CSIR–North East Institute of Science and Technology, Jorhat

D. Banik, I. I. Zhimo, R. L. Bezbaruah and D. Ramaiah*

CSIR–North East Institute of Science & Technology, Jorhat 785 006, India

The CSIR–NEIST, a national multidisciplinary R&D Institute was established to provide solutions to the various problems of the North Eastern India and the country by utilizing the immense natural resources of the region. The significant scientific achievements of the Institute during 2014 are highlighted under the five major areas.

Keywords: Achievements, CSIR–NEIST, scientific.

Significant scientific achievements in 2014

THE CSIR–North East Institute of Science & Technology (CSIR–NEIST), Jorhat, Assam was established as a multidisciplinary laboratory in 1961. The charter of CSIR–NEIST is aimed at utilizing the immense natural resources of the northeast region (NER) of India and also to provide R&D inputs for developing the economy of the region in particular and the country as a whole. Further objectives have been helping the region in solving such research problems that are confronting it from time to time. We also take up long-range problems which would help the economic development and industrialization of the NER. We have been functioning as a link between the state organizations and other national laboratories on problems requiring specialized attention. With this defined mandate, the laboratory has accentuated its R&D activities mainly in six broad areas, viz., agrotechnology, biological, chemical, engineering, materials and geosciences. Under these areas, the significant scientific achievements of the laboratory in basic and high-end exploratory research in 2014 for developing value-added products and technologies having industrial and societal relevance broadly claimed are described below under different headings.

Agrotechnology

The Institute has been engaged in exploration and assessment of the plant resources of the NER and identification of potential medicinal, aromatic and economic plants for development of commercially prospective species and their conservation through extensive genetic diversity studies. During this period, the Institute identified six potential insect pests of stored grains of the NER and developed plant-based fumigants for its effective management and control. Figure 1 shows the stored pulses infested by *Callosobruchus chinensis* (Bruchidae: Coleoptera)[1]. Based on extensive survey and exploration, a new source of tree-borne edible oils has been identified from Gibbon Wild Life Sanctuary, Jorhat, having high medicinal and aromatic values, including the *Litsea cubeba* citronellal-type fruit essential oil.

Figure 1. Major insect pest of stored pulses identified as *Callosobruchus chinensis*.

The Institute was actively engaged in bio-prospecting and bio-profiling of microbes, plants and insects from the North East India gene pool for active biomolecules. Development of a herbal pest control agent effective against the tea pest, red spider mite (RSM) has been one of the significant achievements during the year. RSM is one of the major pests prevailing in tea crop causing huge loss to the industry. From the experimental and field trials, the extract now found to have the potential as a herbal pest control agent [patent application no. 3321DEL2014 (Provisionally filed in India)] has been developed.

Biological sciences

In this area, an attempt to evaluate the association of GSTM1 and GSTT1 genotypes and chronic obstructive pulmonary disease (COPD) among the individuals of non-smokers and smokers irrespective of age and sex was carried out. COPD may develop due to variation in the functioning of antioxidants along with smoking and environmental factors in genetically susceptible individuals. Since there are different views about the antioxidants responsible for detoxifying xenobiotic compound in the

*For correspondence. (e-mail: director@rrljorhat.res.in)

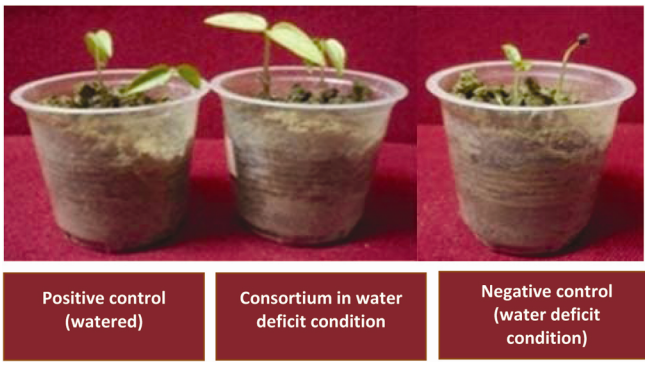


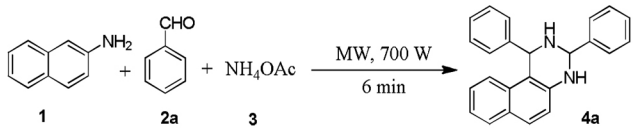
Figure 2. Experiments conducted to determine the growth promoting activity of the consortium of three ACC-deaminase producing PGPR strains under water stress (deficit) conditions.

