI). The process technologies have been standardized for production of cow upper and sheep nappa garment leathers.

High rate biomethanation plant for chrome shavings

A high rate biomethanation plant has been set up by M/s Tata International Ltd. for managing the chrome shavings generated from their leather finishing unit at Dewas, Madhya Pradesh. The capacity of the plant is 2 MT / day. The process technology was developed by M/s Tata International Ltd. The uniqueness of the process is the technology, which offers solution for management of chrome containing wastes from the tanneries. CLRI worked out use of recovered chromium in the process of manufacturing leather. Also the gelatin solution was biologically treated under anaerobic condition and the biogas was used for thermal energy recovery. The treated effluent from the biomethanation plant was tested and disposed in the effluent treatment plant. This plant is the first of its kind in the world implemented and demonstrated with a totally indigenous technology and equipment.

Biomaterial testing devices

CLRI has developed an instrument to study the two dimensional stress deformation (creep) effect in leathers. The two dimensional sample could be held in the sample holder and provision is given for simultaneous application of the load to the four pans attached to the sample holders, by releasing a lever. The strain gauge connects to the sample holders, by releasing a lever. The strain gauge connected to the sample holders records the deformation in four directions. The results obtained from the tests will be correlated,

to understand the surface characteristics transformation as a function of the creep behaviour of leathers. The focus is on upper leathers only, as the results would have direct bearing on shoe uppers.

Analytical methods for eco testing

Xylidines are important precursors for the production of dyes, drugs and various other products used in industries. Due to the high carcinogenic nature of some xylidine isomers, it becomes very essential and relevant to develop suitable analytical procedures to separate isomers as well as enhance detection at very low concentrations. Efforts have led to standardization of micellar electrokinetic chromatography at CLRI against varying parameters such as pH, ionic strength and micelle modifiers and the optimum conditions of these parameters have been ascertained for the best separation and the sensitivity of standard mixtures. The methodology has been applied in environmental studies as well.

3.8 Material Science & Technology

Development of polarization maintaining optical fibre

In the area of avionics, rotation sensing using interperometric fibre optic gyro is now emerging as a potential alternative to existing devices used in aircrafts and tactical missile guidance due to better sensitivity and excellent bias stability. One of the key component in Fibre Optic Gyro (FOG) is the high birefringent polarization maintaining (PM) optical fibre. The basic design and functionality of this fibre are widely different from standard optical fibres used in telecommunication. Only a few manufacturers in the world produce this type of fibre and supply to a very limited extent at an exorbitant price because of its strategic importance. CGCRI has successfully developed PM fibre with an extinction ratio as high as 30

dB at 1550 nm following the MCVD (Modified Chemical Vapour Deposition) process of preform fabrication. A geometrical cross section of the fibre is shown in the figure where the dark elliptical region is the stress inducing boron doped outer cladding and bright circular spot is the germaniumoxide doped core of the fibre. The achievement has opened the possibility of producing the fibre in long length for indigenous optical gyro development. An ambitious programme has already been taken by the defense establishments like RCI/DRDO and DTSR, who sponsored the fibre development programme in CGCRI, to develop FOG with high accuracy.

Development of equivalency chart between UHV & GCV of Indian non-coking coals

CFRI in order to develop the equivalency chart used coals from the major coalfields. It is observed from the scatter plot of different coalfields that the variation within a coalfield is significantly less than the variation between the different coalfields. This is primarily because the UHV concept is based on the role of diluents and it does not consider the organic matrix and petrographic mix of the different coals which ultimately decide the inherent heat value and its burning properties. Due to such high regional variations it is suggested that no single relationship can be adopted for evaluating the GCV value rather relationships specific to individual region may be used for categorizing the coals of that region. The study provided a reliable and scientific basis for making the equivalency charts between UHV and GCV, which can be used for grading the coals in terms of the experimentally determined GCV. Similar studies could be initiated for the thermal coals of Eastern Coalfields Limited and for the coals from BCCL which are going to the power sector. Switching to GCV from UHV for grading would require the equivalency chart for these coals as the chart derived for other non-coking coals should not be applied to them.

Investigation of transport across grain boundary in colossal magnetoresistance (CMR) materials

Epitaxial thin films, polycrystalline films/bulk samples of colossal magnetoresistance (CMR) materials show different magnetoresistance behaviour. In order to understand the role of grain boundaries in these materials, transport across a single artificially prepared grain boundary in epitaxial CMR films has been investigated at NPL. The single artificial grain boundary is realized by depositing epitaxial film on a SrTiO₃ bicrystal substrate. Analysis of dynamic conductance of the grain boundary reveals that three carrier transport mechanisms operate across the grain boundary. These mechanisms exist in parallel, and at a given temperature one mechanism may dominate. At higher temperatures ($T > 175$ K) the transport across the grain boundary involves spin-flip scattering, which established leads to decrease of the bicrystal grain-boundary contribution in magnetoresistance. At lower temperatures (4.2-45K), tunneling through a disordered oxide at the grain boundary dominates, whereas in the temperature range from 100 to 175K, carrier transport is dominated by inelastic tunneling via pairs of manganese atoms.

Long decay luminescent powder

Long decay luminescent powder also known as long afterglow phosphor is capable of emitting light in the visible range not only during excitation but also for a long period of time after excitation is cut off. This phenomenon is known as 'phosphorescence'. Uniqueness of phosphor is that these are excited by daylight, tube light and tungsten lamp whereas normally phosphors require high-energy radiation such as cathode rays, ultra violet rays, X-rays and gamma rays. Conventional long decay phosphor like ZnS:Cu also shows long phosphorescence but decay time is not long enough for certain applications such as warning signs and escape routes etc.

Addition of radioisotopes can produce the required performance level but now its use has been restricted due to safety and environmental considerations. Strontium aluminate phosphor developed by NPL is a non-radioactive material and exhibits a very bright and long lasting phosphorescence whose decay time exceeds well beyond twenty hours. Some of the phosphors developed have decay time more than fifty hours. It has been primarily developed for DRDO but it can very well be adopted for a number of civilian applications, such as, photoluminescence escape routes and rescue guidance system; warning signs; important marking such as of machinery; producing special effects in bars, discotheques etc.; flexible and rigid plastics for switches and consumer goods; toys; sports equipment etc.

