

ANNUAL REPORT 2004-2005

Foreword



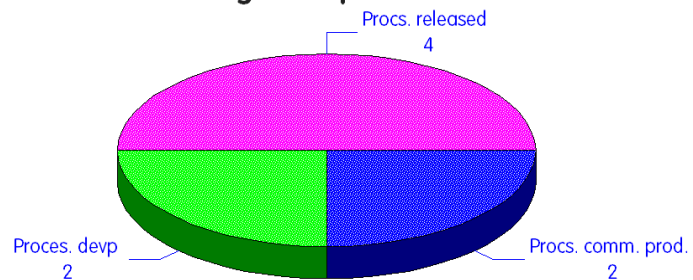
I deem it a proud privilege to present before you the Annual Report of the laboratory for the year 2004-2005. The various national commitments and priorities for the year have been embodied in the report and as demanded by the country's new economic order, the laboratory put its best endeavours towards achieving these national objectives. The laboratory celebrated the year 2004 as the THE YEAR OF SCIENTIFIC AWARENESS starting in July and ending in December, 2004 with a series of scientific awareness programmes spanning the period and held at various pre-appointed places of the North Eastern states for the benefit of students, farmers, teachers, women, NGOs and general public as per the directives of CSIR. All total 28 lectures, 11 open house interactive meets, 6 mobile S&T exhibitions, 1 science motivation programme, 2 extempore speech competitions in science topics were organized, conducted and coordinated for the purpose in urban, rural and interior places of the region by the scientists of the laboratory which happened to be very much rewarding to the targeted sections of the society. In addition to that 6 titles of booklets on scientific awareness, published jointly with the Science Writers' Association of Assam, were released to libraries, schools and village NGOs, etc. Performance wise it had been just an another successful year in matters of R&D and S&T services of the laboratory. The laboratory engaged itself intensely in applied as well as basic research. The spectrum of laboratory's R&D activities mainly focused on five broad areas namely Biosciences, Chemical Sciences, Engineering Sciences, Ecology & Environment and Earth Sciences. Side by Side, the R&D support activities were also strengthened and streamlined and I have no hesitation to mention that very sincere efforts were made by the band of our dedicated workers for fulfilling the tasks expected of us with greater sophistication and standard.

Among the significant achievements the laboratory made during the year under report were the transfer of technologies such as Agro practices of Safed musli, Bioorganofertilizer, Fibres from banana pseudo stem and Low dust chalk pencil to quite a few number of parties from both within the state as well as from other states like Manipur, Tamilnadu and Kerala. Of the new projects contracted by the laboratory during the year, 17 were grants-in-aids, 2 nos were collaborative assignments and 8 consultancies with a total contract value worked out to be at Rs. 2.07 crore. The laboratory rendered about 150 testing/analysis/technical services to more than 175 clients comprising of R&D establishments, industries, manufacturers and other govt. and private user agencies and thereby helping them to add to their economic gains and quite a few of them like ONGC, OIL, Garrison Engineers of Dibrugarh, Jorhat & Sonitpur, NRL, PWD, HPCL, PHE, etc. had been the regular customers. On the societal front a total of 150 hectares of land were newly brought under the cultivation of laboratory evolved agro-technology on Java citronella and Lemongrass in places like Barama, Panitanki, Parkijuli, Kumarikata and Tamulpur of the Bodo Autonomous Council and Kairara and Makhibaha of Nalbari district of Assam together with establishment of 2 nos of oil distillation units in these areas raising the productivity of oil to 20 tonnes per hectare and thereby creating employment avenues for 250 rural youths and their families. During the period a total of 12 projects including 5 consultancies were completed and the final reports were submitted to the respective parties. The laboratory earned Rs. 239 lakh as external cash flow through various contract research and consultancy assignments out of which Rs.0.40 lakh was earned as testing and analytical charges. During the year the laboratory organized 3 important national seminars namely (i) Seminar on Tea Improvement (ii) An interactive Meet on Food Based Industries in NER and (iii) The First National Seminar on Muga (*Antheraea assama*) Silkwom Biocemistry, Molecular Biology and Biotechnology to Improve Silk Production titled SBMBB-2004. The laboratory published a total of 89 research papers in various national and international journals with an impact factor of 1.879 on the average. Nine patents were filed in India and 4 patents were granted in India while one patent granted in abroad. Under the HRD programme 8 staff members were awarded the degree of Doctor of Philosophy in different disciplines of science by the various Indian Universities.

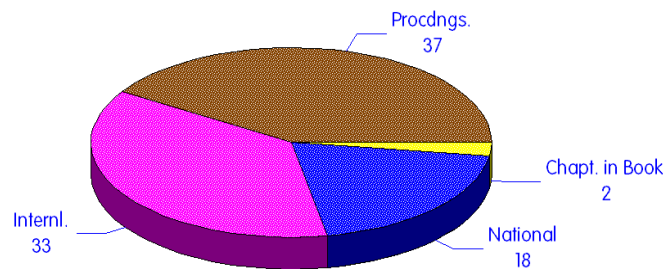
I feel very proud to announce that the reporting year had been one of the most fulfilling years in so far as the achievements of the laboratory are concerned having bagged as many as 5 prestigious national awards which are the remarkable feathers in the crown of its glory. The awards are (i) CRSI Bronze Medal for the year 2005 in recognition of the research contribution in Chemistry conferred on Scientist Dr R C Boruah (ii) BCC B P Poddar Memorial Award in recognition of the research contribution towards protection and improvement of environment conferred on Scientist Dr (Mrs) Neelima Saikia (iii) AMI Louis Pasteur Award for the year 2004 for outstanding research contribution towards discovering a strain of microbe having novel anti tuberculosis activities conferred on Scientist Dr T C Bora (iv) Professor H C Goswami Memorial Fellowship 2003-2005 of the Assam Science Society for significant research contribution in the area of steroid synthesis of heterocyclic systems and development of novel methodologies for organic synthesis conferred on Scientist Dr R C Boruah and (v) NOCIL Award for excellence in design or development of process plant and equipment for the year 2004 (joint) conferred on Scientist Sri Dilip Kr Dutta.

Dr P G Rao
Director

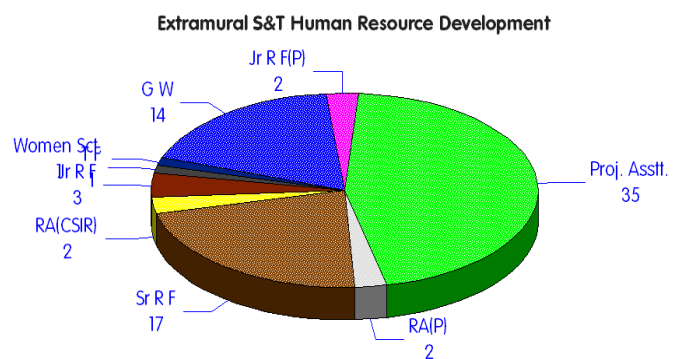
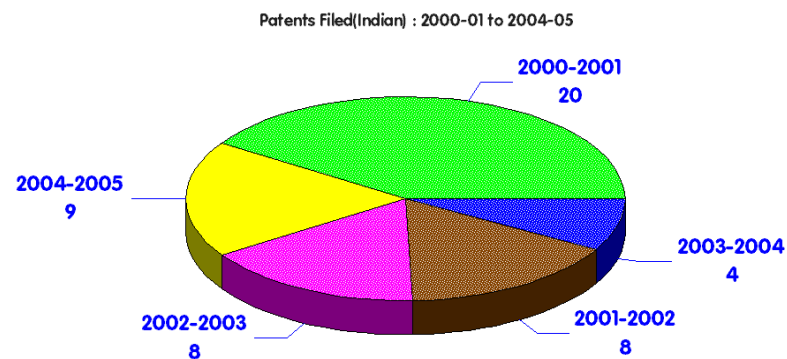
Technological output : 2004-2005



Papers published : 2004-2005



Total : 90 (Avg. IF = 1.879)



Biological Sciences

Introduction of new antibiotic having anti-TB activities in-vitro

Isolation, structure elucidation of a new anti-fungal and anti-bacterial antibiotic was completed. Since the molecule showed anti-TB activities in-vitro, the molecule was investigated in details. Synthesis of absolute stereochemistry and molecular design of the molecule was completed. The new antibiotic was protected by two numbers of Indian Patents and one US Patent. The activities undertaken had vital significance in the national perspective due to the fact that alarming spread of the killer disease tuberculosis, especially in developing and underdeveloped countries owing particularly to HIV epidemic precipitated an urgent need to develop a new drug against TB. According to a report of the World Health Organization, the frequencies and types of life threatening fungal infection among the immuno-compromised patients of HIV have increased dramatically during the last two decades. The fungal infections that appeared towards the later part of medication among TB patients even worsely aggravate the situation. Hence, there was the need for developing a novel anti-TB drug with antifungal activity at the same time. The drug molecule thus discovered had both antifungal and antituberculosic activity and that is why it holds great promises for developing new drug to effectively combat this deadly disease.

Induced immunity in *Antheraea assama* Ww against flacheria causing *Pseudomonas aeruginosa* AC-3

It was for the first time the induction of immunity in *Antheraea assama* Ww larvae against bacterial flacheria. In silkworms the group of disease caused by bacteria are collectively called 'flacheria' reported. This refers to the flaccid condition of the larvae due to the infections of bacterial strains pathogenic to muga silkworm. Antibacterial activity against pathogenic *Pseudomonas aeruginosa* AC-3 causing flacheria was induced by injection of heat-killed cells of the same strain. Experiments on larval survivability and viable cell count revealed peak immune response on the third day. Comparison of the amount of food ingested, excreta produced and larval weight of the saline injected control, live bacterial-challenged larvae and heat killed bacteria injected larvae (vaccinated) confirmed development of immunity against bacterial infection in the 'vaccinated' set of larvae. The haemolymph of *A. assama* larvae was analysed for proteins associated with bacterial infection. Out of the total 32 detected proteins, eleven (A1-2, A15-20, A22-23 and A-29) were constitutively synthesized in both the control and live bacteria injected larvae. Four inducible proteins A4, A9-10 and A21 were detected in the haemolymph of the live bacteria injected larvae. Synthesis of rest of the proteins varied between the control and their live bacteria injected counterparts. General protein profile of 'vaccinated' larvae injected with live bacteria were found to be similar to that of the saline injected control.

Chemical Sciences

Preparation of Novel Class of Pyridosteroids

A solid phase base catalyzed condensation of steroidal b-formyl enamides with nitromethane under microwave irradiation led to a new strategy for the one-pot preparation of a novel class of pyridosteroids via Henry reaction. The Henry reaction has attracted enormous attention as one of the valuable fundamental synthetic strategies for construction of carbon-carbon bonds. The importance of Henry reaction is due to the great potential of the newly formed b-nitro alcohols or nitroalkanes for further transformations. The hitherto known application of Henry reaction has been developed using sonication, high pressure reaction, heterogeneous catalyst and polymer support.

The biological activities of pyridines in natural products and pharmaceuticals make them important target for synthesis. The pyridosteroid derivatives like *Finasteride* and *Abiraterone* have already shown antitumor property and are in clinical practice. The research effort of the laboratory yielded the preparation of b-formyl enamide as an efficient organic synthon. The methodology developed exemplified the first instance for the synthesis of a novel class pyridosteroids under microwave using previously unreported Henry reaction.

Synthesis of dihydropyrazolo (3', 4': 3, 4) pyrrolo(1,2-a)indoles employing intra-molecular 1, 3-dipolar cycloaddition strategy

The potent antitumor antibiotic Mitomycins have attracted a great deal of interest and a variety of molecular manipulations have been reported

without loss of any significant biological activities. Indeed Mitomycin C is a clinically useful chemotherapeutic agent for the treatment of various tumors. The indole nucleus annulated to carbocyclic or heterocyclic rings is present in an astonishing variety of natural products endowed with potent biological activities. The laboratory synthesized various novel dihydropyrazolo(3',4':3,4) pyrrolo (1,2-a)indoles a mitomycin analogues by employing intramolecular 1,3-dipolar cycloaddition strategy. The dihydropyrazolo (3', 4':3, 4)pyrrolo (1, 2a) indoles thus synthesized had direct impact on applied R&D, as these novel heterocycles had the potential as precursors to various mitomycin analogues.

