



# CSIR News

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### In The News

## Vice President releases Herbal Formulation for Management of Diabetes developed by CSIR-NBRI & CSIR-CIMAP

THE CSIR-National Botanical Research Institute (NBRI), Lucknow has come up with a new scientifically validated herbal formulation – NBRMAP-DB. This novel formulation for the management of diabetes was developed jointly by CSIR-National Botanical Research Institute and CSIR-Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow.

NBRMAP-DB, a safe hypoglycaemic herbal formulation, based on traditional knowledge, was released by the Vice President of India, Mr. M. Hamid Ansari on 22 February 2014 at Vigyan Bhawan, New Delhi, and will now be available to industries for commercialization.

Diabetes, a complex metabolic disorder, has become a major health problem the world over. Type II diabetes is the more common form of diabetes constituting 90% of the diabetic population. It is estimated that 61.3 million people aged



Herbal formulation NBRMAP-DB being released by Vice President, Mr M. Hamid Ansari

20-79 years live with diabetes in India. The prevalence of diabetes increased tenfold from 1.2 % to 12.1 % between 1971 and 2000. This number is expected to increase to 101.2 million by 2030 and 77.2 % people in India are said to have pre-diabetes.

## DIRF Data Centre of CSIR-NISCAIR awarded ISO/IEC 27001:2005 Certification



The Digital Information Resource Facility (DIRF) Data Centre of CSIR-NISCAIR, inaugurated by Prof. S.K. Brahmachari, former Director General, CSIR on 26<sup>th</sup> June 2013, has been awarded ISO 27001:2005 Certification. DIRF has been created to provide uninterrupted, authorized and secure access of NISCAIR and CSIR Resources to the scientific community and researchers all over the world. These include NISCAIR Online Journals and many other Digital Resource Databases. DIRF Data Centre is available for hosting of digital resources for CSIR and its Laboratories.



### R&D Highlights

## New Technologies Developed at CSIR-CEERI

**MEMS Vibratory Gyroscope:** Gyroscope is a sensor that measures the rate of rotation of an object. The operation of MEMS vibratory gyroscope relies on the sinusoidal coriolis force induced due to the combination of vibration of a proof-mass and an orthogonal angular-rate input. The gyroscope has a wide spectrum of applications including automotive applications for ride stabilisation and rollover detection; consumer electronic applications such as video-camera stabilisation, virtual reality, inertial mouse for computers, robotics; and military applications.

Keeping in view the wide applicability of MEMS vibratory gyroscopes, CSIR-

CEERI had taken up the task of design and development of such angular rate sensors. The gyroscope developed is the second generation gyroscope which utilises a symmetrical structure and is free from mechanical cross-talk.

A SEM image of MEM vibratory gyroscope recently developed by CSIR-CEERI is shown in Figure 1. The device has been fabricated using UV-LIGA process having 10  $\mu\text{m}$  thick nickel as structural layer. The device chip is 5 mm  $\times$  5 mm in dimension. Also, the prototype device has been characterized for frequency response using Polytec MSA-500 Micro System Analyzer.

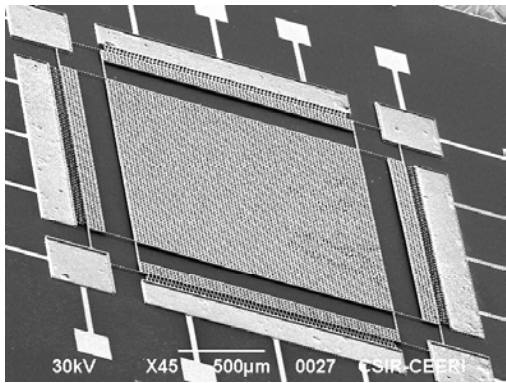


Fig. 1. SEM image of fabricated gyroscope

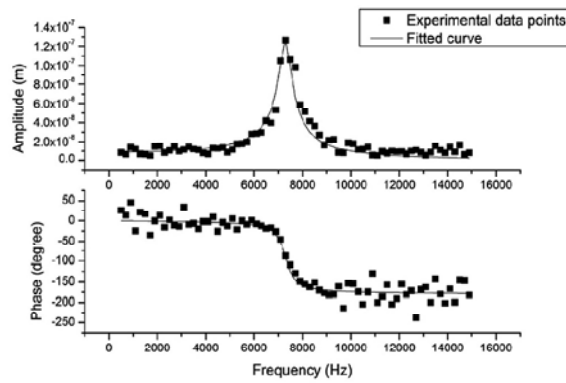


Fig. 2. Measured frequency response



The results are shown in Figure 2. The resonance frequency has been observed at 7.3 kHz against the design value of 7.5 kHz. The excitation voltage for this device is  $40 V_{ac}$  with polarization voltage of  $50 V_{dc}$ .