Reduction of uncertainties in emission coefficient of CO₂ emission from coal combustion

CFRI has carried out studies on Indian coals with the objective of improving upon the reliability of Carbon Emission Factor (CEF) for different categories of coals and also to provide a more reliable basis of the conversion factor (NCV/GCV). Direct measurements of emissions were carried out at different power, cement and steel plants and estimates made for sector specific emission coefficients. The refined NCV and CEF of coals to be used for preparation of the National GHG inventory will provide a better estimate of emissions from the key sectors. Estimation of CO₂ emission with the assumption of a single emission factor of thermal coals and average oxidation factor do not reflect the variance associated with fuel quality from different sources and the combustion technologies/vintage of individual power plants. The emission coefficients of the key sectors obtained from direct measurements will reduce the uncertainties associated with deriving the coefficients for fuel quality.

Nano material catalysts

Under the NMITLI programme, a project on "Nano material catalysts and associated process technology for pre-reforming of hydrocarbons" was taken up at CFRI as a network programme with IICT, Hyderabad and Sude-Chemie (India), Cochin. The project is envisaged in two phases : viz. design and development of nano particulate based catalysts and scale up of the catalyst preparation and process standardization. Stabilization of nano particles is the greatest challenge and CFRI has been engaged in preparing nickel nano based catalysts using different precursors employing sol-gel method. A 100-ml reactor for pre-reforming of naphtha has been designed by CFRI and installed during this year. The reactor has a HDS module to desulphurize the feedstock before it enters the pre-reformer, which can operate upto 600⁰C. Economic production of hydrogen through nano particle based catalysts would significantly influence the economy of fertilizer industry.

Industrial briquetting plant from coke-breeze

CFRI successfully commissioned a briquetted fuel (for industrial use) producing plant within the premises of Gujarat Heavy Chemicals Limited (GHCL), Sutrapada, Varabal, Gujarat. GHCL will be able to reduce import of coke by 15 percent. GHCL was accumulating approximately 20 tonnes of rejects daily from imported coke. The company had contacted CFRI to provide technology for optimum utilization of coke fines accumulated as waste. The Institute after conducting a survey suggested GHCL to establish a plant of 20 tonnes per day capacity. To reduce the production cost, the CFRI scientists successfully utilized the gas and surplus steam of the captive power plant of GHCL.

Coal washing JIG

Based on the design of CFRI a coal-washing JIG of 30 tph capacity is being manufactured by a private party for commercial washing of both coking and non-coking coals suitable for small-scale entrepreneurs. The washability characteristics and subsequent beneficiation and carbonization studies in the pilot plant showed that both Dhansar and Kalyani washed coals and blended cleans with Mohuda washed coals produce good quality coke and are suitable for metallurgical purpose.

Durability study of fly ash bricks

CFRI has setup a facility for determining the comparative durability of fly ash / clay bricks/blocks in different aggressive environmental conditions. These include alkaline, acidic, saline, chloride, CO₂, SO₂, NO₂, UV radiation, temperature and moisture treatment, wetting and drying, normal aging over a period of time. The durability has been tested for different properties such as surface appearance, bulk density, compressive strength, moisture content, loss on ignition, water absorption, efflorescence, wear and tear, fire rating, etc. The study was sponsored by Fly Ash Mission (TIFAC) DST, New Delhi. There was no significant change in most of the properties of bricks when autoclaved and subjected to different aggressive conditions, from that of unexposed bricks. These bricks were quite comparable with clay bricks. This unique facility created for the purpose is used for testing various fly ash based building materials manufactured by various agencies in the country.

Spacer-aided initiation technique for blasting-off-the-solid

CMRI has developed a spacer-aided-initiation technique for blasting off-the-solid. The

technique envisages use of decking in explosive cartridges with air column in between for distribution of explosive energy over a greater length of the shot hole to improve pull, powder factor, detonator factor and fragmentation. It will help to increase the pull for optimum utilization of men and machine. Decking of cartridges is being used in opencast mines all over the world. But, multiple initiation in a single hole is not permissible in underground coal mines because of DGMS stipulation. Based on the studies in the laboratory as well as in coal seams, it has been observed that air gap sensitivity of permitted explosives i.e. capacity of transmitting the shock wave over an air gap from primed or donor to the receptor cartridges increases significantly with confinement. An explosive having only 2cm-air gap sensitivity in unconfined condition may give an air gap sensitivity of over 50cm in coal bed confinement. Thus a series of decked cartridges with intentional air gaps can be detonated with a single cartridge initiation. This property of increase in air gap sensitivity with confinement has been used by CMRI in spacer-aided-initiation technique for the first time in India. Trials carried out with this technique in blasting off-the-solid method have shown promising result through improvement of about 50 percent pull with better powder factor and fragmentation.

Improvement of stowing rate

Depillaring operation in conjunction with sand stowing is being carried out in two collieries. But the rate of stowing has been observed by CMRI to be very low due to incorrect hydraulic profiles, faulty mixing trough, absence of stool bends, too many leakages, etc. On the basis of inspection of stowing range and necessary investigations, modification of existing mixing trough and stool bend design, proper screening arrangements, reduction of bends, etc, have been suggested by CMRI. As a result more than 50 percent improvement in stowing rate has

been achieved by the implementation of the above mentioned modifications.

Development of hydro-mechanical steel cog

Wooden cogs and some box-type steel cogs which are used to support goaf edges, slices and junctions of Indian underground coal mines are having the limitations as they can not be extended for more heights and can not provide required setting load. Moreover, withdrawal system of these cogs is completely manual. CMRI has developed a novel design of steel cog, commercially named as hydro-mechanical steel cog, which can provide a setting load from 5 to 10 t. It can be extended up to a height of 4m and has the facility of withdrawal system with mechanical advantage. The load bearing capacity of this cog is 40t which is highest amongst its class. The design of this device has been patented. The know-how developed has also been licensed for commercial exploitation.