human body, whose functional variation may lead to obstructive disease, this associative study has been taken up between GST gene polymorphism and COPD in populations exposed to coal dust. Our studies concluded that GSTM1 (null genotype) appears to be a risk factor for low lung function in smokers living in the vicinity of open cast coal mine area and the presence of at least one active allele (either GSTM1/GSTT1) seemed to have a protective role in the development of COPD. Further studies with the association of *HMOX1* and *MMP12* genes, will be necessary to elucidate the pathogenesis of COPD as a genetic disease in compliance with the environment with larger sample size[2].

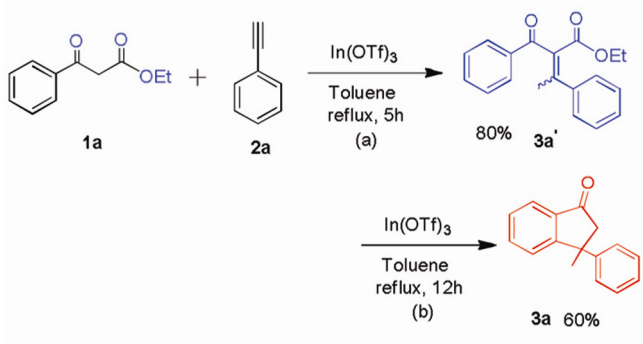
Another study in this area was undertaken to understand the effect of ACC-deaminase producing rhizobacteria on seed germination and plant growth promotion under drought condition for black gram seeds. The root length of the seeds treated with the strains *Ochrobactrum pseudogrignonense* RJ12, *Pseudomonas* sp. RJ15 and *Bacillus subtilis* RJ46 was significantly high with a seed germination percentage of 80, 90 and 100 respectively. When these three strains were used for pot experiments, it was found that the plant response to the consortia of the three strains was remarkably high as revealed in root length, shoot length, fresh weight and dry weight even under drought stress condition (Figure 2).

Chemical sciences

The major thrust of the research in this area has been focused on green approaches for development and value addition of bioactive compounds and biopolymers. Research emphasis has been laid on chemical investigation of some traditionally reputed medicinal plants of NE India for drugs, pest management agents and nutraceuticals. Development of green methodologies for industrially important organic compounds, either natural or from synthetic sources, is another important aspect. During this period, one-pot, atom and step economic (PASE) green synthesis of tetrahydroquinazoline (**4a**) has



Scheme 1.



Scheme 2.

been achieved via microwave-assisted four-component catalyst and solvent-free aza-Diels–Alder reaction strategy which is shown in Scheme 1. The key step of the methodology is the *in situ* generation of both the diene and the dienophile and their subsequent reaction to give the desired product[3].

A novel route for the assembly of β,β-disubstituted indanones (**3**) through a tandem indium catalysed Nakamura addition/hydroarylation and decarboxylation sequence was developed, which is shown in Scheme 2. Indium(III) triflate has shown remarkable ability to catalyse three fundamentally different chemical reactions under one-pot conditions in the absence of any additives or co-catalysts to generate indanones derivatives in good yields[4].

The steroselective vinylation of hetercyclicthiols was studied[5]. A novel method was developed for the preparation of steroid/non-steroid fused 7-substituted pyrazolo [1,5-α] pyrimidines by the one-pot reaction of steroidal/non-steroidal ketones, aromatic aldehydes and 3-amino-1*H*-pyrazoles/5-amino-1*H*-pyrazoles in the presence of potassium tert-butoxide[6] and spiro-1,3-oxazine derivatives by the microwave-assisted cyclization of N-2-(1′-cyclohexenyl)ethyl-acetamides/benzamides[7]. A nimocinol acetate natural product, dysobinin(paniculatin), has been found to be active against breast cancer cell lines via the induction of autophagosome and autolysosome[8].

Another study was also undertaken on *Ricinodendron heudelotii* oil polymer, which was a potential renewable candidate for the preparation of fast-drying binder and resins suitable for surface-coating applications and industry. Figure 3 shows the DTMA curve of *R. heudelotii* oil-based alkyd resin[9].