**Microhotplate Fabricated for Sensor Applications:** A new version of microhotplate has been fabricated using Low

**Electrode Structure for Milk Analyser – A New Version:** In addition to the earlier version, a new version of electrode structure of noble metal sensing materials for electronic tongue applications was fabricated using thick-film ceramic technology. This electrode structure was used in milk analyser (developed by Digital Systems research team) to test for adulteration in milk. It has three

working electrodes of Pd-Ag, Au and Au-Pt and one reference electrode of Pt. It has six printing operations – four for the electrode structure, one Pd-Ag printing on the pads and one for dielectric printing. Soldering of leads for connector adaptability has been

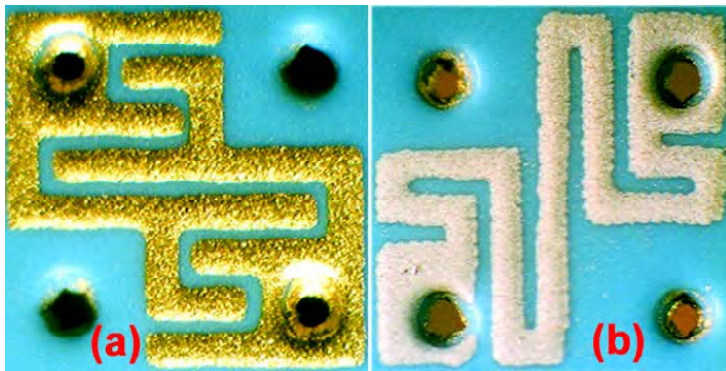


Fig. 3. LTCC Via-Butterfly Microhotplate (a) Electrode side and (b) Heater side

Temperature Co-fired Ceramic (LTCC) technology for gas sensor applications. The hotplates are more rugged and have high temperature stable lead interconnections. The hotplates are used to build microsensors for strategic, biomedical and industrial applications. A temperature of  $300^{\circ}\text{C}$  can be achieved across the microheater with an input power of 1W. It has interdigitated electrodes on the front side and microheater on the backside, which after coating of metal oxide film, can be used for gas sensing. Figures 3 and 4 show the structure before and after lead interconnections.

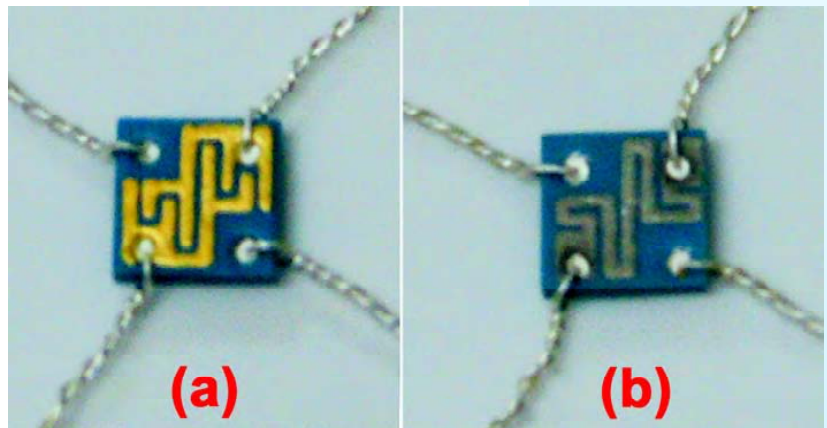


Fig. 4. LTCC Via-Butterfly Microhotplate with interconnections (a) Electrode side and (b) Heater side