DMSO/N₂H₄.H₂O/I₂/H₂O/CH₃CN : A New System for Selective Oxidation of Alcohols in Hydrated Media

Oxidation of alcohols to carbonyl compounds is one of the most important transformations in organic syntheses. The selective oxidation of alcohols is still a challenging task to organic chemists particularly when both secondary and primary groups within the same molecule are present. Many selective reagents for the oxidation of secondary alcohols to ketones have been reported, including halogen based oxidants, e.g. N-chloroacetamide, N-chloro/bromo-succinamide, Cl₂/Pyridine, Br₂/HMPT/NaHCO₃, (Bu₃Sn)₂O/Br₂, NaOCl/CH₃COOH, NaBrO₃/ NaHSO₃ and CeSO₄/NaBrO₃. Other important selective oxidizing agents viz. Mo/Zr/W/Ru compounds, peroxides, dioxirans and enzymatic methods are also efficient reagents for the selective oxidation of secondary alcohols. Oxidation by DMSO and related methods are widely used in organic syntheses, although few examples of primary-secondary selectivity are reported. Aliphatic primary and secondary alcohols were oxidized in the presence of allylic or benzylic alcohols using DMSO/(CF₃CO)₂/Et₃N system. The competitive oxidation of alcohols with Me₂SO/(COCl)₂/Et₃N at 60°C has demonstrated that alcohols bearing electron deficient groups are generally less reactive and secondary alcohols were oxidized at faster rates than primary. However, the methods of oxidation by DMSO have disadvantages, because of their involvement under anhydrous and low temperature conditions, use of moisture sensitive and toxic reagents, bases and in some cases, occurrence of Pummerer rearrangements (upto 50%). Therefore, development of better selective reagent is desirable. The work presented here is the better reagent developed in the laboratory for selective oxidation of alcohols in hydrated media. The work is important in the light of oxidation of alcohols to ketones especially in preparation of industrially important compounds such as benzaldehyde. The reaction is important in selective oxidation of secondary alcohols in the presence of primary alcohol groups.

16-dehydropregnenolone acetate (16-DPA)

In recent times the organic chemistry research has shifted its focus from better yield to Green Chemistry which give attention to chemical reactions that eliminate or decrease the use of hazardous substances. 16-DPA is an important intermediate in the synthesis of steroidal drugs. It is industrially prepared by the oxidation of pseudodiosgenindiacetate (PDA) a furostadiene intermediate obtained from diosgenin an important phytochemical available in certain plants of this region. PDA is prepared by reacting diosgenin with acetic anhydride. Currently 16-DPA is prepared by chromic acid oxidation of PDA which is not environmentally friendly. Green oxidation reactions require the use of hydrogen peroxide or ideally air or molecular oxygen as oxidant and water as solvent. The use of hydrogen peroxide in certain chemical reactions is a favoured reagent to reduce the use of environmentally toxic inorganic oxidizing agents so that environment-friendly processes can be developed. In this work attempt was made to replace chromic acid by hydrogen peroxide. Hydrogen peroxide and a Gr (VI) inorganic compound (catalyst) was used as the oxidizing agent. The reaction was studied in a water - organic solvent bi-phasic system. This system was capable of converting PDA to 'disone'. Disone was then converted to 16-DPA with acetic acid.

This reaction was subjected to several parameter studies such as effect of solvent, phase-transfer catalyst, pH, additives, temperature, mode of addition, recycling of catalyst, etc. The reaction was slow at 25°C (96 hours) but moderate at 70°C (4-6 hours). The reaction produced a side-product (20-30%) along with disone and finally 16-DPA. The reaction could be successfully carried out at room temperature to reduce oxidation and side-

product formation to a greater extent and by using non-halocarbon solvents. Further work needed for overall improvement.

A facile strategy for the convenient reduction of 16-dehydropregnenolone acetate to pregnenolone acetate was accomplished by using magnesium metal and zinc chloride in aqueous medium in excellent yield. The reduction reaction was generalized to aliphatic conjugated enone and alkynes. The methodology provided first example for in-situ generation and utilization of an activated zinc for reduction reaction in aqueous media.

One-pot synthesis of pyridosteroids was accomplished from β -formylenamide via Henry reaction. The base catalysed solid phase condensation of β -formyl enamides with nitromethane under microwave irradiation afforded a novel one-pot synthesis of pyrimidines.

Ester hydrolysis by solid-supported reagents

Ester hydrolysis is an important reaction to deprotect alcohols. Reports are available on hydrolytic or non-hydrolytic chemical methods for ester hydrolysis using homogeneous or heterogeneous reagents. Solid-supported heterogeneous catalyst has the increased importance in deacetylation reactions as they can be easily separated from the reaction mixture by simple filtration. They can be recycled which make them attractive in both the economic and environmental point of view. Deprotection of acetates are reported with alumina, zeolite and acid resins. Natural alumina is used in deacetylation of aryl acetates and alkyl acetates under solventless condition only where as large volume of solid is needed to adsorb the substrate. Zeolites have specific pore dimensions for which esters of specific size can only diffuse into the cavities and get hydrolyzed. Anion exchange resins are useful for deesterification of sugars and nucleotides only and are costly reagents. In order to study the de-esterification reaction a solid SiO_2 - supported inorganic system was prepared to examine its activity against esters. It was observed that diosgenin acetate was converted to its corresponding alcohol diosgenin on refluxing in methanol in presence of the reagent. The reaction was completed in 5 hours. Similarly cholesteryl acetate was deacetylated in 8 hours at 25°C. The reaction did not proceed in ethyl acetate or acetonitrile. In order to generalize the reaction, a series of esters were treated with the reagent in dry methanol and stirred at 25-65°C for 1-5 hours whereby alcohols were obtained in 80-95% yield. Presence of water (5%) inhibited the reaction. N-Acetyl compounds and ethers were resistant to the reagent. Aromatic esters are easily deacetylated. The reagent could be recycled 4 times. The surface of silica gel probably forms a reaction field where reagents and substances were accumulated by absorption and binds the reactants in close proximity for the reaction to occur.

Vanillin from lignin/ferulic acid

Vanillin is currently manufactured from guaiacol, a petroleum based chemical. Preparation of guaiacol is carried out from phenol in two steps. Phenol itself is prepared from benzene, a carcinogen. Guaiacol is converted to vanillin in more than one step. Another method is vanillin from cellulose industry waste lignins. But due to improved method of pulping and stringent conditions imposed in pulp industry very little lignin is available for this purpose. Also, such lignins are used as fuel in cellulose industry itself. Therefore, there is need to prepare vanillin the most used food additive from a renewable source. During the period preliminary work was carried out to prepare vanillin using hydrogen peroxide as the oxidizing agent from ferulic acid, a renewable compound from agro-waste such as bran of rice, wheat, maize, beet, etc. Ferulic acid is the model compound of lignin which served as the raw material for vanillin. Vanillin formed was in low yield. But the result had significance in the sense that this was the first attempt to convert lignin to value-added aromatic aldehydes using a Green oxidizing agent the hydrogen peroxide. Further work was in progress.

Cleavage of phytosterol side chain

Phytosterols are important raw materials for a range of steroid compounds. However, they become attractive when their side-chains are cleaved. Microbial and not chemical methods are suitable for the cleaving. Cholesterol has been taken as a model compound to study the microbial cleavages of phytosterols such as stigmasterol and β -sitosterol. (a) Microbes and chemical methods are applied to cleave the side chain of cholesterol and stigmasterol, a phytosterol. One strain of each of *Arthrobacter*, *Curvularia* and *Microbacterium* and seven other strains were tested against cholesterol, but only the *Arthrobacter* was found to be effective in complete degradation of the substrate. But the desired products AD/ADD were not formed. (b) In developing Green Chemistry, method for phytosterol side-chain degradation work was continued. The problem faced in the work was the rapid oxidation of the 5,6 double bond of phytosterols. So far no report was available on this work. However, $\text{CoCl}_2\text{-H}_2\text{O}_2$ produced 7-keto cholesterol as the major product. FeCl_3 -*t*-butyl hydroperoxide converted stigmasterol to 7-keto stigmasterol as the reaction product. Therefore, retention of the 5, 6-double bond was successfully done in oxidation of phytosterols using hydroperoxides.

Direct synthesis of novel pyrimido (4,5-c) pyrimidine derivatives

An electron rich substrate 6-((dimethylamino) methylene)amino uracil undergo (4+2) cycloaddition reactions with various heterocumulenes viz arylisocyanates and arylisothiocyanates to give novel pyrimido(4,5-d)pyrimidines after elimination of 1,3-dimethylamine from the cycloadducts and oxidative aromatisation. This procedure provides a convenient method for direct synthesis of pyrimido (4,5-d)pyrimidine derivatives under thermal conditions. These results also illustrated that the novel pyrimido derivatives, as synthesized, are useful substrates for the generation of an array of fused nitrogen heterocycles.

Synthesis of Biologically active 4H-Benzo (b)pyrans

4H-Benzo(b)pyrans are an important class of compounds that possess a wide range of biological activities such as anti-coagulant, anti-cancer, spasmolytic, diuretic, anti-ancaphylactia, etc. A highly expedient method for the synthesis of 4H-Benzo(b) pyrans via a three component cyclocondensation reaction under microwave irradiation using simple and inexpensive sodium bromide as catalyst in solvent free conditions was evolved.

Bioactive Molecules Project

From the five lists of plants supplied to RRL Jorhat by the Apex committee under the CSIR Coordinated programme on Bioactive molecules from the plant sources, different parts of 23 individual plants namely leaves, barks, fruit, seed, whole plant, root, etc. were separately taken-up for extraction. Each part of the plants were extracted with 3 different solvents namely EtOH, EtOH : Water, and Water. Each extracts were dried under vacuum below 50°C and a total of 74 dried extracts were sent for bioevaluation to different identified laboratories. One sample of each of the extracts was sent to CLRI for storing as a reference sample.

The following activities were found for a number of plant extracts: anti-dementia (12), anti Parkinson's (6), anti-anxiety (7), and anti-ulcer (3).

Friedel-Crafts benzylation of benzene using Zn and Cd ions exchanged clay composites

Metal ion exchanged clay composites such as MII-Mont and MII-Mont(AT) where M = Zn and Cd; Mont = Montmorillonite Clay of the types Mont1 (SWy-2) and Mont2 (Neelkanth); AT = acid treated; were synthesized, characterized and evaluated as catalysts for Friedel-Crafts reaction particularly for benzylation of benzene. XRD study revealed that, in general, the basal spacing (d_{001}) increases as the interlayer cations of Na-Mont or H⁺-Mont were exchanged with Zn²⁺ or Cd²⁺ ions and interlamellar spacings were maintained in the range 3.9-5.3 Å and 4.3-6.0 Å respectively at room temperature. The basal spacing (d_{001}) of Mont1 supported composites were higher than Mont2 and therefore substantiate the advantage of the former over the latter in preparing metal ion-exchanged clay composites useful as solid acid catalysts. During the initial benzylation reactions, Cd²⁺-exchanged composites, in general, showed higher activity but in the long run Zn²⁺-exchanged clays exhibited higher catalytic activities. In general, acid treated metal ion exchanged clay composites exhibited higher catalytic activity than non-acid treated ones because the former showed higher surface area as well as higher acid sites.

The study gave some knowledge about the mechanism and reactivity of solid acid catalysts (montmorillonite clay based composites) relating to Friedel-Crafts alkylation reactions.

Preferential solvation of ions in a solvent mixture.