Spray forming of aerospace grade Mg-Alloy ZK31 (Mg-Al-Zn)

The spray deposition of Mg-alloy is very challenging primarily because of their extreme reactive nature and strong affinity for oxygen to form MgO, which is detrimental for its mechanical and other properties. Mg-alloy, AZ31 (Mg-Al-Zn) has been successfully spray deposited at NPL by disintegrating liquid melt by a stream of Argon gas and depositing the atomized gas through atomization in an inert atmosphere. It has been possible to spray deposit Mg-alloys devoid of any MgO phase, as suggested by the X-ray diffraction results. The microstructure of the spray formed deposits indicated equiaxed grains with no indication of any dendritic features normally observed with conventional cast alloys, which is due to the unique rapid solidification mode associated with spray forming.

Design and simulation of phosphosilicate glass antireflection coating for solar cells

Phospho Silicate Glass (PSG) is grown in situ on the heavily doped n^+ front emitter during diffusion of phosphorous in p-Si at temperature range 800-900°C using $POCl_3$ liquid dopant source. NPL conducted study provided an insight to the growth rate of the PSG and incorporation of phosphorous into silicon dioxide. This results in the change in refractive index of the PSG and makes it suitable for application as antireflection coating for silicon solar cells fabricated by P-diffusion in p-Si by the above process. It will allow one to use the PSG which is grown in situ over the n^+ -emitter region during the formation of p-n junction structure based silicon solar cell using p-Si wafers to use as a low cost antireflection coating on these solar cells.

Performance evaluation of Tri - Flo separator treating Indian coals

RRL, Bhopal has worked out an efficient coal cleaning technique known as Tri - Flo separator. The salient features include: two-stage separation in one pass; high sharpness of separation due to multi-stage cleaning; and lesser wear as solids have little contact with the body of the separator. A test rig of Tri-Flo separator was designed, fabricated and installed at RRL, Bhopal. Experiments were conducted on Tri-Flo separator using coal samples from Nandan area of MP and Moonidih area of Jharkhand at identical operating conditions. Based on these results, the performance of the Tri-Flo separator has been optimised. The results have indicated that the Tri-Flo separator can achieve organic efficiency as high as 97%. This effort was sponsored by Department of Coal through CMPDIL, Ranchi.

Energy Management Cell

Energy Management Cell has been established at CFRI Unit Nagpur specifically, to provide

total solution in energy audit and conservation which has benefited the industries in reducing their energy and financial bill. The cell conducts awareness programmes. About 15 major detailed energy audits have been conducted so far. The clients are likely to be benefited by the recommendations made in these reports.

S&T by CMRI

CMRI continued to extend testing, evaluation and consultancy services to the mining companies and mining equipment manufacturers in India and abroad dealing with explosives and accessories, mine ventilation and safety equipment, roof supports, personal protective equipment, flameproof and intrinsically safe equipment, electrical cables, mining and allied industrial components, wire ropes, cage and suspension gear components, aerial rope ways, etc, for their safe use in mines and other hazardous areas. Mine gases, metals, minerals, coal, etc, have also been analyzed by CMRI as the S&T services to various mining and allied industries.

3.9 Physical and Earth Sciences & Technology

Advance forecasting of cyclone track using a global circulation model

Relatively rare but a regular component of our climate system, tropical cyclones pose a serious and growing threat to many coastal areas world over; there is increasing demand for better accuracy as well as longer range for tropical cyclone forecasts. There are also issues, such as the effect of an intense system like a tropical cyclone in the embedding large-scale environment, that cannot be properly addressed using Limited Area Models (LAM)-the traditional tool for dynamical forecasting of cyclones. Simulation experiments carried out at C-MMACS showed that a relatively new class

of Global Circulation Models (GCM), combining the advantages of LAMs and global models, can provide both longer range and better accuracy for such critical parameters like track and intensity. For seven cyclones representing different locations, seasons, years and strength, simulated tracks and land-fall locations show, with initial condition more than 5 days ahead and only monthly climatology of sea surface temperature (SST), less errors than those from current operational forecast 48 hours in advance. Other interesting features of the simulations include selective intensification from multiple incipient systems. The results opened up a new approach to forecasting as well investigating dynamics of tropical cyclones.

Experiments at C-MMACS were designed, taking into account that tropical cyclone formation has a strong seasonality that varies from one basin to another. For the Bay of Bengal the occurrence of tropical cyclones has a secondary maximum in May and a primary maximum in the October-November period. Two strong points of the simulations were considerably longer lead and relatively low error in track and landfall forecast. The errors in 7-day simulations were often smaller than 5-day simulations. The consistent performance of the model for different conditions with only climatological SST made it an attractive tool for tropical cyclone forecasting. In an actual application one could generate multiple forecasts, each for an ocean basin, with a grid that has been critically evaluated for the basin. Future studies both for more rigorous validation as well as for improving forecast skill are necessary and are under progress. To address the former point, increase in the size of the hindcasts and inclusion of other important parameters like rainfall and intensity in the evaluation process has been planned. For the latter, improvement through higher resolution, better choice of schemes etc. is possible and is under investigation.

Establishment of continuous recording GPS systems in north eastern region

GPS Geodesy is used all over the world to monitor seismotectonic activities. IGS (International GPS Service for Geodynamics) is a coordinating agency which maintains a GPS tracking network of 300 permanent stations all over the world. The data of these stations and their precise positions and velocities along with precise orbits of satellites is made available to the GPS user community through global archives of IGS. Many countries have established their own national GPS networks for earthquake hazard, based on the IGS network. Department of Science and Technology (DST) of Government of India are in the process of establishing such a National network with participation from various research and academic institutions. As a first step towards it, C-MMACS had established five permanent GPS stations at Bangalore, Kodaikanal, Ladakh, Hanle and Almora in collaboration with Indian Institute of Astrophysics (IIA) and G.B. Pant Institute of Himalayan Geology (GBPHIED). Six permanent GPS sites were established by C-MMACS in the north-east India during 2002, which form part of the national network of GPS stations envisaged by DST for monitoring the geotectonic activities in the Indian subcontinent. These stations were set up in collaboration with local Universities in the north-east. These sites were chosen so as to answer specific questions related to Indo-Burma Convergence, and the tectonic relationship of the Shillong Plateau with the Himalayas. The GPS derived velocities of these sites form a key input for the earthquake hazard quantification of the north-east. The GPS data collected will give precise coordinates and velocities of these sites which can be used as reference coordinates for the regional campaign mode GPS surveys in the north-eastern region. Also the Zenith troposphere delay derived by analyzing the GPS data at these sites can be used for the calculation of perceptible water vapor in the atmosphere.