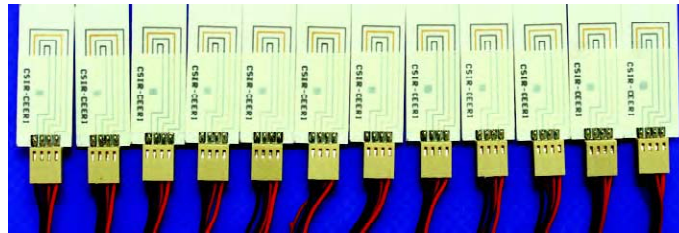


Fig. 5. New version of noble metal electrodes fabricated on ceramic with leads attached

provided. The fabricated electrode structure is shown in Figure 5.

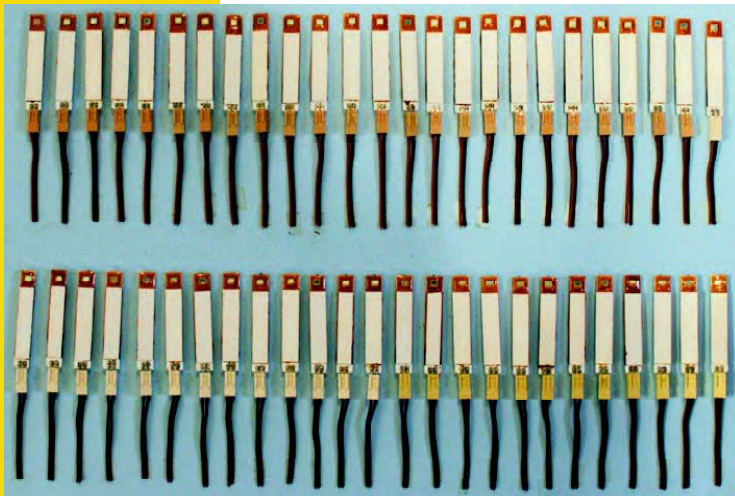


Fig. 6. Packaged EGFET microsensor probes

**Packaging of EGFET Microsensor:** An extended gate field effect transistor (EGFET) is a device used to measure pH of a chemical solution. Four different metal oxide thin films viz.  $Ta_2O_5$ ,  $ZnO$ ,  $SnO_2$  and  $Al_2O_3$  are used for sensing the pH. Packaging of EGFET devices was done using dam and fill technique. The device is packaged in the form of a vertical strip so that the sensing part can be easily dipped in the chemical solution for pH measurement. The conductor lines and conductor pads are printed using thick film Palladium-Silver paste. The complete packaging process involves a series of steps including die bonding, wire bonding, capping, encapsulation, etc. The packaged device can be easily connected externally with

commercially available MOSFET to measure the pH. Fifty packaged EGFET microsensor probes were handed over to CECRI, Karaikudi for testing and evaluation (Figure 6).

#### Sensor Module in LTCC:

Earlier, a version of sensor module had been fabricated incorporating two ASICs for differential pressure sensors, whereas the new version is based on a single ASIC for absolute pressure sensor. In the new version, the number of components has been decreased, thereby; the performance and reliability of the device has been significantly improved.

Absolute pressure sensor developed by MEMS research team and ASICs developed by the IC Design research team of CSIR-CEERI were integrated using indigenously developed LTCC technology. The module was tested up to 25 bar of pressure and also for a pressure range of 1-5 bar. The complete LTCC sensor module and the various stages of its fabrication are depicted in Figure 7.