Electrical conductivity, speed of sound, viscosity, and FT-Raman spectra of potassium thiocyanate solutions in 5% and 10% methanol-water (w/w) mixtures were measured as functions of concentration and temperature. The conductivity and the structural relaxation time suggest the ion-solvent and solvent-separated ion-ion associations as the salt concentration increases in the mixtures. The Raman band shifting due to C-O stretching mode of methanol for the solvent mixtures revealed the formation of methanol-water complexes. The significant changes in Raman bands for the C-N, C-S, and O-H stretching modes indicated the presence of SCN⁻-solvent interaction through N-end, "free" SCN⁻ and solvent-separated ion pairs as the potassium thiocyanate was added in the methanol-water mixtures. The relative changes corresponding to H-O-H bending and C-O stretching frequencies indicated that K⁺ is preferentially solvated by water in these solvent mixtures. The appearance and increase of intensity of a broad band at 940 cm⁻¹, upon salt addition, was attributed to the SCN⁻-H₂O-K⁺ solvent-separated ion pairs. No Raman spectral evidence for K⁺(H₂O)_n species was observed. The preferential solvation of K⁺ and SCN⁻ in the methanol-water mixtures was verified by the application of Kirkwood-Buff theory of solutions. This theory confirmed that K⁺ is strongly-preferentially solvated by water, whereas SCN⁻ is preferentially solvated by methanol component.

Adsorption of humate ion and allied organic anions on the surfaces of oxides of iron, alumina, silica and their mixtures

Kinetics of adsorption of benzoate and phthalate on α -alumina surfaces were performed at constant ionic strength, $I = 5 \times 10^{-4}$ mol dm⁻³ and pH 5 at 25, 30 and 40 °C. Kinetics showed that the rate of adsorption of phthalate was "2 times more than that of benzoate on α -alumina surfaces at 25 °C. The adsorption of benzoate and phthalate on α -alumina surfaces were carried out over a wide range of concentration of adsorbate at fixed ionic strength, $I = 5 \times 10^{-4}$ mol dm⁻³ and pH 5-10. The adsorption isotherms for both the systems were found to be Langmuir in type. The maximum adsorption density of phthalate was 1.1-5.1 times more than that of benzoate on same adsorbent under similar condition. This difference was attributed to the presences of adjacent -COOH group in phthalate. The activation energy for both the system was calculated using Arrhenius equation. The other thermodynamics parameters like Gibbs free energy, enthalpy and entropy were also calculated. The surface complexations of benzoate and phthalate on α -alumina surfaces were investigated using the Fourier transform infrared (FTIR) spectroscopy. Benzoate form binuclear bridging complex with α -alumina surfaces at pH 5 and 6 depending on the splitting of the asymmetric and symmetric bands and their difference. But phthalate formed outer and inner sphere surface complexes depending on the pH of the medium.

Synthesis of absolute stereochemistry and molecular design of the new antifungal and antibacterial antibiotic produced by *Streptomyces* sp. 201

The absolute stereochemistry of 2-methyl heptyl isonicotinate, the new antifungal and antibacterial antibiotic produced by *Streptomyces* sp.201 was established by achieving its total synthesis. For SAR study a series of analogues were synthesized by changing the length of the side-chain and their bioactivity were assessed against different microbial strains.

Highly efficient synthesis of C-13 side-chain of taxol using Shibasaki's asymmetric Henry reaction

Taxol, an antimicrotubule agent isolated from *Taxus brevifolia* has attracted much attention in recent years because of its efficacy in the treatment of various types of cancer. The most attractive way of obtaining taxol at present is its partial synthesis from 10-DAB III, a diterpene analogous to taxol but devoid of the C-13 side-chain, which co-occurs with taxol in fairly high yield (1 g/kg) in the leaves of the European yew (*Taxus baccata*). Thus, by synthesizing the C-13 side-chain and linking it to 10-DAB III, taxol can be synthesized. Significantly improved preparation of the taxol side-chain that was not only considerably shorter and higher in yield, but also experimentally much simpler involving Shibasaki's asymmetric Henry reaction as the key step was reported.

A short asymmetric total synthesis of (-)-chloramphenicol using a selectively protected 1, 2-diol

Nitrite ester was projected as new alcohol protecting group by synthesizing selectively protected 1, 2-diol from epoxides. Stability of this new protecting group under variety of reaction conditions was studied. A general route for the synthesis of antibiotics like chloramphenicol, thiamphenicol fluoramphenicol or their modified analogues was developed using this strategy. Efficiency of this strategy was established by achieving a short asymmetric total synthesis of widely used broad-spectrum antibiotic (-)-chloramphenicol

Iodine Catalyzed Conversion of β -Dicarbonyl Compounds into β -enaminones within a Minute under Solvent Free Condition.

β -enaminones are versatile intermediates for the synthesis of many bioactive molecules with a heterocyclic unit. Their basic structural units $\text{RNH-C}=\text{C-Z}$ ($\text{Z} = -\text{COCH}_3$ or $-\text{COOC}_2\text{H}_5$) are responsible for the synthesis of many therapeutic agents from both natural and synthetic sources including taxol, anticonvulsivant anti-inflammatory, and duocarmycin class of antitumour agents as well as quinoline antibacterials and quinoline antimalerials. Synthesis of β -enaminones from β -dicarbonyl compounds was achieved in high yields within a minute using primary and aromatic amines and catalytic amounts of iodine under solvent free conditions at room temperature.

A New method for the synthesis of 4-Substituted 3, 4-dihydropyrimidin-2(1H)-ones

Compounds of the type 4-Substituted 3, 4-dihydropyrimidin-2(1H)-ones are of much interest these days due to their wide range of biological activities. They have a pharmacological profile similar to that of classical dihydropyridine based calcium channel modulators and many other biological activities. In continuation of the on going interest in the use of cheap and commercially available catalysts along with microwave irradiation for important organic transformations, Biginelli condensation was looked into for synthesizing 4-Substituted 3, 4-dihydropyrimidin-2(1H)-ones. Condensation of an aldehyde, ethyl acetoacetate and urea or thiourea under microwave irradiation in presence of 10% iodine adsorbed on neutral alumina gave substituted 3,4-dihydropyrimidin-2 (1H)-ones in excellent yields.

A new methodology for the synthesis of galactosylated serine

Glycopeptides or glycoproteins are wonder molecules in biological systems. Glycopeptides or glycoproteins have ability to transmit wide range of sophisticated information. In addition to their critical role in communication events, glycosylated protein have greater resistance to thermolysis and proteolysis. Glycosylated enzymes shows greater stabilities to temperatures and organic solvents. Glycosylation allowed proper folding of proteins. Glycoprotein in deep-sea fish allows them to survive against temperature as low as -20°C inhibiting ice nucleation and crystal growth. Glycosylated

protein were used for targeted drug delivery, gene deliveries, anti-adhesives against pathogenic bacteria, developed into bacterial capsular polysaccharide-protein conjugate vaccines, anti-cancer vaccines, enzyme replacement therapy and biosensors. For these wide spectrum of biological implications, glycopeptides/glycoproteins are continued to be the attractive centre of synthetic studies.

A new methodology for the synthesis of galactosylated serine was developed as depicted in scheme above.

First total synthesis of verbalactone, a macrocyclic dilactone isolated from *Verbascum undulatum*. The dilactone was synthesized efficiently for the first time in a stereoselective manner in 5.2% overall yield involving a Barbier-Grignard reaction, a Sharpless asymmetric dihydroxylation, monotosylation, epoxidation, ring opening of the epoxide, hydrolysis and lactonization. A d-lactone, (+)-(3R, 5R)-3-hydroxy-5-decanolide was also formed along with the dimeric lactone.

Verbalactone is a macrocyclic dilactone isolated from the roots of *Verbascum undulatum* Lam., a biennial plant of the genus *Verbascum* that belongs to the family Scrophulariaceae. This molecule showed activity against three Gram-positive bacteria with MIC=62.5 mg/ml and five Gram-negative bacteria with MIC=125 mg/ml and was found to exhibit interesting antibacterial properties. This macrocyclic lactone is a symmetrical dimer of the lactone, a d-lactone, (+)-(3R, 5R)-3-hydroxy-5-decanolide and which is a potent inhibitor of the enzyme HMG-CoA reductase inhibitor. It is the first example of a 1,7-dioxacyclododecane unit being present in the ring system of a natural product.

Highly regioselective ring opening of epoxides

Seven step synthesis of a cytokine modulator (-)-cytoxazone was achieved in 47% overall yield. The key feature was the highly regioselective epoxide opening with azide nucleophile promoted by molecular sieves. This molecule selectively inhibited the signalling pathway of Th 1 cells but not Th 2 cells. The molecule was recognized a formidable synthetic target.

Engineering Sciences

Development of enantio-selective membranes

Enantio-selective membranes prepared from condensation products of single amino acid isomer with glutaraldehyde embedded in polysulfone matrix were found to be feasible for resolution of racemic amino acid. The separation factor achieved was as high as 2.4. A quantitative structure-activity analysis was made to correlate separation selectivity and permeation rate with molecular structure in terms of hydrophobicity of amino acids as the parameter deducing implication for design of appropriate amino acid enantio-selective membranes. For resolution of racemic alcohols such as atenolol, propranolol etc. of pharmaceutical importance, cholesterol glutamate as the chiral selector was shown to be effective in a liquid membrane system where facilitated transported mechanism could be exploited to effect the resolution of racemic compounds of therapeutic value.

Engineering analysis of esterification and trans esterification reactions using cross-linked enzyme crystals (CLEC)

Lipase from *Mucov melhei* and *Pseudomonas cepacia* cross-linked with glutaraldehyde was successfully exploited to carry out stereo-selective trans esterification of 2-o-benzylglycerol with vinyl acetate to give 2-s- of benzyl glycerol acetate which is an important cardio-vascular drug intermediate. The enantio-selectivity achieved was as high as +95% enantiomeric excess of s-isomer. CLEC offers advantage of easy catalyst recovery and recycle. The same CLEC was shown to provide high conversion of esterification of lauryl alcohol giving lauryl laurate, an important plasticizer. Suitable kinetic models were developed for both the reaction and kinetic parameters determined through non-linear regression analysis.

Design of bioreactor for production of ginsenoside via plant cell suspension culture

Under a CSIR network programme, technology development work on production of ginsenoside - a terpenoid saponin and versatile multi-purpose drug, through plant cell culture using a stabilized cell line of American ginseng was initiated in collaboration with CIMAP, Lucknow. The attractive feature of the programme was development of specialized bioreactor and improved downstream processing techniques for achieving better techno-economic benefit of the process technology. The target for generation of total technology.

was fixed and collaboration with user industries planned. The possibility of exploiting membrane bioreactor for improved ginsenoside production by plant cell culture was examined through complimentary studies. The knowledge thus generated opened up avenue for new and efficient technology development particularly in the field of separation and purification technology to be applied in various fields such as drug and pharmaceuticals, waste water treatment, refining of vegetable oils, separation and purification of substances having antioxidant properties etc. The studies on membrane and lipase catalyzed reaction have led to generation of technological knowledge base for (i) racemic resolution of therapeutically important drug/drug intermediates, (ii) an environmentally benign process for a chiral drug intermediate of high therapeutical value and market demand. Stirred bioreactor (1 lit) and airlift bioreactor (3 lit) optimization studies were planned for immediate future work under the technology development protocol.

Development of manufacturing process for tea polyphenols

So far, no attempt to utilize leaves produced by small tea growers of Assam for production of tea polyphenols was reported. Therefore, the work had the potential for developing a manufacturing process for tea polyphenols from the said raw material which in turn will help reducing present crisis in the country. The development of a suitable process for tea polyphenols having good anti oxidant properties and high export market potential was in the advanced stage.

Biotransformation using enzyme

Cross-linked enzyme crystals of porcine pancreas lipase was prepared by the reaction of crude porcine pancreas lipase with glutaraldehyde and the cross-linked product was characterized by IR analysis. By using these enzyme crystals, kinetics of the esterification reaction between lauric acid and lauryl alcohol was studied. The product concentration was analysed by GLC and from % conversion versus time profile, initial rate was calculated and the mechanism of the reaction was found to follow Ping-pong-Bi-Bi mechanism. Similarly, kinetics of the esterification reaction between isoamyl alcohol and acetic acid was also studied. Cross-linked enzyme crystals of Pseudomonas cepacia lipase was also prepared in the same procedure. Effect of solvent on the synthesis of 2-phenethyl acetate by transesterification between 2-phenethyl alcohol and vinyl acetate catalyzed by CLEC Pseudomonas cepacia lipase was studied.