On a plate tectonic scale these sites provide valuable information on the Indo-Burma convergence and also the convergence and strain accumulation in the eastern Himalayas.

Freshwater flux climatology over the Indian Ocean

In recent years, there has been increased interest in the study of air-sea fluxes in general and freshwater flux in particular over the tropical oceans, as it plays a major role in the oceanic transport/circulation. Very little is known about it for the data sparse regions like the Indian Ocean due to the non-availability of the basic parameters needed for the computation of freshwater flux. Over the Indian Ocean, the precipitation estimates are totally lacking or unknown due to the lack of *in-situ* measurements. Climatology and the annual cycle of the freshwater flux over the Indian Ocean have been examined by NIO using the newly available Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite data (HOAPS). The climatological estimate of precipitation from HOAPS is able to depict the mean annual patterns over the tropical Indian Ocean much better than the microwave estimate, even though the sampling was not as good as for a geostationary satellite. The annual cycle of freshwater flux shows that the Bay of Bengal is a moisture convergence region most of the year as compared to the Arabian Sea, which is a moisture flux divergence region. Further the build-up of moisture in the southern Indian Ocean is also clearly seen from March to June, indicating its major role in the summer monsoon activity over the Indian subcontinent.

Offshore limit of coastal ocean variability in the eastern Arabian Sea

Continental shelf is generally considered as the region where very large variations in coastal water characteristics occur due to a variety of physical processes active in the area. Therefore,

the shelf break is generally seen as the offshore limit of variability of the coastal water characteristics. In the eastern Arabian Sea, since the shelf width ranges from 50 km in the southern part to about 140 km off Mumbai region, the shelf width scales have generally been considered for defining the coastal variability limit. However, recent hydrographic observations in the eastern Arabian Sea provided evidence to show that the variability limit could extend beyond the shelf edge into the deep ocean. Based on hydrographic observations and satellite altimeter (TOPEX/Poseidon) information, vertical sections of temperature from two contrasting seasons – south-west (SW) and north-east (NE) monsoons – when projected together by NIO are found to intersect offshore at 350-400 km from the coast along a transect in the eastern Arabian Sea during 1996. Formation of such intersections along transects from south to north in the entire eastern Arabian Sea is noticed in the hydrographic data of 1987-88 also. Existence of these intersections has further been authenticated by the altimeter-derived sea level anomalies.

Reconstruction of late quaternary monsoon oscillations

The sedimentary records from continental margins represent an ideal archive to study various sedimentary processes and for deciphering the past fluctuations in the climate system and possible forcing mechanisms. The nature and composition of clay minerals thus accumulated is expected to provide valuable information on the type and intensity of weathering on land. Although several factors influence the ultimate distribution of clay minerals in the ocean, a careful and independent evaluation of these processes carried out at NIO indicated consistent climatic signals on clay minerals. The clay mineral records of the cores document a generally weak summer monsoon condition and resultant reduced hydrolysis

activity during the last glaciation, which was interrupted by discrete events of humidification at ~ 28000 and 22000 yr BP. Precipitation and terrigenous input increased considerably between 15700 and 14800 yr BP, indicating a regional climatic augmentation during the early deglaciation.

The phosphorite story: “Present is key to the past”?

Studies carried out by NIO on the quaternary phosphorites of the continental margin off Chennai indicate that the bottom dwelling microbial mats which thrived on the shallow shelf during the low sea level conditions are responsible for phosphatization. The bacteria associated with the decaying microbial mats utilized phosphorous supplied by continental sources and rapidly precipitated phosphate. The availability of a high percentage of phosphorous in seawater seems to be an important controlling factor for the formation of phosphate stromatolites. The composition of these phosphorites differs from the modern phosphorites in upwelling regions, but are similar to the ancient Cambrian (~500 Ma) apatite stromatolites. This constitutes evidence that they could have formed under similar conditions. More importantly, this similarity also provides a valuable insight into the environment of formation of ancient phosphatic deposits. While it has been the opinion of majority that the modern phosphorites are of inorganic origin, NIO study reveals that the *microorganisms are the key players in both modern and ancient phosphatic deposits.*

Estimation of sea surface salinity in the Bay of Bengal

Sea surface salinity (SSS) has not been monitored from space so far while satellite measurements of the sea surface and the lower

atmosphere have become an integral part of the global observing systems. A SSS product measured from satellite would enhance the availability of salinity measurements in par with the larger number of sea surface temperature (SST) observations. NIO has developed a new technique for retrieval of sea surface salinity (SSS) from space-borne satellite measurements of Outgoing Longwave Radiation (OLR) through the ‘Effective Oceanic Layer (EOL)’. It is envisaged that the SSS estimated in this way may be useful in improving the existing climatologies at least for those parts of the world ocean where intense convection is the regular feature, such as the tropical Indian and Pacific Oceans. In this method EOL parameter, representing the thin upper oceanic stratified layer takes into account both temperature and salinity for linking the convection in the atmosphere. EOL is estimated in the top 30 m, as the depth of the shallow stability maximum varied between 20m and 40 m in the Bay of Bengal.

Mercury and lead tolerance in hypersaline sulfate-reducing bacteria

Microorganisms contribute to the biogeochemical transformations of metals and organic matter. The anaerobic sulfate-reducing bacteria (SRB) play a significant role in coastal ecosystems where more than 50% of biodegradation takes place through sulfate-reducing activity (SRA). Salt pans are sites where different ions, including metals, become concentrated. Studies on metal microbe interactions are generally restricted to aerobic bacteria, anaerobic consortia and sometimes to mesophilic SRB. Studies at NIO of a few hypersaline isolates of SRB with Hg and Pb at elevated concentrations of the metal salts showed that sulfate-reducing bacteria (SRB) HSR1, HSR4 and HSR14 isolated from the salt pans of Goa grew best at 90-100% salinity on substrates like formate, acetate, lactate, butyrate, ethanol and benzoate. They were gram

negative, non-sporulating, non-motile rods lacking in desulfovirdin and cytochromes. The HSR 1 and 14 were tolerant of both the test metals up to a certain concentration. At the end of 14 days, growth was on par with the control in the presence of Hg although the concentration of Pb was double that of Hg, HSR4 could grow and respire better. The hypersaline SRB have adapted to grow under extreme environmental conditions, although their habitat for isolation may not necessarily reflect their ability to tolerate and proliferate under adverse conditions. HSR4 was more adapted than the other two. Some of these forms could prove useful to mitigate high levels of toxic metals. Some highly toxic forms of elements and compounds can be biotransformed to innocuous forms through reductive metabolism by anaerobes.