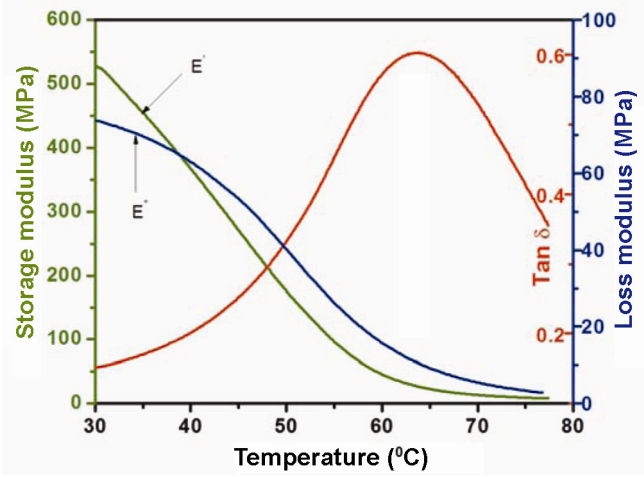


Figure 3. DTMA curve of *Ricinodendron heudelotii* oil-based alkyd resin. E′, Storage modulus; E″, Loss modulus.

Materials science

The activities under this area include the modification of montmorillonite clay by acid activation. The purified Na-Mont. was activated with minerals acids in order to produce a matrix having high surface area and nano-range pores on the surface. These activated montmorillonite clays were designated as Mont.-AT-I, Mont.-AT-II, Mont.-AT-III and Mont.-AT-IV, indicating the activation time of 15 min, 1, 2 and 4 h respectively. The XRD pattern (Figure 4) shows the depletion of layered structure on prolonged acid activation. The N_2 adsorption/desorption isotherm curves for mesoporous matrix are also produced as shown in Figure 5 (refs 10–12).

In another attempt, the synthesis and catalytic transfer hydrogenation reaction was carried out in the presence of stabilized Rh^{o}-nanoparticles–montmorillonite clay composite (Scheme 3)[13].

With an objective to synthesize metal nanoparticles on the graphene oxide/graphene, the graphene oxide nanosheets were decorated with gold nanoparticles (Au NPs-rGO) using an ecofriendly route and studied for biocompatibility to HeLa cells and their antibacterial activity against Gram-positive and Gram-negative bacteria. Au NPs-rGO showed good biocompatibility to cervix carcinoma, human (HeLa) cells, while possessing high antibacterial activity against two Gram-positive bacteria (*Staphylococcus aureus* and *Bacillus subtilis*) and two Gram-negative bacteria (*Escherichia coli* and *Pseudomonous aeruginosa*). The bacterial cell death was due to leakage of sugars and proteins from the cell membrane in contact with Au NPs-rGO composite material. Figure 6 shows the TEM images of the Au nanoparticle on the reduced graphene oxide sheets[14].

To develop the hierarchical porous solid as catalyst and catalytic support, Fe_3O_4@SBA-15 was successfully synthesized and characterized. The synthesized Fe_3O_4@SBA-15 catalyst is magnetically recoverable and exhibited better catalytic activity[15]. It was found that Fe_3O_4 nanoparticles can be effectively incorporated into the matrix of MIL-101(Cr) to fabricate a Fe_3O_4@MIL-101 magnetic nanocomposite which behaves as a magnetic

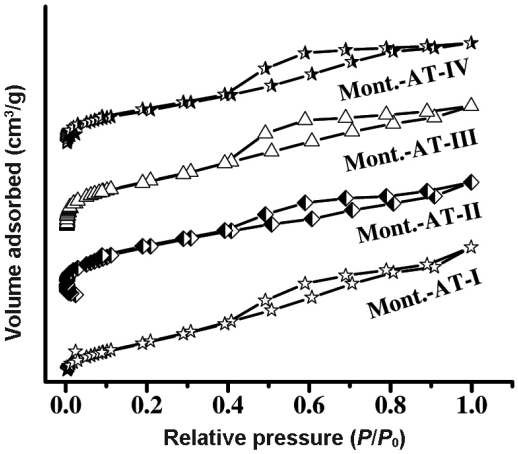


Figure 5. N_2 adsorption/desorption isotherm of different montmorillonite clays.