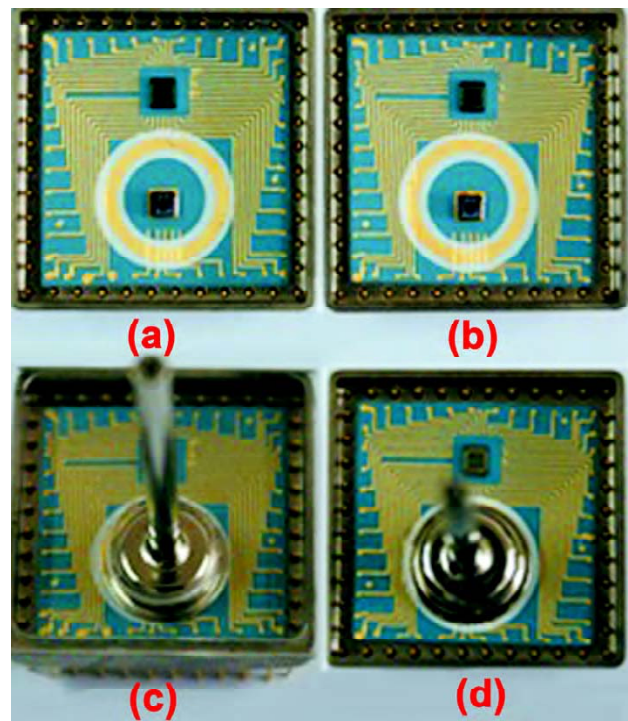


Fig. 7. Pressure sensor module fabricated using LTCC technology (a), (b) before sealing, and (c) (d) after sealing

# In Search of new Solvent Systems for Bio-macromolecules towards Preparation of Functional Materials



Natural biopolymers have many advantages over their synthetic counterparts in terms of biodegradability, biocompatibility, sustainability, easy and cheaper processibility, etc. To establish these readily available bio-macromolecules as possible building block materials for the preparation of new and advanced materials of practical applications, the main issue that needs to be addressed is the solubility of the biopolymers in suitable solvent systems in substantial amounts. Many of the well known biopolymers such as starch, agarose, carrageenan, chitosan, sodium alginate, DNA, etc., are soluble in aqueous medium at elevated temperatures or at room temperature. However, biopolymers like cellulose, chitin, etc. need special binary solvent systems for solubilization.

The existing solvent systems suffer from drawbacks such as lengthy dissolution time, low thermal stability, structure instability in harsh pH situation, toxicity of the solvents and so on eventually limiting the applications of the potential resources for advanced material preparations.

Due to well known and widely documented unique properties such as low vapour pressure, high boiling point, ability

to break hydrogen bonds, recyclability, tunable physical and chemical properties etc., ionic liquids (ILs) and deep eutectic solvents (DESs) could be the choice as solvents when an alternative solvent system is sought for biopolymers. We have designed new types of bio-based ionic liquids consisting of plant growth regulators as anions and DESs obtained by heating mixture of choline chloride and urea/thiourea/ethylene glycol/glycerol/mannitol/sorbitol, etc. (Figure 1).

Solubility of DNA in the bio-based ionic liquids shown in Figure 1 was investigated. It was observed that the biomolecule was soluble in choline indole-3-acetate and choline indole-3-butyrate up to 3.5% and 2.5% *w/w* in 6 h at room temperature. No structural degradation of the molecule was observed for the sample solubilised in choline-indole-3-acetate (chol-IAA). However, the molecule was found to be degraded in choline-indole-3-butyrate (chol-IBA).

It was conferred that, the DNA bases interacted with the choline moiety via cation- $\pi$  interactions. In the case of chol-IAA, the cationic group interacted with the phosphate groups of DNA and cation- $\pi$  interaction