NIO led marine archaeological explorations

Mahabalipuram: Explorations at Mahabalipuram (near temple region) – famous for its fabulous art and architecture of Pallava dynasty, on the east coast of India, brought to light a large number of man made stone structures at water depths of 5 - 8 m. The important structures found include walls, steps and platforms. Based on the coastal archaeological data, the date of construction of these structures could be assessed to be in between 1500 and 1200 years BP.

Goa Waters: Explorations of shipwreck at Sunchi Reef in Goa waters, found Chinese ceramic, Martaban pottery, round bases of wine bottles and neatly trimmed stone bricks. A brass metal tube (artefact) 56 cm long which could be part of a telescope, viewfinder or blunderbuss or gun was also retrieved. The Martaban pottery collected from Sunchi Reef are similar to those found in Mombasa wreck. The Thermoluminescence age of Martaban pottery, collected earlier, is deciphered to be 360 ± 40 years. These findings indicated that the wreck

pertains to the Portuguese period.

Gas-charged sediments and gas hydrates in the western continental margin of India

The western continental margin of India is biologically highly productive. Organic matter deposited in such environments is diagenetically transformed by bacteria and/or heat and break down to methane and other organic compounds. Thus, the main source of methane hydrate formation is from organic matter and it is 6-7% of organic matter on the continental slope and 2% in the deep Arabian Sea sediments. Nearly 30,000 line kilometer echosounding, high-resolution shallow seismic data were collected by NIO along track lines spaced at 20 km interval across the western continental margin of India and analyzed. Occurrence of methane-bearing gas-charged sediments and pockmarks in the shelf and gas hydrate horizons along the slope and rise was deciphered. Significant contributions of gas from the slope sediments to the upper strata and the overlying waters are indicated by buried/exposed pockmarks and the prominent plumes are represented by strong echoes in the sediments. These pockmarks occur as conical and dish-shaped incisions often truncating the strata above the sub-bottom reflector. Distinct gas plumes rise from a few meters to about 70 m above the seafloor. The existence of an acoustic turbid zone beneath the pockmarks and a continuous supply of gas from below towards the pockmarks indicate the sediments as gas-charged. The presence of bottom simulating reflectors (BSRs) in slope-rise areas off Goa suggest the presence of gas hydrates in water depths >500-2200 m. Over the Laccadive ridge complex, BSR lies at about 460 milliseconds below the seabed where the water depth is found to be nearly 2000 m. Indian marine bivalves: potential source of antiviral drugs

Marine bivalves are abundant in coastal and estuarine waters of India. Here bivalve fishery

is constituted mainly by clams, mussels and oysters. Molluscan fishery is not well-organised along the coast. They are exploited in large quantities by traditional methods and sold live in the market for human consumption. NIO carried out investigations with Russian scientists showed that Indian green mussels (*P. viridis*) are not only a rich source of protein for human consumption, but also a potential source of antiviral drug. The extract from the mussel showed high antiviral activity when tested with various viral strains such as influenza, hepatitis, RSV and herpes.

Understanding gondwana land

Palaeomagnetic studies were undertaken by NGRI on Govindgarh sandstones, Upper Rewa Group of Vindhyan formations and Trans-Aravalli Marwar Supergroup Jodhpur sandstones from central India. The data generated reveal that they are contemporary. This indicates that India forms a tectonic trio with Madagascar and Seychelles in the Rodina Supercontinent at around 750 Ma ago.

Groundwater sanctuary

Studies have been carried out by NGRI in low rainfall, groundwater overdraft hard rock granite terrain of Gurukanipalli Watershed, Chittoor district, A.P. These efforts have resulted in evolving groundwater sanctuary in the waste land part of catchment area for meeting the water requirement of problem villages. The village water supply has been commissioned under gravity and siphoning without depending on energy.

Geochemical baseline map

Geochemical baseline maps have been prepared for the first time in Cauvery basin for environmental management as a part of Global Baseline Program. These maps will be helpful in finding out the future contamination due to anthropogenic sources.

Geotechnical investigations by NGRI

NGRI systematically undertook diverse geotechnical investigations during the period:

- ☞ Applied for the first time the multi channel analysis of surface waves (MASW) method for geotechnical investigations and microzonation studies in the country;
- ☞ Conducted surveys to determine depth of the bedrock, P and S wave velocities information and dynamic elastic properties for the underground rail corridor to be constructed by Delhi Metro Rail Corporation;
- ☞ Undertook study for laying of two pipelines, by Gas Transportation & Infrastructure Company Limited from Jamnagar to Bhopal; and Goa to Hyderabad for transportation of hydrocarbons;
- ☞ Conducted surveys for Damodar Valley Corporation (DVC) for the construction of Unit-IV power generating unit (210 M/W) site at Mejia, West Bengal.

Surface modification and phase stabilization in nanophase materials

Extensive X-ray photoelectron spectroscopic studies have been undertaken to understand the role of surface modification in the nanophase stabilization of several electronic materials. Study conducted at NPL reveal that the Cu₂O nanoparticles are stabilized by the formation of a CuO cap surface layer of thickness of 1.6 nm. Electronic structure studies show effect of electron confinement and formation of defect states that pin the Fermi level. Electronic excitations by Dense Swift heavy ion irradiation of these CuO stabilized Cu₂O nanophase is demonstrated to be useful to tailor the structural and optical properties of nanocrystalline Cu₂O phase, without destroying the nanocrystallinity.