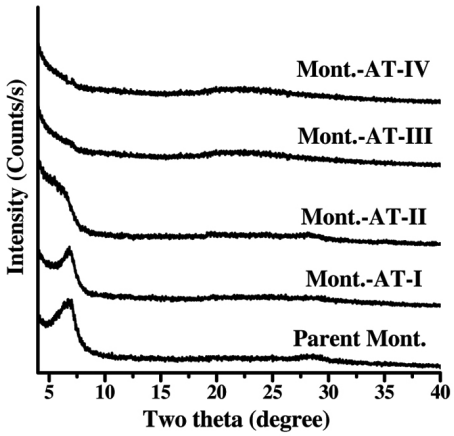
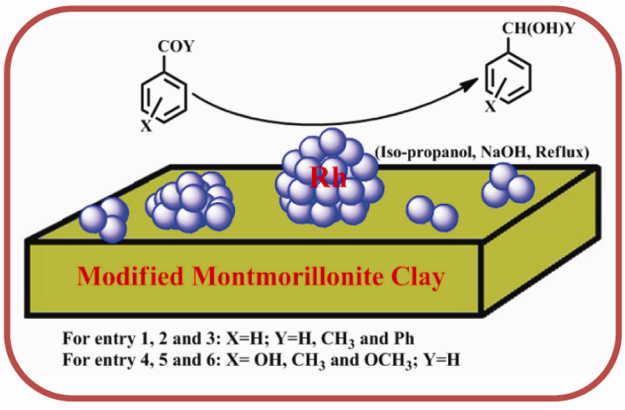


Figure 4. Powder XRD pattern of different montmorillonite clays.



Scheme 3.

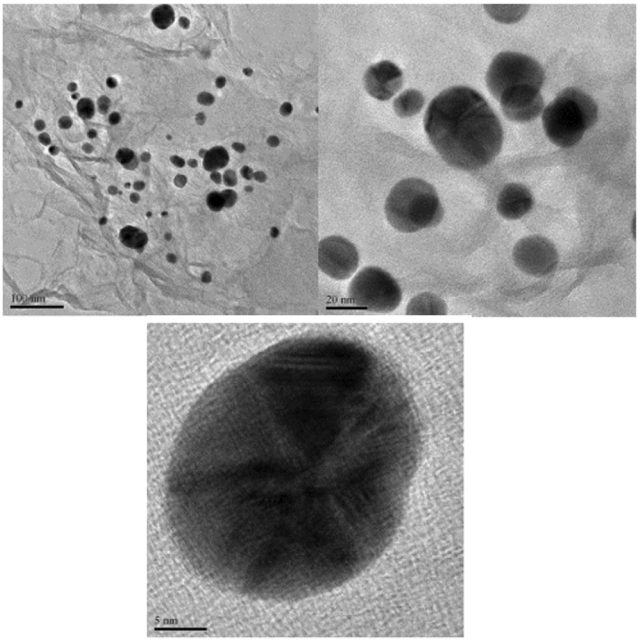


Figure 6. TEM images of the Au nanoparticles on the reduced graphene oxide sheets.

nanocatalyst for the solvent-free oxidation of benzyl alcohol[16]. In another attempt to develop the potential rhodium complexes of functionalized phosphines and nitrogen-donor ligands for synthesis, reactivity and catalytic carbonylation of alcohols, the cationic carbonyl complexes of the type [M(CO)L]Cl (**1**) [M = Rh (a) and Ir (b); L = P′($CH_2CH_2PPh_2$)$_3$] have been synthesized and characterized. These complexes showed catalytic activity towards the hydroformylation of alkene. The yields of the aldehyde products are in the range 55–75% (ref. 17).

For effective desulphurization for quality enhancement of clean coal from high-sulphur Assam coals, extensive evaluation/characterization has been carried out. The ionic liquids and ultrasonic energy were used for oxidative desulphurization and deashing of industrially important high-sulfur sub-bituminous NE Indian coals. The thermogravimetry–derivative thermogravimetry (TG–DTG) profiles of the beneficiated coals revealed their improved quality for use in thermal plants with better combustion efficiency[18–20]. Apart from these, detailed studies were carried out on the utilization of natural resources for development of wood substitute composite and synthesis of novel composite material using coir fibre for engineering applications[21,22].