Control of high speed River bank erosion with particular reference to the rivers of Lower Himalayas in Arunachal Pradesh

Most of the hilly rivers possess high-speed flow of water body because of gradient. River banks are therefore unstable due to its erosion. Quite some time, such type of erosion threatens road section when it comes to the line of intersection of its alignment. Karshingsa is one such worst effected road section of National Highway NH-52(A) located in the Eastern Lower Himalayas. The NH-52(A) is the only suitable road communication media to the capital of Arunachal Pradesh, connecting the plains of Assam and the capital - Itanagar. Karshingsa area is curved by a wide river valley called Dikrong. The area comprises of some Hillocks, which are composed of some unique form of soil successions. Geologically this Karshingsa area is termed as Sinking Zone. Landslide of mostly rain fed occurs every year during June-July which is normally triggered by the toe erosion. A large scale and long duration landslide of continuous nature was occurred during 1998 which created havoc and loss of life and property and interrupted the surface communication

for a period of three months. As a remedial measure to prevent the toe erosion and subsequently the probable landslide, a very large scale Crated stone masonry was constructed during 2000-01 at toe of the hill flange bearing the road section. The study revealed the following :

(i) Crated masonry work built as per traditional thumb rule practice without foundation structure (i.e. barrier) in a high-speed river basin to control erosion directly as well as to protect the sererity of uphill landslide indirectly is the most temporary measure. So, Crated masonry without barrier foundation is a meaningless remedial measure to control bank erosion, adoption of which thus contribute loss money only.

(ii) To achieve a sustainable and meaningful economic protection measure against Bank erosion, Barrier Piles (as developed) must be installed beneath such Crated masonry in high-speed river, which also help in reduction of severity of landslide at its uphill location.

(iii) Fruitful design efforts have been achieved by developing complete set of formulae so required to control bank and bed erosion of any river effectively and permanently. The formulae are given in Effective Depth of Local Scour below perforated hydraulic structure :

n which, L_s = length of the hydraulic structure, W_s = Width of the hydraulic structure, P_{Soil} = Permeable value of the subsoil, P_s = Permeable value of the perforated hydraulic structure, which is to be assumed according to its void ratio after construction i.e. 35-45% of V_w . And V_w =maximum velocity of moving water body at central zone.

The practical problem faced at field is the determination of minimum length/depth of such perforated hydraulic substructure to retain its position permanently, which is not available till date. Because there is no exact method of design to determine length of such floating structure in the form of Pile in scouring zone to protect both bank and bed. Thus, the minimum length of substructure

In which, F = Factor of safety to be considered between 1.2-1.5

For example : Calculation reveals the minimum length of Barrier Pile foundation in a site condition with Silty-clay layer and Hard soil-Soft rock layer are $\min D_f = 3.64$ m and $\min D_f = 11.08$ m respectively.

This new development would bring a new era of construction to protect the river bank permanently, when it would come into force of massive implementation in any scoring river basin in the country and abroad. Initially, it was developed to protect the toe erosion which is generating landslide in a section of NH-52(A) at Karshingsa, Arunachal Pradesh. Of course, efforts are being made to implement in a river located in Assam.

Development of Utility Oriented Device/Equipments

(1) Automatic Pole Barricade

To stop the traffic both vehicular and pedestrian from entering into a restricted/protected area or for security check, manual pole barricade is generally used which is operated by using a rope attached to the pole barricade. To operate such type of pole barricade the operator has to be stationed personally near the barricade. The new device `Automatic Pole Barricade' as developed in the laboratory was motorized with remote control and accident safety attachments so that it could be placed in a strategic position of a security system.

(2) Bio-mass drier

The biomass drier has been developed for drying out food grains, pulses, vegetables, and also drying of processed wet materials like chinks, hand made paper etc. The advantages of this drier was (i) Efficient drying of food grains, pulses, vegetables, and also drying of processed wet materials like chinks, hand made paper, etc. (ii) Removal of moisture of the material being dried without damaging the important ingredients (iii) Retains valuable essential oil and micronutrient, vitamins of food products (iv) Homogeneous and uniform drying including process material which is required to be dried to obtain desired product (v) Utilization of agro-waste materials like husks, saw dust, dried tree leaves, tree barks, etc as energy source for the drier and (vi) cost effective simple agro-waste drier for versatile use. Use of Biomass drier in the present context had a great implication of averting pollution, saving energy and for generating employment avenues in rural areas.

(3) Dip coating equipment

This is an equipment for deposition of catalytically active materials, protective agents and other desired suspensions for coating on a solid surface. For deposition of catalytically active materials, protective agents and other desired suspensions for coating on a solid surface, utilization of dipping technique at different dipping programmes viz. speed of dipping, retention time, speed of withdrawal etc. has been universally carried out. For different devices with computer control systems are available which are very costly and require skilled manpower to operate. The developed equipment ensured a low cost device with simple attachments for application of coatings of different catalytically active materials, protective agents, etc. on a solid surface without skilled manpower. A computer-controlled version of dip coating equipment is commercially available in the market at a cost of Rs. 6 lakh. The device developed at the laboratory was simple motor driven and costwise very cheap. The fabricated dip coating equipment was in use for different laboratory study.

(4) Multipurpose Oil Expeller

The multipurpose oil expeller was developed for crushing, pressing and expelling out oil from smaller and bigger oil bearing seeds like mustard, sesam, nahar, etc. The advantages of this oil expeller were - (i) The device was robust, compact with minimum components (ii) Easy for maintenance and cleaning after each operation (iii) Handled any type and size of oil bearing seeds (iv) Easy in operation and handling without requiring special skill and (v) Temperature rise was maintained to desired level so as to maintain the quality of expelled oil.

Earth Sciences

Seismotectonic study of Chedrang valley and the Style of faulting associated with the 1897 Shillong Earthquake

The Chedrang valley, Garo Hills, Meghalaya is known as the rupture area of great Assam earthquake (M=8.5).

A detailed study has been carried out in the region based on digital seismic waveform by establishment of modern broadband seismograph and recent past seismic database. From the study on Seismotectonics of Chedrang fault and its vicinity it is observed that epicentres align along with Dudhnoi, Chedrang and Samin faults for the earth tremors of magnitude 1.0-4.0, 2.1-5.0 and 2.1-4.0 respectively. The micro-tremor activity is mainly associated with Chedrang, Dudhnoi and Samin faults at the depth 10-20 km and also indicate the gradual decrease of activity at depth intervals 20-30, 30-40 and 40-50 km. From the frequency distribution of depths, the bottom of the seismogenic zone is inferred to be at 30 km. Absence of seismic activity is observed in association with Dapsi reverse and Dauki faults. The activity is significantly less in south of Brahmaputra valley bordering Meghalaya. The seismic activity is highest in the depth interval 10-20 km compared to other depths. P-axis orientation of all the events inferred from waveform modeling, including thrust and strike slip type solutions are predominantly north northwesterly directed. The presence of thrust solution exclusively in 0 - 30 km depth range with P-axis oriented NNW indicates the prevailing stresses in the region. An interpretation has been made towards the style of faulting and palaeoseismicity associated with the 1897 Great Assam Earthquake and its implication for region tectonism incorporating

geophysical and geological data. The palaeoseismic data suggest a 1200-year interval between 1897 event and its predecessor and it is identified that northern boundary fault as a major seismic source.

The study will provide an opportunity for development of algorithms for computation of earthquake ground motion parameters and data wherever available would be appropriately scaled to produce designed ground motion parameters as function of magnitude and hypocentral distances. The results obtained form a basis for evaluation of potential for surface-fault rupture assessment of maximum earthquake magnitudes towards probabilistic seismic hazard and risk analysis.

The research activities planned pertains to study of the source characterization of the earthquakes, originating from North Eastern Region of India, through determination of focal mechanism solutions by waveform inversion, based on amplitude spectra of broadband record by calculating Green's function for a trial depth by discrete window method. Begin to develop and validate numerical algorithms for simulating 3D earthquake source including dynamical model. Determination of source parameters and fault geometry e.g. stress drop, rupture area, rupture length, source dislocation, seismic moment and the principal stress direction with an aim to development of attenuation models to explain waveform data with simultaneous investigation of horizontal and vertical attenuation/distance relations under several different earthquake scenarios. To understand better and explain the physical mechanism of tectonics and occurrence of earthquake in North Eastern region of India, the measurement and interpretation of elastic wave attenuation within the interior of the earth is an important study in earthquake seismology, as it directly relates to the effect of source path and receiver. The study of coda waves represents the homogeneities in the medium and provides the information about the average attenuation properties of the medium. The coda wave amplitude on a seismogram are explained by two backscattering model. The first is the single scattering model, which assumes that the scattering wave field is weak and does not produce secondary scattering when it encounters another scatterer. In this study, the attenuation of coda waves are measured as a function of frequency using the data from local earthquakes with the help of single scattering model.

Attenuation of Coda wave in North Eastern Region of India

To understand better and explain the physical mechanism of tectonics and occurrence of earthquake in N E region of India, the measurement and interpretation of elastic wave attenuation within the interior of the earth is an important study in earthquake seismology as it directly relates the effect of source path and receiver. Several studies have already been made on different aspects but less study has been made on seismic attenuation in the region. Therefore study of coda waves represents the homogeneities in the medium and provides the information about the average attenuation properties of the medium. Site specific average attenuation pattern is particular is one of the prime input to the goals of engineering seismology in connection with the response of each soil type with the known fact that younger softer soils amplify ground motion relative to older more competent soils or bedrock. The result has the useful application in seismic source-path characterization. The attenuation model estimates the higher and lower attenuation structure of the region in particular. This information will then form the basic information in designing the optimum criteria for construction of heavy civil engineering structures of importance. Further, it is also useful for obtaining better understanding of seismotectonic of the region and earthquake hazard estimation.

Study of complex geological structure and source modeling of N E India

Under an Indo-Russian collaborative programme, the study was undertaken. The study aimed at characterization of earthquake source and determination of velocity structure. The study facilitated source characterization, assessment of seismotectonics of the region under different magnitude-depth scenario of the earthquakes which are expected to be of direct utility to the seismic hazard estimations. The processing and analysis of broadband digital seismogram paved a way for new understanding of the seismicity and seismotectonics to delineate seismic source zone, characterization of seismic sources for hazard assessment.

Source zone characteristics and site amplification behaviours in seismic microzonation

The North Eastern region of India is considered to be seismically one of the most active regions of the world. It is very unfortunate that the region has a scanty history of the past earthquakes which is hardly sufficient for future hazard estimations. On the other hand, the population of the region is fast increasing thereby accentuating the need for rapidly increased irrigation, power generation and industrialization through utilization of natural resources. At present the region is economically most important due to the growing national demands for coal, petroleum/petroleum industries and hydroelectric power generation, etc. However, the vast natural resources of the region are located in the areas where there is marked susceptibility of earthquake and landslides. Therefore, all our development activities in the years to come should be thoroughly assessed for evaluating the increasing risk posed by earthquakes.

The destructive earthquakes that the country witnessed recently had significantly demonstrated enormous damages and loss of life in specific areas due to site dependent factors like soil condition and engineering design, etc. A phenomenal increase in human population and rapid urbanization has been observed in most cities including the state capitals of the NE India. The risk to the population concentration is further compounded by the degradation of the physical environment caused by inappropriate activities of man. In such a situation, the variation in local soil parameters and seismic environment demands detail scientific investigation. Therefore, assessing the earthquake probabilities along major tectonic lineaments, characterizing the earthquake source zones, effects of local geology on seismic ground motion in terms of site amplification are of vital need for quantification of earthquake hazards. The seismically active tectonic lineaments covering a 300 km radius of greater Guwahati were identified using RRL-J local seismic network data for the period 1982-2003. The seismogenic behaviours and earthquake probabilities of the major tectonic lineaments were investigated and plotted on a map using GIS software. Further, the local site conditions of greater Guwahati were studied for 175 locations (March 2003 to September 2004) for preparing site amplification contour map in collaboration with other participating institutes. To carry out similar investigation for other state capitals of NE India as practical measure of seismic microzonation for thickly populated urban localities in the region.