The monoclinic CuO phase transforms to the cubic Cu₂O phase. It has been also shown that the presence of a CdTeO₃ layer modifies the crystal structure of the CdTe nanoparticle core by introducing a large number of stacking faults. The CdTeO₃ cap in case of the cubic CdTe is amorphous and is crystalline for hexagonal CdTe. Thus, a structural transformation in the nanoparticle core mediated solely by surface effects has been observed for the first time in any nanoparticle system. Due to large surface area of Gd nanoparticles, the interaction of gaseous species with rare earth metals is expected to be enhanced resulting in large changes in hydrogen sensing characteristics of nanoparticle films capped with a polycrystalline Pd over-layer. A detailed study at the Pd-Gd interface clearly demonstrated the suitability of using nanophase Gd for hydrogen sensors and storage.

Coherent procedure for calibration of force transducer

The force transducers (measuring/ proving instruments) all over the world are being calibrated periodically to establish national traceability either through NMI of the country or through accredited laboratories. In the era of growing awareness of quality assessments, MRA demands that the calibration data and its analysis should be acceptable to the member countries of MRA. This is possible only if the procedures adopted to calibrate and analyze the data are similar in all respects. The situation however, is not that conducive, as different countries follow different standards for the calibration of force proving instruments used for verification of the testing machines. For example, USA follows ASTM standard, Europe follows EN and in Asia standard procedure based on ISO are followed. The major differences in these calibration procedures lie in the number of force cycles taken at same position or at different positions, loading regime/ sequence, method of calculating the interpolation error, etc. Studies have revealed

differences in calibration data under identical conditions following the different calibration procedures. The need was thus felt to evolve a coherent written calibration procedure, which may incorporate the salient features of most of the prevalent written calibration standards.

A detailed investigation was carried out at NPL to calibrate a well-characterized force transfer standard of 5 kN full scales on the newly developed 5 kN dead weight force machine following the different written calibration standard procedures viz. ISO 376-99/ EN 10002-3-1994, IS 4169-1988 and ASTM E74-2000. The data has been analyzed, and a coherent calibration procedure has been proposed. In the said procedure six force cycles are taken, three of these at one position enabling evaluation of type A uncertainty, which has not been taken into consideration in the standard procedures. Further, the minimum deviation of the calibration data from the interpolation curve obtained with the procedure as compared to that obtained following other standard procedures proves the superiority of the proposed procedure. The proposed procedure, if accepted for calibration of force transducers, uniformity in force measurement would be brought about at international level leading to mutual acceptability of calibration procedures and hence the calibration report followed by different countries. Further, it would help in bringing about uniformity and ease of trading in force standard machines manufactured by different countries, which hitherto are based on the calibration procedures adopted by respective country.

Precision force transducers

NPL has designed and developed novel precision strain gauge force transducers based on an axe-symmetrical diaphragm pierced by a number of holes. It is for lowering down the measurement uncertainty in force measurement and improving the reproducibility of the transfer force standard. The spring element has been

designed to act as multiple bending beams arranged symmetrically around the axis for transverse force stability. A finite-element software has been used to optimize the design of the force transducers in the ranges 100kN, 200kN and 500kN.

Upgradation of standards and calibration facilities

NPL has been maintaining the national standards of various electrical and electronic parameters and disseminating them throughout the country by providing apex level calibration and testing. Several standards and calibration facilities have been upgraded viz. AC & LF power (single phase), primary standard of AC & LF voltage (1-3 V), reference standard of AC & LF voltage, AC high current ratio (50Hz), LCR measurements at high frequencies (75 kHz – 30 MHz), and DC resistance. To fulfill the obligation under global Mutual Recognition Arrangement (MRA), NPL has participated in several Key and Supplementary Comparisons of Standards under BIPM and APMP to establish international equivalence of its standards. So far 38 intercomparisons have been included in Appendix B of BIPM database. 456 entries for Calibration & Measurement Capabilities (CMC) in the area of Electricity & Magnetism have been accepted for inclusion in Appendix C of BIPM database.

3.10 Science & Technology for the Society

Biovillages: geranium as catalyst of green hope

CIMAP signed MoU with Technology Information, Forecasting and Assessment Council (TIFAC), New Delhi, last year for commercial cultivation of geranium in Uttaranchal, through community participation, in an end-to-end mission. Under this scheme, entitled "Technology dissemination, commercialization and utilization of Geranium

(*Pelargonium graveolens*) cultivation through processing and value addition of end products in Uttaranchal at bio-village level", CIMAP has demonstrated the cultivation of geranium in Kumaon region of Uttaranchal in 46 farmers' field during the crop year 2001-02. Installation of distillation units and harvesting of the crop for distillation was also done. Three distillation units were designed, fabricated, installed and commissioned, one each at the geranium bio-village sites, i.e., Someshwar, Dangoli and Gagrigol in Uttaranchal to facilitate the distillation of the crop produced in the respective bio-villages. Quality planting material was generated on a large scale at CIMAP research facilities and transported to beneficiary farmers at Uttaranchal. The germplasm will be multiplied *on site* in the selected bio-villages for expansion of cultivation.

Forty-six farmers of Almora and Bageshwar were inducted into the project in its first phase. They produced quality geranium oil from their fields. About 19 tonnes of geranium biomass produced was distilled to produce about 20 kg oil, with 0.1% recovery. Oil samples were evaluated at CIMAP. The marketing of the produce was arranged as per commitment. To mark the occasion, Shri Bachi Singh Rawat, Hon'ble MoS, Govt. of India, handed over a part of the oil to industrialist Ramakant Harlalka, on 4th August, 2002 in a function held at field station, Purara. Efforts were on to establish bio-village clusters in Uttaranchal leading to the social transformation through mediculture-based entrepreneurship in the state. This move, to attain self-sufficiency, bears importance in view of Indian imports of about 140 tonnes of geranium oil, which will be substituted by home grown geranium oil in the northern hills.

In the second and third phase of the project, 229 farmers were identified from eight villages in Almora, Nainital, Bageshwar and Chamoli

districts. One tenth of the total planting material has been supplied to the farmers as resource plants which will be multiplied *on site*. Fourteen farmers received training to multiply the planting material. These farmers have also gained sufficient knowledge on plant protection measures. Six villages have been identified for the installation of low cost distillation units to process geranium herb in the project area. One village, Gwaldam, has been earmarked for the near organic cultivation of geranium. In total, 42 vermicompost pits have been constructed in farmers' field in this village. Scientists provided all possible help to the beneficiary farmers covered under the project and collected soil and yield data.