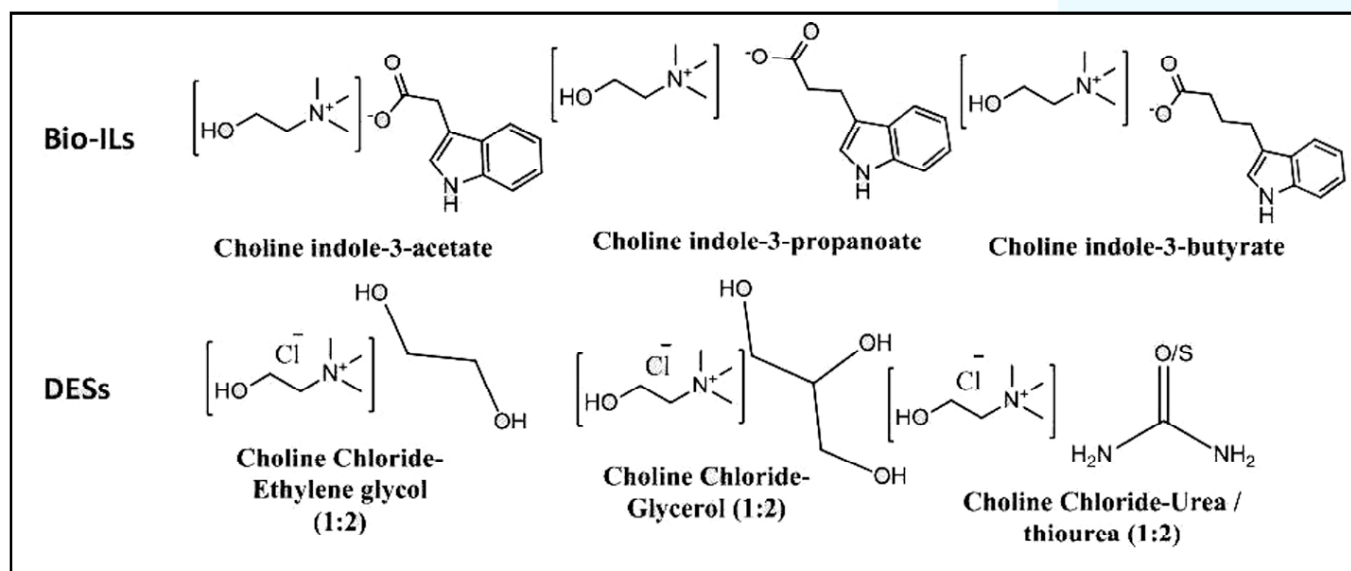


Fig. 1. Chemical structure of few bio-ionic liquids and deep eutectic solvents used in the study

prevailed among the IAA and DNA bases making the molecule soluble in the ionic liquid. In the case of chol-IBA, although the above interactions made the molecule to solubilise in the IL, perhaps the geometry of IBA did not favour the chemical and structural stability of DNA.

Upon further research, the DNA was found to be soluble in the DESs consisting of the mixtures of choline chloride and glycerol (choCl-Gly 1:2) and ethylene glycol (choCl-EG 1:2) upto 2.5% *w/w* in 6 h and 5.5% *w/w* in 2 h respectively at room temperature (Figure 2). Here too, chemical and structural stability of the DNA molecules were observed during the dissolution process.

Further, the chemical and structural stability of DNA stored in the solvents at room temperature (30°C) for six months was also established. The regenerated DNA from the DESs was found to be stable in wide range of pH and temperature.



Fig. 2. Dissolution of DNA in deep eutectic solvents, recyclability and reusability of the solvent

Furthermore, recyclability of the DESs with very high yield (90-92%) for three consecutive reuses in the dissolution of DNA was established.

DESs consisting of the mixtures of choline halide (chloride/bromide)-urea, choline chloride-thiourea, chlorocholine chloride-urea and betaine hydrochloride-urea were found to be effective solvent systems for the dissolution of  $\alpha$ -chitin, the second most abundant biopolymer after cellulose (Figure 3).

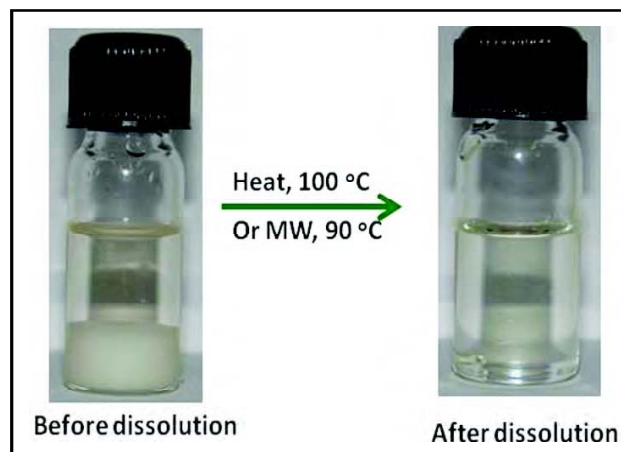


Fig. 3. Dissolution of  $\alpha$ -chitin in a deep eutectic solvent prepared by heating the mixture of choline chloride and urea

The dissolution of the biopolymer in the DESs was carried out by conventional heating, heating under microwave irradiation and heating assisted by ultrasonication under an inert atmosphere. Microwave and ultrasonication helped to reduce the time and temperature required for dissolution. Maximum dissolution of the biopolymer (9% *w/w*) was observed in the DES consisting of choline chloride-thiourea. No remarkable degradation of chitin during the dissolution process was observed, which showed a positive indication for the wider application of the solvent systems for chitin.