Environmental Sciences

Wealth from Waste: Building Bricks from Oil Field Effluent Treatment Plant Sludge

A process for preparing common masonry bricks utilizing petroleum oil field Effluent Treatment Plant (ETP) sludge was developed. The process was utilized in brick production in commercial brickfields near Lakwa, Dist. Sivasagar, Assam. Using sludge from the ETP of Lakwa oil field. The field is the largest oil bearing structure of ONGCL in North East India and generates about 12 m³ sludge per day. The sludge often contains 7-10 % hydrocarbon (very high in comparison to the permissible limit of 3% for safe disposal by land filling) and is environmentally hazardous. The sludge contains various other trace elements also.

Bricks prepared by replacing about 30 % of the raw materials by the sludge conformed to the Indian standard specification for common burnt clay building bricks. In the process, the water in the sludge served as the process water, the hydrocarbons burnt and provided partial fuel requirement and the inorganic materials were fixed as constituents of the bricks. The Toxicity Control Leaching Protocol (TCLP) tests showed that the bricks met the Environmental Protection Agency (EPA) requirement for trace metal leaching. Standard size bricks prepared using the sludge and firing in a commercial coal fired kiln showed high compressive strength and low water absorption capacity. The advantages of using the sludge in brick making are therefore (1) Elimination of the environmental problem associated with disposal of the hazardous hydrocarbon bearing sludge (2) Led to saving of about 30 % fuel and time requirement (3) No process water was required. (4) Reduced the environmental pollution caused by coal burning in brick manufacturing North East India is situated in Indo-Burma Mega Bio-diversity Hot Zone. Development of the process for utilizing environmentally hazardous oil field ETP sludge in brick making would contribute to the environmental protection of the sensitive region. The process would also provide

economic benefits to the brick kiln owners in terms of saving of fuel cost, time requirement and consequently increased production capacity. The work was carried out with grant-in-aid from Ministry of Environment & Forests, Govt. of India, New Delhi and with active participation from Pollution Control Board, Assam, ONGCL, Nazira, Assam and Brick Kiln Owners.

Novel hydrotalcite based ceramic monolith for decomposition of environmentally harmful N₂O gas

Under the project an approach was made for coating reactive oxides derived from Hydrotalcites over ceramic honeycomb type monoliths, which not only provided uniform heat and pressure gradient but also a very high activity due to the supporting of the reactive oxide particles over certain alumino-silicate matrix formed in situ by additional components present in the coating composite. The novelty in the present approach for controlling toxic N₂O gas by coated monoliths lied on the unique property of Hydrotalcites of possessing an anionic crystalline charge over their layers. At 500°C temperature and a space velocity of 5 hr⁻¹ over 70% decomposition of N₂O from a flow of about 1000 ppm in Helium to environmentally acceptable N₂ and O₂ was obtained. N₂O is a so-called 'green house gas' and in all the world over there is an urgent need for controlling such gases. According to 'Kyoto protocol' those developing countries who promotes industrialization with reduced emission of such green house gases would register "Carbon Credits" for such efforts. Apart from the use of N₂O in this technique, there is the prospect of fabricating more so called 'end-of-the pipe' decomposition catalysts/adsorbents for other toxic gases like NO, NO₂, CH₄ etc. or H₂S, SO₂ etc. The project was funded by Ministry of Environment and Forests, Govt. of India, New Delhi.

Membrane based oily waste water treatment for waste water ex ONGC drill sites specific to the NE Region

A membrane based process was developed using oily waste water ex ONGC drill sites of Borhola oil fields. As the oily waste water is released for surface disposal, the pollution problem becomes enormous. The method offered scope for tackling the problem economically and effectively with elimination of the use of chemicals. The process developed at RRL was based on indigenously fabricated membrane module of spiral type and was specific to the oily waste water generated in oil production site of N E Region ONGCL fields. Oil removal over 95% by permeation through micro porous hydrophilic membrane could be achieved at relatively low capital and operating cost using modular packaged units in a cascade system. Based on the results of the investigation, it was proposed to take up a collaborative project with ONGCL for process scale-up and design studies towards implementation of the process technology. Accordingly, linkage was established with corporate office of ONGCL at New Delhi for pursuing the programme. ONGC is the user for the oily waste water treatment method developed by the laboratory and the beneficiaries will be the common people, particularly in the nearby areas of the oil fields of some specific regions of the NE region of India.

Material Sciences

Synthesis of novel rhodium (I) and ruthenium (II) carbonyl complexes of P-O, P-S and P-Se donor ligands and their applications as catalysts

(a) Rhodium(I) carbonyl complexes (Rh(CO)₂ClL)(1) where L = Py-2-CHO(a), Py-3-CHO(b) and Py-4-CHO(c) were synthesized and characterized by elemental analyses, IR, ¹H and ¹³C NMR spectroscopy. The complexes 1 underwent oxidative addition reactions with different types of electrophiles such as CH₃I, C₂H₅I, C₆H₅CH₂Cl and I₂ to yield (Rh(CO)(COCH₃)ClL)(2), (Rh(CO)(COC₂H₅)ClL)(3), (Rh(CO)(CO-CH₂C₆H₅)Cl₂L)(4) and (Rh(CO)Cl₂L)(5) complexes respectively. The kinetic study of the complexes 1 with CH₃I revealed a two stage kinetics and the second stage reactions were faster than

that of the first stage by about 80-100 times. The rate of reaction of 1a was higher than that of 1b and 1c. The catalytic activity of complexes 1 in carbonylation of methanol, in general, was higher (TON 800-1250) than that of the well known species $(\text{Rh}(\text{CO})_2\text{I}_2)^-$ (TON 650).

The study gave some knowledge about the mechanism and reactivity of rhodium(I) carbonyl complexes related to catalytic carbonylation of methanol and other for preparing value added products.

(b) The reactions of polymeric complex $(\text{Ru}(\text{CO})_2\text{Cl}_2)_n$ with triphenyl-phosphinechalcogenides ligands Ph_3PX ; X=O(a), S(b), Se(c) in 1:1 molar ratio form five coordinated complexes of the types $(\text{Ru}(\text{CO})_2\text{Cl}_2(\text{Ph}_3\text{PX}))$ (1a-c) while 1:2 molar ratio produces six coordinated $(\text{Ru}(\text{CO})_2\text{Cl}_2(\text{Ph}_3\text{PX})_2)$ (2a-c) complexes. The complexes 1a-c and 2a-c exhibited two equally intense $\nu(\text{CO})$ bands in the range 2059-1989 cm^{-1} and 2050-1980 cm^{-1} respectively indicating cis-disposition of the two terminal carbonyl groups. The values of $\nu(\text{CO})$ frequencies irrespective of the complexes, in general, followed the order $\text{Ph}_3\text{PO} > \text{Ph}_3\text{PS} > \text{Ph}_3\text{Pse}$ which may be ascribed in terms of "Soft-Hard" (Ru(II)-O) and "Soft-Soft" (Ru(II)-S/Se interactions). The $\nu(\text{PX})$ bands of the complexes observed in the range

and their difference. But phthalate formed outer and inner sphere surface complexes depending on the pH of the medium.

Characterization of limestone resources of NE Region for value addition and rational utilization.

The physico-chemical characterization of Umrangshu limestone was completed and those from Lumshnong, Jayantia hill (Meghalaya) is in progress. Umrangshu limestone was highly fossiliferous, dominated by Nummulite fossils. The compressive strength (hardness) of the rock lies in the region "222 - 272 kgf/cm^2 ". The limestone contains predominantly calcite and small to trace amount of clay minerals and pyrite. The chemical compositions from different sites of the deposit did not differ much. The Limestone contained around 52% or more CaO. The optimum temperature for calcinations of the limestone was worked out.

Alkali activated blended cements: Mechanical strength, Pore solution composite, and Zeolite formation

Lime reactivity of meta-kaolin in presence of alkali (0.01-0.07N NaOH) was determined at "550C". Strength of the mortar cubes increased with alkali concentration and lied between 112 - 162 kg/cm^2 . The hydration products exhibited reversible dehydration and cation exchange characteristics.

Evaluation of shape composition of silt particles collected from Tanga and Bicham dam of NEEPCO, Kameng Hydro Electric Project

Under the project the petro-fabric composition of four samples of river silt from four locations of Tanga and Bicham dam site of NEEPCO, KaHEP, Bhalukpong, Arunachal Pradesh were evaluated. The particle size distribution, clay, silt and sand contents of the samples, the composition of the samples as per shape etc. were determined. The project was completed and final report submitted. The party will utilize the results of the investigation for designing the turbine blades for the hydroelectric project.

Development of thermally stable cross-linked polymer as water shut off agent for oil recovery

Anionic cross-linked polymers of acrylamide is frequently used as water shut off agent in the oil recovery processes. But this polymer degrades at high temperature in presence of multivalent brine. Work carried out to develop high temperature stable cross-linked polymer for the same. It was observed that cross-linked polymer of N, N-dimethyl acrylamide- sodium salt of acrylamido methyl propane obtained by using inorganic cross-linker, Cr-acetate is

a thermally stable (>1200C) brine compatible. The cross-linking behaviour of the copolymer was studied using organic cross-linker, hexamethylene tetramine (Hexamine) -hydroquinon at 90-95⁰C. Variation of cross-linking parameters such as effect of concentrations of the polymer, effect of concentration of cross-linker, effect of the presence of mono or bivalent brine at different pH and temperature on gelation time were studied to achieve the appropriate gel-time. It was observed that the gel polymer is stable in presence of brine even at 100⁰C. Further work is continued.

In order to study the depositional tendency and the origin of crude oil, asphaltenes and kerogens from a near by source were pyrolysed. The pyrolysed products were analysed by GC/MS. It revealed that asphaltenes and the crude oil originates from the same source, kerogens. Waxes were separated at different temperatures by solvent extraction method and characterized by GC and DSC.

Study on Fractionation of High Waxy Distillate (obtained from vacuum distillation unit) using short path distillation for the Production of Different Grades of Waxes

HWD feedstock was distilled by applying SPD Unit using Evaporated temperatures in the range 190-230 ⁰C, pressure 0.001 mbar and flow rate 0.9-1.6 L/h. Altogether 24 fractions were obtained by varying the evaporated temp. and flow rates. It was observed that (i) Distillates fractions were free from asphaltenes (<200 ppm) (ii) Maximum yield was 76%, distilled at 230⁰C using 1.2 L/h and 0.001 mbar pressure. The work, carried out in collaboration with IOCL, AOD, Digboi, was completed and the final report was submitted to the party.

LaCl₃.7H₂O Promoted Regioselective Ring Opening of Epoxides Using NaNO₂ in Ether-Water System: A Facile Synthesis of 2-Nitro-alcohols

Epoxides are very useful building blocks in organic synthesis due to the high reactivity of their three-member ring. The availability of some epoxides in optically active form has enhanced their use as synthetic intermediates; a reaction sequence allowing an impressive access to a large variety of compounds in optically active form. Due to ambient character of the NO²⁻ nucleophile, still it is difficult to open epoxides with NO²⁻ nucleophile to produce only the 2-nitroalcohols and avoid formation of the corresponding β-hydroxy nitrite esters. A convenient and efficient synthesis of 2-nitroalcohols was achieved by ring opening of epoxides using LaCl₃.7H₂O and NaNO₂ in ether: H₂O system at room temperature. The reaction afforded the corresponding products in good to excellent yields under mild conditions.