S&T for employment generation for women

In order to promote employment generation among women Self Help Groups (SHGs), CECRI has adopted 'Perungondan Viduthy Village Panchayat' at Pudukkottai District, Tamil Nadu. A cashewnut industry is being set up. District Rural Development Agency (DRDA), Pudukkottai will be providing funding for this effort.

Ceramic membrane based technology for removal of arsenic and iron from contaminated ground water

CGCRI has developed a ceramic membrane based technology for simultaneous removal of arsenic and iron from highly contaminated ground water. The process developed removes arsenic down to < 10 ppb - the level specified by WHO and iron content below 0.1 ppm (WHO specification is 0.3 ppm). A pilot plant was installed at Akrapur, Barasat, West Bengal in collaboration with Public Health Engineering Directorate (PHED), Govt. of West Bengal where ground water containing arsenic 0.9 - 1.3 ppm and iron 5-12 ppm is being treated successfully to produce safe drinking water conforming to the WHO specifications. About 500 litres of safe drinking water is being

produced daily and distributed to the local inhabitants. Being satisfied with the performance of the above pilot plant unit, PHED, Govt. of West Bengal has approached for installation of more units with higher capacity (2500 LPD) in different parts of arsenic prone areas of Barasat Municipality. Installation of the units was in progress.

Lead-free Jaipur blue pottery

CGCRI Naroda Centre has developed body composition, engobe and matching glaze totally free from lead and other toxic ingredients present in the raw materials used for making traditional Jaipur blue pottery. This has been achieved without sacrificing original aesthetic appeal but drastically reducing the rejection of the wares. It has opened up greater export potential by way of elimination of lead in the product and achieving greater cost-effectiveness. The technology has been transferred to Rural Non-Farm Development Agency (RUDA), Jaipur for disseminating the same to the blue pottery artisans of Jaipur and several other regions of Rajasthan. The Govt. of Rajasthan has since released the technology to them and CGCRI Naroda Centre has provided active technical support for successful implementation of the technology in those areas. The artisans have since started routine production of crockery and several other diversified products with better market potential.

Improving quality and yield of salt recovered from Sea/inland brines by the marginal salt producers in Gujarat

About 50% salt produced in the country is in the unorganized sector. The marginal salt producers across the country are unaware about the correct methodology of salt manufacture and hence the quality of salt produced by them is not up to the desired level. The price derived by them for their produce is thus much lower. CSMCRI along with other Government and

non-Governmental Agencies like Rural Technology Institute Gujarat (RTIG), and Self Employed Women's Association (SEWA) analyzed the problems being faced by marginal salt producers across Gujarat State. Periodical training programmes are being arranged at various places of Gujarat to make the Agarias aware of the importance of producing quality salt. CSMCRI imparted training to the marginal salt producers in South Gujarat and established a model salt works at Dharasana Village in Valsad District with the financial support from RTIG. Taking this as a model farm, the marginal Agarias were able to produce good quality industrial grade salt from sea brines, which was sold to user industries at a much higher price. The revenue earned by the agarias was almost double as reported by the Cooperative Society at Dharasana.

Desalination by Reverse Osmosis

Prototype RO plants for long-term field study: Under the DST sponsored project, CSMCRI installed two RO plants of 2000 liters/hour capacity, one each at Kalyanpur village of Bhavnagar district, Gujarat and Kasari village of Jhunjunu district, Rajasthan. The plant has six spiral elements each of 4" dia x 1m size made from our TFC membranes. The pilot plant in Gujarat is operating with 10,000 ppm brackish water to give about 600 ppm water with 94% salt rejection. The pilot plant installed in Rajasthan is treating brackish water of about 2200 ppm TDS to give a potable drinking water of about 250 ppm TDS with 90% selectivity.

Development of Solar Powered R.O. unit:

Two solar powered R.O. units of 8 l/hr and 15 l/h capacity were designed and fabricated on behalf of Rajiv Gandhi National Drinking Water Mission (RGNDWM). One unit was installed at Science Park, Jaipur for publicizing and promoting the concept while the second unit was installed for conducting field trials in

Bahadurvas village of Jhunjunu district, Rajasthan. Both the units are operating with the help of two solar photovoltaic (PV) panels.

Animal powered R.O. for brackish water desalination for village community: CSMCRI has developed a unique water desalination system, which uses animal energy to energize the high-pressure pump to effect brackish water desalting by R.O. process. The desalination system, which runs on animal power, consists of speed increaser, high-pressure pump and membrane modules. The above system can produce 300-500 liters/hr product water from feed water whose TDS is in the range of 3000-5000 ppm.

Pesticide removal unit for producing potable water free from organic pollutants

NEERI has developed a unit for producing potable water free from organic pollutants viz., γ -HCH, p,p'-DDT and p,p'-DDD and p,p'-DDE, total coliforms, faecal coliforms, turbidity and total organic carbon (TOC). The unit is tap attachable and has the capacity to store treated water, consumes no electricity and is easy to operate and cost-effective. It comprises of two cylindrical shaped interconnected chambers. The filter materials incorporated in the unit are indigenous GAC as an adsorbent for OCIPs and TOC, and sand-iodine mixture as a disinfectant medium for coliforms. Efforts are in progress to extend the application of the system for the treatment of other priority pollutants in water and modifications in its design aspects.

Fluoride mapping

NGRI carried out systematic mapping of fluoride in Rajgarh tehsil of Rajasthan. The study revealed pockets of higher concentrations. For these pockets remedial measures were suggested to help improve the quality of ground water. The studies also delineated the buried Kandli river course in the region.

Polymer modified concrete

CECRI has developed a water soluble polymer to improve the miscibility and workability of resin based concrete. The polymer was used as an admixture and evaluated in various mechanical and corrosion tests. The polymer modified concrete is found to be superior in property when compared to ordinary portland cement concrete. Water soluble system has been developed to minimize the pollution due to evaporation of solvent as in the case of resin based mortar.