Geosciences

As NE India has a complex structural framework with changing behaviour of seismic activity in different tectonic domains controlled by ancient plate margin, the research priorities under this area include source characterization, seismic microzonation, earthquake precursors, fluvial geomorphology, geo-environmental studies and awareness creation on earthquake hazards among the masses. Over the years the institute has established a wide seismic network covering the entire NE India for on-line seismic monitoring and real-time event location besides running several standalone seismic stations and subnets. During the year 2014, the Institute carried out seismic vulnerability assessment of major cities in NE India and the site amplification characteristics of Shillong city have been estimated. Active tectonics and palaeoseismic studies using geophysical parameters, along the mountain frontal part of eastern syntaxial bend, Lower Dibang valley and Lohit districts of Arunachal Pradesh were also carried out.

Engineering sciences

Under this area, the Institute was committed to taking up R&D in various sub-areas such as soil stabilization for use in roads and building construction; seismic assessment and risk assessment of buildings, transport phenomena in solid/liquid membrane-based separation processes; scale-up studies of bioprocesses in bioreactor and downstream processing; nanostructured membrane materials; mechanical design and product development, environmental studies and disaster mitigation. During the period, an indigenous nanostructured membrane has been developed and characterized by IR, XRD, SEM, TEM, pore diameter and permeability analysis. The pore sizes of the prepared membranes are in the range 52–70 nm. Figure 7 shows the SEM photomicrographs of cyclodextrine membrane. Spiral wound membrane module has been designed and fabricated for large-scale separation of value-added products (Figure 8). Also, extraction of some value-added products from plant samples such as *Artocarpus lakoocha* Roxb. and *Morus alba* L. have been

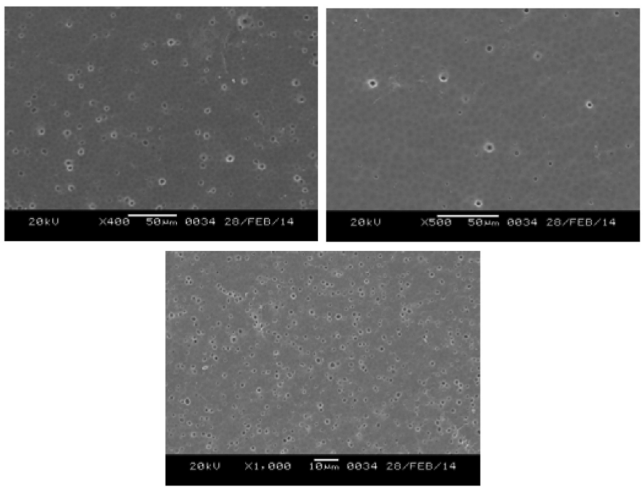


Figure 7. SEM photographs of cyclodextrine membrane.

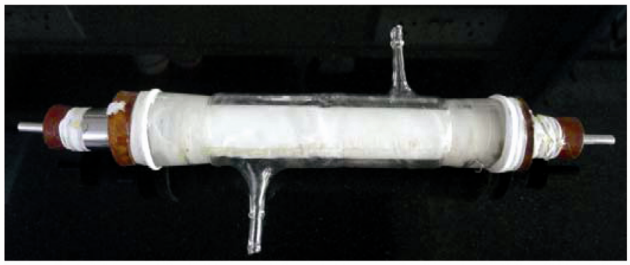


Figure 8. Spiral wound membrane (CD) module.

done using suitable extractant considering greener approach. During the investigations, the extraction kinetics of resveratrol from *A. lakoocha* and *M. alba*, has been established using suitable kinetic model [Patent application no.2853DEL2014]. Extraction of natural dye from the seed of *Mallotus philippensis* (Lam.) Mull. Arg. has been studied using suitable extractant. The extracted dye has been separated using indigenously developed nanofiltration membrane. The purity of the separated dye has been found to be >90%.

Rural technologies for societal development

Under this major thrust area of the Institute, several rural technologies were developed for societal upliftment which include the agropractices of citronella, lemon grass (BLI-ARUN – an improved variety) and various other medicinal, aromatic and economic plants, production of mushroom spawn, etc. Apart from these, the other rural technologies developed during this period included low dust chalk pencil, liquid deodorant cleaner, herbal freshener, herbal incense stick with mosquito repellant properties, bacterial formulation for crop enhancement and yield improvement and TP-16 biofertilizer. All these technologies were successfully commercialized in the NER for employment generation and societal upliftment.

In a nutshell, the Institute has been actively engaged in the basic and translational scientific research as well as for the societal development, thereby benefiting the rural population.

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