Montmorillonite K-10 Clay as an Efficient Solid Catalyst for Chemo selective Protection of Carbonyl Compounds as Oxathiolanes with 2-Mercaptoethanol

The protection-deprotection sequence is probably the most recurrent functional group interconversion in multistep organic synthesis. Amongst the numerous protecting groups employed to protect aldehydes and ketones from nucleophilic attack, 1, 3-oxathioacetals have long been used as a protective group and an acyl anion equivalent in C-C bond forming reactions. Moreover, the use of oxathiolanes is much more convenient than the corresponding O, O-acetals or S, S-acetals because they are comparatively more stable than O, O-acetals under acidic conditions and easier to remove than the corresponding S, S-acetals. Montmorillonite K-10 clay was found to be a mild and efficient solid catalyst for the protection of a variety of carbonyl compounds as oxathiolanes with 2-mercapto-ethanol in good to excellent yields. In addition, by using this catalyst, high chemoselective protection of aldehydes in presence of ketones was achieved.

Formation of Heavy Oil-in-Water Emulsion for Pipeline Transportation

The diverse factors affective the viscosity of surfactant stabilized Panidihing crude oil (of ONGCL) emulsion for pipeline transportation as oil-in-water emulsion was studied. The influence of concentration of surfactant/surfactant combinations, the oil content of the emulsion, the salinity of water and the speed of mixing on both stability and viscosity of the emulsion were investigated in details. Hydrophilic/hydrophobic emulsifier combinations were used in the preparation of phase inversion. Phase inversion occurred at a well defined amount of hydrophilic emulsifier. Asphaltene was found to play an important role in the stabilization of emulsion.

Kinetic Study of the Atom Transfer Radical Polymerization of n-Docosyl acrylate

The atom transfer radical polymerization (ATRP) of n-docosyl acrylate (DA) was studied at 80°C in N, N-dimethylformamide (DMF) using the carbon tetrabromide/FeCl₃/2, 2'-bipyridine (bpy) initiator system in the presence of 2,2'-azobisisobutyronitrile (AIBN) as the source of reducing agent. The rate of polymerization exhibited first-order kinetics with respect to monomer. The linear relationship between molecular weight of the resulting poly(n-docosyl acrylate) with conversion and narrow polydispersity of polymers indicated the living characteristics of polymerization reaction. The significant effect of AIBN on the ATRP of DA was studied keeping (FeCl₃)/(bpy) constant. A probable reaction mechanism for the polymerization system was postulated to explain the observed results.

Atom transfer radical polymerization of (meth)acrylate monomers is a developing field and at present extensive work is being carried out in this area as this method of polymerization yields well defined and narrow molecular distribution polymers.

Acid Mine Drainage from Northeastern Coal fields : its assessment and management

The problem of AMD has been widely felt by the coal mining industries of North Eastern region of India. A substantial deposit of high sulphur sub-bituminous coals, mostly of tertiary origin exists in North East India. These coals are of high organic sulphur content (75-90%) with less of pyritic content. But the formation of acidic drainage in the coalmines is very much pronounced. In order to understand the mechanism of AMD formation in these mines, and co-relate with that of naturally occurring AMD samples from mine sites, simulation study by aqueous leaching has been taken up. This type of leaching study had not been adequately carried out so far for the high sulphur coals of N E India. In order to study the mechanism of pyrite oxidation and consequences thereof, a study based on the aqueous leaching of the coals from collieries, Makum Coalfields under NECL, Margherita was carried out. The laboratory studies showed the formation of highly acidic water with low pH and its relationship with conductivity, TDS, and sulphate ions. The study also confirmed acid generating potential of the coal samples from the active and abandoned mines, possible build-up of heavy metal contamination in surface and ground water systems. The physico-chemical characteristics of the mine water samples discharged with seasonal variations to the nearby river systems were evaluated. The characteristics of soil, effluent water samples and sediments from the point and non-point sources showed similarities with those of simulated acidic drainage from coals and mine rejects. The processes were developed in the laboratory and scaled up levels to manage the acidic drainage, simulated from high sulphur weathered coals and coal fines. The study would generate knowledge about the genesis of the problem Acid Mine Drainage in the coalfields of N E region, its mechanism of formation, effects on the environment and its management.

Gainful Utilization of high sulphur coals

North Eastern Region of India is having a deposit of high sulfur coal in the order of about 900 MT, widely distributed in the states of Assam, Nagaland, Meghalaya and Arunachal Pradesh. These coals belong to the tertiary age. These coals don't find gainful utilization industrially because of their inherent sulphur contents. The mining has also not been extensive because of difficult geo-mining conditions. The physiochemical attributes of these coals differ

with other Indian coals in caking properties, low ash and high sulfur and volatile matter contents. Because of stringent environmental regulations, these coals cannot be utilized as such. Although physico-chemical characterization and resource quality assessment of N E coals have been reported, a systematic detailed study is required to be done for the coals of this region. The detailed investigation on geo-chemistry, nature, mode of occurrence and distribution of trace elements have not been adequately done so far. Research on mineral matter and trace element distribution of N E coals has been very scantily done, particularly with respect to the relationship between distribution patterns and the geological context (age, sedimentology etc of N E coal fields). With the primary objective of studying such relationship and to build up a database on mineral matter and trace elements in N E coals, a systematic study for resource quality assessment & characterization would be taken up. Therefore this study was of special significance for contemplating the usage of high sulphur coals of the region. The study gave us the avenues for gainful utilization of N E coals industrially as well as in the domestic sectors. Detailed characterization of the elements harmful environmentally would open up avenues for utilization. Another aspect was tried for optimum production of cokes in non-recovery type of carbonization with sole heating systems.

Demineralization of Assam coal

Demineralization of coal from different size fractions under laboratory condition Makum Coal Field, Assam was standardised and showed that over 50 % mineral matters could be removed by using water alone as well as by using additive. Further jigging experiments in semi-plant scale using water and additive were initiated.

Petrographic study of coal from North East India

Coal is made up of heterogeneous materials consisting of macromolecules of high molecular weight. Its composition varies with places of occurrence and its structure changes with its matrix. The basic chemical structure of coal that has been widely accepted today was built up from synthesis of X-ray diffraction, infrared, mass spectrometry and nuclear magnetic resonance studies.

For a sufficiently large and strain free crystallites in polycrystalline specimen, diffraction theory predicts that the lines of the powder pattern will be exceedingly sharp. The difference and abnormally weak lines can be explained by a spectra in which layers stacked in hexagonal close packing alternate in a random manner with layer stacked in cubic close packing. On the other hand two dimensional lattice lines are characterized by terminating sharply on the low angle sides but falling off gradually in intensity on the high-angle sides. Such reflections are produced by two-dimensional lattice i.e. random layer lattices. A broad intense scattering peak with a d_1 - value from 4 to 5 Å, which has been indexed as the "gamma band". It can be mentioned that the origin of the peak has not yet been successfully explained. It may be due to a packing effect of aliphatic side chains to alicyclic structure with parallel stacking. It is also indicative of a short-range order of aromatic lamellae, which has been disturbed by side group. Crystalline dimensions along the C-axis (LC) and in the layer sheet direction (LA), the average number of carbon atoms (N) per aromatic lamellae, packing of the aromatic lamellae and the gamma bands of coal from North East India (i.e. Lakhapani Area of Assam) were studied using X-ray diffraction technique. Random layered structure values for mean lamellae diameter (LA) and crystalline size dimension (LC) was found to be 22.33 and 8.4 Å respectively. The average number of atoms and number of layers determined by X-ray method was found to be 23 and 2 respectively. The position of g -band was found to be 4.18 Å. Further works under this field was in progress.

Utilization of Bast Fibres obtained from wild and cultivated non-conventional plants available in the North Eastern region for producing cordages and textile yarns

The fibres extracted from outer bark portion of certain plants are called **bast fibres**. These fibres have sufficient strength and useful for producing ropes, twines, threads and yarns useful for making fabrics. Certain wild and cultivated species of plants were identified in this region producing good quality of bast fibres. *Hibiscus asculentus* (Bhindi), *Hibiscus cannabinus* (Kenaf), *H. sabdariffa* (Tengamora), *Crotalaria juncea* (Seenn hemp), *H. abelmoschus*, *Boehmeria nivea* (Ramie) etc. are some of the plants from which good quality bast fibres were extracted in laboratory scale and the physical strength properties of fibres were evaluated. On the basis of extraction of fibres, further work such as bleaching, softening, twine and yarn making would be carried out. It was aimed to develop an appropriate technology in cottage or tiny scale sector for manufacturing fibre and yarn producing items like cordage, wall hangings, carry bags, doormats, twine, ropes hessian cloth and yarn for making fabric.

Development of New Building Construction Materials and technologies

Different agro and agro-industrial wastes like Paddy husk, Banana plant fibre, Rice straw etc incorporating polymeric waste like waste plastics, carry bags, empty mineral water bottles etc were used for converting wood substitute products. The finished wood substitute products were water proof, termite proof and suitable for use in doors/windows, frames and other panel products useful as alternative building construction materials. Both the waste materials were mixed at different ratio and moulded to different shape for evaluation and testing for the required properties. One of the major objective of the proposed work was to develop a technology that directly helps in pollution abatement. The polymeric wastes caused a major pollution at the same time agro and agro-industrial wastes also cause pollution due to their disposal problems.

Commercially important products from plant materials and cellulosic wastes available in the North Eastern Region
Process for manufacture of industrially important speciality paper boards by utilizing waste cellulosic materials such as cotton, rags, gunny waste, tailor cuttings, press cuttings/secondary fibres available in the North Eastern Region to produce value added products was developed. Investigation was carried out for development of speciality paper & paperboards such as paper board, packaging board, imitation leather board, medium density fibre board etc. Investigation for developing suitable environmental friendly pulping process to make pulp from different types of readily available cellulosic waste materials like gunny waste, Hosiery cuttings, secondary fibres, old office records, cotton waste etc was made. Attempts were made to make industrially important paper and paperboards by varying digestion condition and blending ratio as per requirement of the finished products like imitation leather board, speciality board for packaging and their end uses. Emphasis was given to reduce the cost of production of the finished product so that the product becomes cost effective.

Plant Sciences

Development of protocol for mass multiplication of *Bambusa balcooa*

Development of a very efficient reproducible protocol for mass multiplication of a very important Bamboo species i.e. *Bambusa balcooa*, indigenous to North-East India through tissue culture technique was achieved. In-vitro regenerated plants showed 90% survivability. Till date no report is available towards multiplication of this bamboo species by means of application of biotechnological tools. *Bambusa balcooa* does not produce seeds after gregarious flowering. As per report flowering cycle occurs between 35-100 years. Hence, this species is needed to be cultivated only through vegetative propagation. However, for mass scale propagation classical techniques are insufficient as well as inefficient and tissue culture is the only viable method.

In vitro regeneration protocol of '*Homolomena aromatica*' schott

In vitro regeneration of *H. aromatica* showed 90% survivability. Users and traders collect the species from wild source and sell in the market. Present market price is in the range of Rs 4000-5000/kg of oil. Due to its natural low rate of regeneration coupled with slow and insufficient conventional methods of vegetative propagation, utilization of micro propagation protocol will be quite justified for industrial utilization.

Evaluation of Phenotypic and Chemotypic variants and documentation of folklore medicinal plants

-Two phenotypic variants of *Cinnamomum tamala* were evaluated from taxonomic and economic point of view.

-Taxol and 10-DBA contents of *Taxus baccata* sub. Sp. *Wallichiana germplasms* collected from its different habitats of Eastern Himalaya were analysed. Taxol content in the needles and bark ranges from 151.71 to 1345.58 mg/kg and 85.96 to 209.97 mg/kg whereas 10 DAB content varies from 532.88 to 3856.79 mg/kg and 294 to 464 mg/kg respectively.

-55 sps. of ethno-medicinal plants of Dibru-Saikhowa Biosphere Reserve in Assam was recorded. These plants are used against Jaundice, hydrophobia, gynae-cological problems, piles, hypertension, malaria and wounds.