Eco-friendly process to combat fouling - an alternative to antifouling paints

An eco-friendly process to combat fouling has been developed at CECRI. Unlike the conventional fouling prevention methods, in this system no chemical or hazardous substance is used to combat fouling. This system does not warrant dry-docking, as fouling is prevented completely. Hence the exchequer of dry-docking and the business loss due to the inactivity of the vessels, are prevented. The fouling proof nature of the system not only conserves fuel but also enhances the efficiency of the marine installations. The fouling proof and eco-friendly nature of the system, completely eliminates the release of toxic ions from operating vessels and emission of pollutants during dry-docking compared to the existing antifouling systems.

Development of sensors

CECRI has developed an analytical methodology for the quantitative estimation of sub-milli-molar levels of the anti-microbial agent triclosan. The methodology has been integrated into a prototype sensor for use in personal care products. For ELFE sensors for underwater applications, electrode pairs with extremely low self-noise levels (nanovolt) have

been developed. The electrode pairs also show near-identical characteristics (differential voltage signal $\leq \mu\text{V}$). The fabrication of electrodes is optimized with regard to the choice of electrolytic bath constituents, metal purity and addition agents. Electrode characteristics have been optimized for different sizes and shapes. ELFE sensors are strategically important from their naval applications and hence the indigenous development of the electrodes for the above sensor assumes high importance.

Dynamics of the interfacial protection using redox property of Electronically Conducting Polymer (ECP)

CECRI has provided a new insight into the understanding of the corrosion protective action of the redox features of ECP. It would help in modulating the ability of redox functionality of the polymer. The protocol evolved in this finding facilitates simple and easy screening of potential candidates of ECPs for corrosion protection role of the desired substrate. The Al/Al₂O₃/polyaniline interface in corrosive medium has been examined through AC impedance spectroscopic analysis whose experimental data has been simulated using equivalent circuit model. Diagnostic approaches on nature and type of protective role especially for polyaniline at corroding Al interface have been evolved. This type of synergization of experimentally observed values and simulated values have provided a new platform for predicting the protective action of ECP in general, polyaniline in particular for the first time.

Corrosion resistant portland pozzalona cement

CECRI has standardized a process which involves addition of suitable organic and inorganic inhibitors in powder form while

blending fly ash with portland cement during the manufacture of portland pozzalona cement at the blending stage. Development and evaluation studies have indicated that the addition of suitable inhibitors, the durability factor against corrosion of steel rebars has been increased by several times due to excellent corrosion resistant property of this product even in severe environment. The synergistic effect of the inhibitors offer better passivation to the steel reinforcement embedded in such concrete in spite of the lower alkalinity of the portland pozzalona cement. This process serves the dual purpose of disposal of waste product viz. fly ash and utilization of the same for durable construction even in severe corrosive environments. The product has been commercialized.

Cadmium plating on maraging steel parts of SARAS and LCA

The cadmium plating on wing flap tracks made up of maraging steel is being carried out using the technology developed at CECRI for plating on maraging steel using a hydrogen embrittlement free cadmium plating solution. The wing flap tracks of SARAS aircraft are made of maraging steel and nitrided for increasing its surface hardness. These components are cadmium plated for enhancing corrosion resistance. During cadmium plating the tracks are masked and remaining areas are plated and then chromated. Also cadmium plating on Light Combat Aircraft (LCA) uplock components, made of maraging steel, was successfully done by CECRI. The uplock system for the LCA designed by Aeronautical Development Agency (ADA) Bangalore consists of a variety of components of varying sizes made of maraging steel. These components are cadmium plated and chromated prior to assembly of the uplock. Suitable jiggging and masking procedures were identified for the various types of components and about 1000 components processed. This technology

has been transferred to Aeronautical Development Agency, Bangalore.

Clean technology park for electroplating units

CECRI and Science & Technology Entrepreneurship Development scheme (STEDS) jointly initiated steps to establish a clean technology park for electro plating units at Karisalkulam village near Madurai. A common effluent treatment plant to serve all the industries is to be set up in this park. In order to implement quality management system, training will be imparted to persons from plating industries. Action on land acquisition and other formalities like EIA, NOC etc., is in progress.

Cultivation of aromatic plants and production of essential oil

RRL, Jorhat has implemented a DBT sponsored project entitled cultivation of aromatic plants and production of essential oils for earning the livelihood by the ST population of Arunachal Pradesh. About 135 families have benefited. The beneficiaries have covered about 300 acres of unutilized lands with initial free supply of 7.00 lakh citronella slips by RRL Branch Laboratory, Itanagar and its subsequent multiplication. Through this project, the people of Arunachal Pradesh have found a way of generating income out of so far unutilized degraded, jhum and waste lands. Seven citronella distillation units of 600 kg/batch were installed in six different villages for production of oil through seven registered Co-operative Societies. The societies purchased the citronella grass from the beneficiaries and produced about 14000 lit. of citronella oil for marketing and earned profit. Necessary market assistance has also been provided by the branch laboratory.

Marine sanitation device for "Kettuvallom"

A unique selling point for Kerala's tourism industry is its backwaters. An overnight ride and stay on a "Kettuvallom" houseboat is a highlight

of a holiday in Kerala. The Kettuvallom was traditionally used for cargo transport using Kerala's extensive waterways. It is made from local materials; jackwood seasoned with fish oil and jointed using coir fibre. The kettuvallom and traditional boat building skills had become almost extinct with the dominance of road transport. Now the kettuvallom has been resurrected, outfitted with modern amenities including bed, bath, kitchen and solar power and has proven to be a unique tourist attraction. The disposal of sewage from Kettuvallom, however remains an unsolved problem. Discharging waste into the same water used for swimming and fishing is obviously unattractive. It has the

potential to damage the image of this unique tourist attraction, besides being a real public health issue. The Department of Tourism, Government of Kerala, contracted RRL, Trivandrum to design a "Marine Sanitation Device" (MSD) suitable for Kettuvalloms. RRL designed and developed a modular MSD. It was fabricated using rotomolded LLDPE technology. A prototype unit has been installed on board a kettuvallom and was undergoing extensive testing. It could achieve complete treatment of houseboat sewage and sullage using a combination of biological processes. It is compact for underdeck fitting and its power consumption is limited.