Agropractices developed

Agropractices of *Chlorophytum arundinaceum* and *Plumbago zeylenica* were developed. Among 10 accessions of native Lemongrass introduced RLJ-TC-10 was found to be superior to OD-19 (control) on the basis of yield of oil & citral content.

Search for new sources of aroma chemicals

Constituents of essential oil of *Homolomena aromatica* (Linalool 65%), *C. sulphuratum* (Linalool 92%, Geraniol 55%, Cinnamaldehyde 62%, Methyl cinnamate 72%), *C glanduliferum* (myristicin 40%, Safrol 35%, elemicin 22%), *Litsea cubeba* (Citral 90%), *C jawaracusa* (Pipertone 78%), *Lippia germicuta* (Geraniol 32%), *Alpinia galanga* (1,8 cineole 67.5%) and *Aristolochia indica* (transpinocarvol 24.2%, *pincarvone* 14.2% & μ -pinene 16.9%) were determined.

Identification of fungal species

22 fungal species associated with *Taxus baccata* were collected, cultured & characterized for identification. Among these, fungal broth supernatants bearing code DR, IBI, BFE, TDBO showed antifungal activity. Antifungal activity of volatile essential oils extracted from *Eletraria cardamon*, *Mentha citrata*, *Cinnamomum zeylenicum* were tested against storage fungi of black gram (*Phaseolus mungo*). Maximim inhibition of growth of individual fungal pathogen was observed at a concentration of 500 ppm. Organoleptic tests revealed that the cooked samples of oil treated pulse were found to give better taste & flavour as compared to untreated lots indicating consumers acceptability.

Evaluation of plant extracts for growth retardant behaviour against Mosquito Bug

39 extracts were evaluated for feeding deterrent and growth retardant action against the Tea Mosquito Bug, *Helopeltis theiovora*. 8 lead samples were taken for dose dependency studies and the EC50 values were estimated.

Extracts of 11 plant species were found to be effective egg laying deterrent (*Ovipositor Deterrents*) against the pulse beetle, *Callosobruchus chinensis* found to possess strong antifungal activity.

Evaluation of mushroom sps.

Two sps. of mushroom viz. *Calocybe indica* and *Pleurotus djamora* were introduced. Chemical composition of *Quercus serrata* evaluated for cultivation of *Lentinus edodes* (Shiitake mushroom). Cellulose, Lignin, Ash, Nitrogen content estimated in fresh as well as impregnated *Q. serrata* wood log. Cultivation of *Lentinus edodes* utilizing *Q. serrata* wood log were standardized.

Search for chemo types of *Litsea cubeba* for N E germplasm for exploiting high quality essential oil of commercial utility (DBT). Leaf & fruit extracted from *Litsea cubeba* collected from different locations of Arunachal Pradesh, Meghalaya & Assam showed variation which ranged from 0.8% to 3.2% and 1.2% to 4.6% respectively. The constituents were categorized into citral (87%), *sabinene β -pinene* (62%) and Linalool (75%) types.

Introduction of medicinal plants

Seven sps. of medicinal plants viz. *Croton tiglium*, *Stepania elegeus*, *Rauvolfia serpentina*, *Tylophora indica*, *Nepenthes khasiana*, *Xanthoxylum armatum* and *Chlorophytum arundinaceum* were introduced and their efficient mode of multiplication is studied.

Development of taxonomic key of *Cinnamomum* sps.

A taxonomic key to 27 members of *Cinnamomum* growing in NE India, represented by 15 species and 19 infraspecific categories was developed based on their foliar epidermal characters. The study supported the occurrence of 15 species against the previous report of only 12 taxa of species entities from the region indicating 3 taxa of species category as new record to the flora of N E India. It will help in identifying the different accessions of *Cinnamomum* sps.

Vermicompost

The spent up grass from citronella distillation units was of no use and usually burnt away. Efforts were made to utilize this spent up grass along with farm weed for producing vermicompost by using suitable strain of earthworm. About 1000 kg of vermicompost was produced, the field performance of which was underway.

New strain of *Cymbopogon flexuosus* developed

A new strain of *Cymbopogon flexuosus* designated as BLI-1 having high essential oil (1.0-1.12%) and low citral (16.1%) content was developed by RRL branch of Arunachal Pradesh. The biomass yield of this strain was about 70-75 t/ha. Since the citral content is quite low, effort was underway to increase the citral content by breeding with a high citral content clone of SD-68 strain of *C. Flexuosus*. The laboratory thus far raised F6 Progeny. Encouraging

results in respect of oil (0.86%) and citral content (88.90%) were recorded. Selection was also made for the strains having 0.80% oil and 92% citral. Further work was in progress.

Novel method of multiplication developed

In view of multiplication of plant material by tissue culture in the interior areas, a novel method for multiplication of *Piper longum* using cut leaf was developed at RRL branch of Arunachal Pradesh. In this method each leaf could produce minimum 2 plantlets within 45-50 days. Further work was in progress.

Introduction of plant species

The RRL Branch of Arunachal Pradesh introduced the plant species *Kaempferia galanga* for acclimatization and subsequently multiplied under the climatic conditions of Itanagar. Work for development of Agrotechnology was in progress. High-density crop recorded maximum yield of rhizome per unit area in comparison to low-density crop. Four accessions of *Artemisia annua* were also introduced through NBPGR, New Delhi for acclimatization and seeds were collected for further multiplication and R&D at Nursery-cum-demonstration centers established by the RRL Branch in higher altitude of Arunachal Pradesh.

Societal activities

Biosciences

Promotion, cultivation and processing of aromatic plants and mushroom for socio-economic development of North Eastern region

Under societal mission, the agro-technology of Java citronella, Lemongrass and Mushroom were introduced in the farmer's field which benefited the rural people. Beside this, *Cymbopogon* sps. were found to control soil erosion in certain locations. The following users and beneficiaries were benefited from these technologies

(i) Bodo Autonomous Council Area (Barama, Panitanki, Parkijuli, Kumarikata & Tamulpur)

(ii) Manab Shakti Jagarn, Kairara, Nalbari, Assam

(iii) Nava Jawan Sangha, Kshudra Makhibaha, Assam.

Quantification of benefits

(i) Employment generated - 250 nos. (ii) Productivity of the crop - 20t/ha

(iii) Area covered - 150 ha

(iv) No. of distillation unit set up - 2 Nos.

Development of agro-technologies on Patchouli (*Pogostemon patchouli*) and *Cymbopogon flexuosus*

The RRL Branch Laboratory, Itanagar developed the following agro-technologies for its extension activities and commercial cultivation in Arunachal Pradesh : (i) The agrotechnology of Patchouli (*Pogostemon patchouli*) (ii) A new strain of *Cymbopogon flexuosus* designated as BLI-1. This new strain had high essential oil (1.0-1.12%) and low citral (26.1%) content. The biomass yield of this strain was about 70-75t/ha. To increase the citral content of this strain, breeding work by hybridization method was taken up. Systematic evaluation of this huge and almost scientifically untouched flora of Arunachal Pradesh necessitated quick identification of medicinal and economic plants for developing technologies and exploring new/better source of chemicals that could contribute to the economy of the ethnic population of the state. Further, the economically promising endangered species are subjected to agronomic trials at different agro-edaphic conditions of Arunachal Pradesh. Since the state has varied agro-climatic conditions the developed technologies would not only augment the knowledge but would also help in extending the cultivation of selected medicinal and economic plants for the socio economic upliftment of the rural sector of Arunachal Pradesh in particular and the northeastern region in general. The agro-technology on Patchouli was released to eight local farmers

Creating awareness and promotion of medicinal plants available in Arunachal Pradesh for the production and marketing of medicinal herbs towards sustainable development of ST population of Arunachal Pradesh

Under this DBT funded project the following activities were carried out :

- The third Nursery cum Demonstration Centre of medicinal plants was established at Ziro (4370 ft. msl), Arunachal Pradesh. With this BLI completed the establishment of three different centres at three different altitudes of Arunachal Pradesh.

- Twelve awareness-cum-exhibition and two workshops on medicinal plants were conducted at Roing, Jairampur, Hayuliang, Amliang, Telluliang, Loiliang, Tezu and Tafragram area of Arunachal Pradesh. More than 1319 villagers/farmers attended these programmes.

- On the request of the Deputy Commissioner, Lohit & Anjaw district, seedlings/rooted cuttings/seeds of different medicinal plants were supplied to seven model medicinal plants garden established in different places of the said two districts.

- Supplied seedlings of *Kaempferia galanga* (1700 nos.), *Piper longum* (1300 nos) to prospective farmers of Arunachal Pradesh.

- Sent medicinal plants samples to different traders of India for developing market potentiality.

Medicinal plants appropriate to the climate were introduced for multiplication and demonstration. Plant saplings of medicinal plants viz. *Piper longum*, *Kaempferia galanga*, *Rauvolfia serpentina* were distributed from RRL Branch, Nursery-cum-demonstration centers of Bomdila and Roing to promising cultivators for multiplication and cultivation. Consequent upon the effective awareness programme conducted by Branch laboratory of Itanagar, a number of ST farmers of Doimukh, Roing, Along, Bolen and Pangin are of Arunachal Pradesh were inclined to take up commercial cultivation of *Stevia rebaudiana* for which negotiations were on with the buyers for Buy-back arrangement.

Under an another DBT funded project titled 'Promotion & Production of Aromatic oil, Mushroom and Vermicompost for Revenue Generation of the ST population of Arunachal Pradesh' 4 training programmes were organized at places like Jairampur, Itanagar, Roing and Along under the districts of Changlang, Papumpare, Lower Dibang valley and West Siang with the participation of 271 farmers. ST villagers of different areas showed keen interest for mushroom cultivation and with the mushroom spawn produced at RRL branch. About 500 bags of mushroom spawn were distributed to various NGOs, farmers and individuals of Arunachal Pradesh.

Empowerment of SC/ST and weaker section population of North East India through cultivation of Non-traditional remunerative plantation crops
Five acres of land were brought under the cultivation of aromatic plants and 180 beneficiaries were imparted training in cultivation & processing of aromatic plants.

Central Sector Scheme Supplementation complimentation of State efforts through work plan - Dev. Of Medicinal & Aromatic Plants

Under this programme, quality planting materials of Java citronella, Lemongrass, Safed Musli, *C. citratus* have been multiplied and distributed to the growers with necessary training & demonstration. In herbal garden, 10 sps. of medicinal plants was multiplied in Jorhat and 11 species of medicinal plants were introduced at Imphal, Manipur. The work was carried out with the financial grants received from Directorate of Arecanut & Spice Development, Govt. of India, Calicut.

Promotion of intensive cultivation of edible mushroom in certain ST population of Mizoram for socio-economic development .

At Saiha in South Mizoram, beneficiaries were selected to grow mushroom. Preliminary training on cultivation of mushroom was given to the above beneficiaries.

Analytical services rendered

During the year analytical services were rendered to various agencies of the North Eastern region which included Numaligarh Refineries Ltd., Oil and Natural Gas Commission, N F Railways, Army Establishments, Tea Gardens, Government and Autonomous Institutions, Educational Institutions including universities of the NE region and other private entrepreneurs. The materials evaluated included feed, food, drinking water, fertilizers, micronutrients, agrochemicals including pesticides, edible and essential oils. A total of 222 such samples were evaluated and an amount of Rs. 1,68,765/- was earned by the Analytical Chemistry division of the laboratory. Students from RRL Central School were given lectures on pH and its determination by the scientists and they were given practical demonstration on various types of pH measurement techniques. A group of Biotechnology PG students of the Assam Agricultural University was given lectures on spectroscopic and chromatographic analysis as Instrumental method of analysis being a part of their academic curriculum.

R&D Support Activities

Information & Business Development Division

The Information & Business Development Division (I&BD) as usual continued to discharge the dual responsibility of maintaining liaison activities with industrial houses, entrepreneurs, Govt departments, private and public sector industries, etc. having served as a window of the laboratory to the outside world on the one hand and coordinating the overall business development activities of the laboratory on the other hand. The foremost task of the division had been to consolidate the gains of research and development of the laboratory and to help the entrepreneurs and users who were in need of RRL's technologies, demonstration, training and technical assistance, etc. The technical exhibitions organized by the division contributed significantly towards creating awareness about the institute and its works and also for building the institutional image in the public eye.

The division brought out the laboratory's regular publications such as Annual Report and regular issues of RRL Jorhat News which are the main mouth pieces of the laboratory. In its efforts for giving wide publicity of the laboratory's technologies, expertises, knowledgebases, etc. and with a view to gearing up the business strategies, the division issued various press releases on important events and achievements from time to time, sent materials to Head quarters for publication in the CSIR Annual Report and CSIR News, released advertisements in various souvenirs and journals, publishing special articles, reports, etc. in the local and regional dailies, contributing to audio-visual media like Doordarshan, All India Radio and producing video films on the activities and achievements of the laboratory. The division published the revised and enlarged edition of 'RRL Jorhat Technologies', Vision Document of the laboratory and also brought out a very special publication titled 'Highlights : 2004-05.

The division was instrumental in the transfer of RRL technologies such as the Agrotechnology on Safed Musli, Bioorganofertilizer, Fibres from banana pseudo stem and Low Dust Chalk pencil to a number of parties from within the state as well as parties from outside states like Manipur, Tamilnadu and Kerala, etc. The division handled IPR matters of the laboratory and extended IPR services to scientists as well as outside parties in matters of filing and obtaining of patents. A total of 9 patents were filed in India during the year under report and 5 Patents were granted including 1 Foreign Patent.

The division responded to numerous queries relating to technology transfer and R&D of the laboratory and took care of 4000 visitors comprising of students, teachers, VIPs, industrialists, entrepreneurs, etc. and continued to maintain the records of testing, analytical and technical services rendered by the laboratory to outside parties, projects undertaken and completed, etc. The division prepared the quarterly statement on Research Utilisation Data (RUD) for CSIR HQrs and the Statement on Monthly Service Tax payable by the laboratory to the government. It also prepared suitable replies to the Audit queries relating to R&D receipt and expenditure and attended to Parliament Questions on R&D matters of the laboratory. During the year the division processed 20 new research project proposals for sending to respective funding agencies and 16 research project proposal were materialised out of the projects processed earlier and new combined together. As usual, the division was responsible for conducting the Customer Satisfasction Evaluation of the various services rendered by the laboratory to the its clients in close association with the CSIR Hqs and the Customer Satisfaction Index for the laboratory during the year was found to be 3.5 out of 4.

The division played a lead role in organizing various meetings and exhibitions of the laboratory. The year was celebrated as the 'YEAR OF SCIENTIFIC AWARENESS 2004' in the laboratory beginning in the month of July, 2004 and ending in December, 2004 with a series of scientific awareness programmes spanning the period and held at various pre-appointed places of the North Eastern states for the benefit of students, farmers, teachers, women, NGOs and general public as per the directives of CSIR. All total 28 lectures, 11 open house interactive meets, 6 mobile S&T exhibitions, 1 science motivation programme, 2 extempore speech competitions in science topics were organized, conducted and coordinated for the purpose in urban, rural and interior places of the region by the scientists of the laboratory which happened to be very much rewarding to the targetted sections of the society. In addition to that 6 titles of booklets on scientific awareness, published jointly with the Science Writers' Association of Assam, were released to libraries, schools and village NGOs, etc.. It also organized National Technology Day on May 11, 2004, CSIR Foundation Day on 26 September, 2004,

National Science Day on 28 February, 2005 and 44th Foundation Day of RRL on 18 March, 2005.

During the period the division organized and participated in a number of industrial and S&T exhibitions which are listed below :

-Exhibition organized on the occasion of National Children's Science Congress held at Cotton College Campus, Guwahati during December 27-30, 2004

- Exhibition held at Margherita organized on the occasion of Annual Conference of Purbanchal Tai Sahitya Sobha during February 4-6 , 2005

-Vendor Development Programme-Cum-Industrial Exhibition organized by Small Industries Service Institute, Ministry of Small Scale Industries, Govt. of India, Guwahati held at POW Institute of Engineering & Technology, Jorhat during February 12-14, 2005.

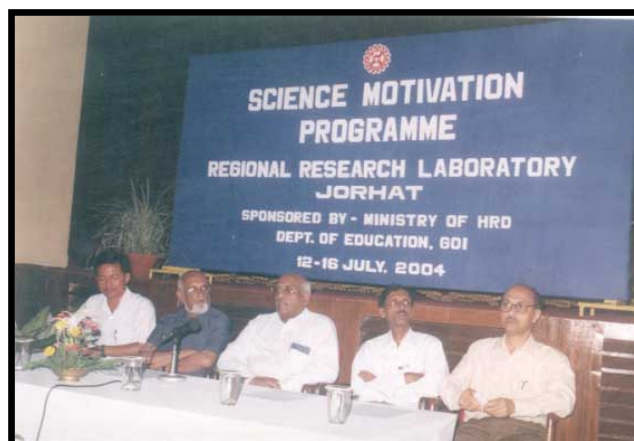
- S&T exhibition held in the state level Kishan Mela in Itanagar, Arunachal Pradesh organized on the occasion of 19th Arunachal Statehood Day by the Arunachal Government during February 20-21, 2005.

- The North Eastern Agriculture Fair/Exhibition held at Assam Agricultural University, Jorhat during March 02-04, 2005 organised by AAU-Jorhat.

-Technology Exhibition on 'Appropriate Technologies for Development' organized by State Council of Science, Technology & Environment of Meghalaya held at Shillong during March 09-11, 2005.

-Science Exhibition of the Sankardev Bidya Niketan and Mobile Exhibition Van displaying RRL Technological exhibits on April 24, 2005.

Planning



The Planning Division prepared the Annual Plan 2005-06 and project budgets of the laboratory highlighting the major R&D achievements and resources requirements. The division also prepared the Annual Project Report of Network Projects and compiled the major achievements of the laboratory during 10th Five Year Plan period. The manpower deployment in inhouse, grant-in-aid, sponsored and consultancy projects were analyzed, updated and reviewed by the division and the resource use efficiency was examined. Resource requirements and its utilization were reviewed in various stages and corrective

measures were taken for better R&D management. Audit queries on the working of RRL Jorhat from the Comptroller and Auditor General of India (CAG) were replied to.

Interaction with R&D support divisions and sections were maintained and support of R&D activities and other inputs were given from time to time. During the year various information on R&D progress, manpower utilization, financial allocations and other database information were supplied to CSIR Headquarters and other organizations. Database on manpower, project budget, inventory of important equipment and statistical profile of the laboratory were utilized for efficient R&D planning. A special database had been maintained and updated on the Ph D work carried out at this laboratory.

In the human resource development activity the division organized one five-day Science Motivation Programmes for selected high school students and science teachers from various parts of Assam, Nagaland, Mizoram and Manipur and three one-day programmes for talented high school students and teachers of Jorhat, Sivasagar, Dibrugarh and Golaghat districts during the year. The programmes generated a lot of enthusiasm among the participants and they were highly benefited. The programmes were sponsored by NCSTC, DST, New Delhi and the Ministry of Human Resources Development, Govt. of India, New Delhi. Two project proposals were submitted for financial grant for organizing a series of such programmes during the next financial year. During the year, the division organized an essay writing competition on science topics among the wards of RRL staff on the CSIR Foundation Day. A semi-extempore speech competition was also organized on the National Science Day.

The division was actively associated in planning and organizing a series of science popularization programmes in the north-eastern region under the 'Year of Scientific Awareness 2004' celebrated by the laboratory.



Library & Documentation

The Library & Documentation Section continued to provide library and information services to the R&D departments of the laboratory, Research Fellows, outside students and individuals, universities of the NE region, institutes like Rain Forest Research Institute, Jorhat, Institute of Biotechnology and Geotechniques Studies, ONGC, Jorhat, Tea Research Association, Tocklai Experimental Station, etc. During the period the library added 250 books and 9 IS specifications to its stock. The library subscribed 82 foreign and 86 Indian journals and added 500 bound volumes to its collection. The Patent Inspection Centre of the library continued to receive Indian patent specifications to its stock for inspection by laboratory scientists as well as other outside public. During the period 300 Indian patent specifications were received in the center. 46 Gazette of India Notifications received by the library were scanned and necessary information supplied to various users of the laboratory. The library obtained 122 Indian and foreign papers published from NISCAIR, New Delhi and other information centers on advance payment and supplied 118 articles to several universities, information centers and R&D organizations on request. It also collected 700 Annual and other reports from various R&D and academic institutions.

The library continued to provide CAS and SDI services to the users on regular basis besides bringing out 'Current Abstracts', 'Current Topics' and News Index regularly. Literature survey and searching were done for different topics of various disciplines as and when required by the scientists. It brought out bibliographies on the topics titled (1) An Annotated Bibliography on Ethnobotany of North Eastern Region comprising of 119 abstracts searched from Chemical Abstracts and other sources. The bibliography was compiled for the CSIR Task Force Project 'Development of new building construction materials'. The library continued to maintain the database on publications and presentation of research papers from the laboratory. A database on the theses of RRL Jorhat was prepared and updated. Database on 'Current Information' collected from journals received in the library was updated using CDS/ISIS for publication of 'Current Contents'. The database on 'Lib Sci' collected from the library and information science journals was updated using CDS/ISIS for publication. Reference services were done as and when needed by the regular as well as outside users. The reprography section of the library copied 88,602 page documents during the period and earned an amount of Rs 9088/- through reprographic services to outsiders. It also earned an amount of Rs 6350/- as membership fee from the outside institutions, individuals and students during the period. Under the modernization plan, the library was linked with the outside world in general and CSIR in particular through Internet facility. Computer terminals were provided to the users for their accessing and searching in E-mail and Internet.

Project, Monitoring & Evaluation

PME Cell was involved in the monitoring of the externally funded as well as CSIR Network & Task Force Projects from their initial stages to the submission of final reports. The Cell continued to maintain R&D receipt records and Project Folders of such projects. The Cell prepared the ECF commitments of various divisions for the reporting financial year on the basis of the projects that were on going as well as those which were in pipeline. Monthly and fortnightly statements of department-wise ECF positions of the laboratory were also prepared highlighting the receipts from Govt. departments, public and private sector organizations, etc. The total ECF of the laboratory during the financial year 2004-2005 amounted to Rs 254.746 lakhs which comprised receipts from Govt. departments/Ministries, Public Sector Industries and Private Sector organizations to the extent of 90.09%, 7.98% and 1.93% respectively. The commercial Rupee value of ECF was worked out to be Rs 25.24 lakhs being 9.91% of total ECF. During the year 26 new projects were contracted, out of which 8 were consultancy, 17 Grunts-in-Aid and 1 Collaborative. In consultancy projects an amount of Rs 3.815 lakhs was realized from existing projects and Rs 11.316 lakhs from newly sanctioned projects leading to a total of Rs 15.131 lakhs. In Grant-in-Aid projects, an amount of Rs 141.905 lakhs was realized from existing projects and Rs 85.320 lakhs from newly sanctioned projects leading to a total of Rs 227.226 lakhs. In Collaborative projects, an amount of Rs 4.080 lakhs was realized from a new project. Rs 5.217 lakhs was received as technical services charges. Rs 3.07

lakh was received as premia and royalty. The Cell attended to the Scientific Audits, prepared the audit replies on the matters of R&D receipts and expenditures. Keeping in view the directives received from the Govt. of India, the Cell took upon itself to implement the Projectisation, Project Accounting and Zero Based Budgeting in the laboratory since April, 2003 and it has now been successfully incorporated into the IMPACT. The Cell coordinated the job of working out the Service Tax due and accrued from the various services rendered by the laboratory during the year for computational and other purposes. The Cell updated the Organisation Chart of the laboratory according to changes that took place in manpower, status of the employees, deployment of manpower and retirements, etc. The Cell reviewed the performances, progress and work plan of CSIR Network as well as other R&D Projects with Director and HoDs and Area Leaders of the concerned departments.