Further, in subsequent developments DESs consisting of the mixtures of choline halide (chloride/bromide)-urea and choline chloride-thiourea were used as solvents to prepare  $\alpha$ -chitin nanofibers (CNFs). CNFs of diameter 20-30 nm could be obtained using the DESs comprising of the mixture of choline chloride and thiourea. The CNFs thus obtained were used to prepare calcium

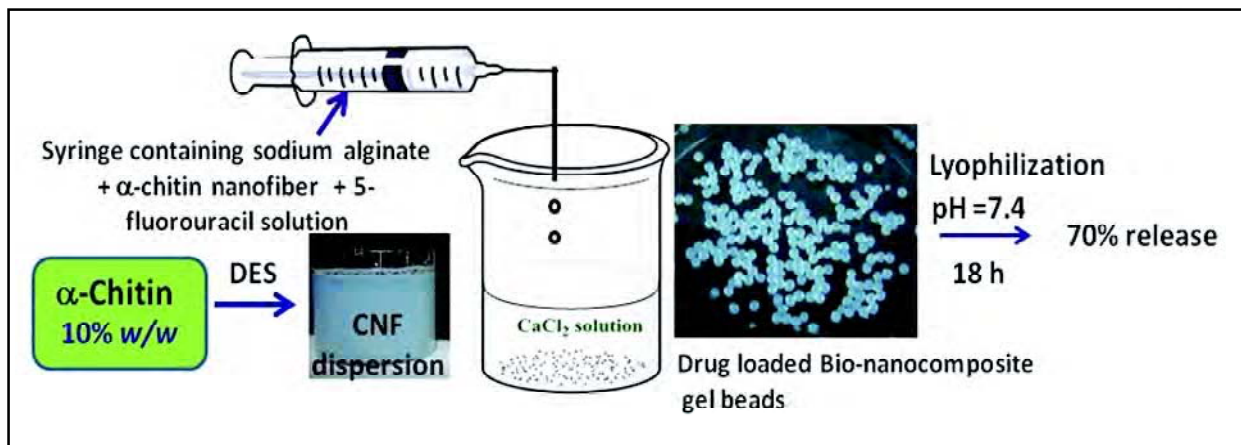


Fig. 4. Preparation of 5-fluorouracil embedded chitin nanofibers-calcium alginate nanocomposite gel beads

alginate bio-nanocomposite gel beads having enhanced elasticity in comparison to Calcium-alginate beads. The bio-nanocomposite gel beads thus obtained were used to study slow release of 5-fluorouracil, an anticancer drug (Figure 4) at pH 7.4.

In order to prove the suitability of bio-based DESs for the functionalization of DNA, the giant bio-macromolecule was functionalized using iron oxide ( $\text{Fe}_3\text{O}_4$ ) nanoparticles and protonated layered dititanate sheets ( $\text{H}_2\text{T}_2\text{O}_5 \cdot \text{H}_2\text{O}$ ) in a deep eutectic solvent (obtained by heating the mixture of choline chloride and ethylene glycol in 1:2 molar ratio). The hybrid material thus obtained showed magnetic and antibacterial properties against both gram positive (*Bacillus subtilis*) and gram negative bacteria

(*Escherichia coli*, *Shigella flexineri*, *Pseudomonas fluorescens*) (Figure 5a).

Further, it was found that Ti sheets interacted with the phosphate moieties, while Fe interacted with the base pair of DNA in the hybrid material (Figure 5b). Further, the structural and chemical stability of DNA in the hybrid material was also observed.

To test antibacterial properties of the hybrid material, colony formation unit (CFU) was calculated after overnight incubation at 37 °C and result in CFU/mL (mean  $\pm$  SD) was calculated. In LB agar plate, difference of one logarithm was observed in CFU of *P. fluorescens*, *S. flexineri* and *B. subtilis* containing 5 mg/mL of hybrid material in comparison to the control sample. No bacterial colony was observed after overnight incubation in

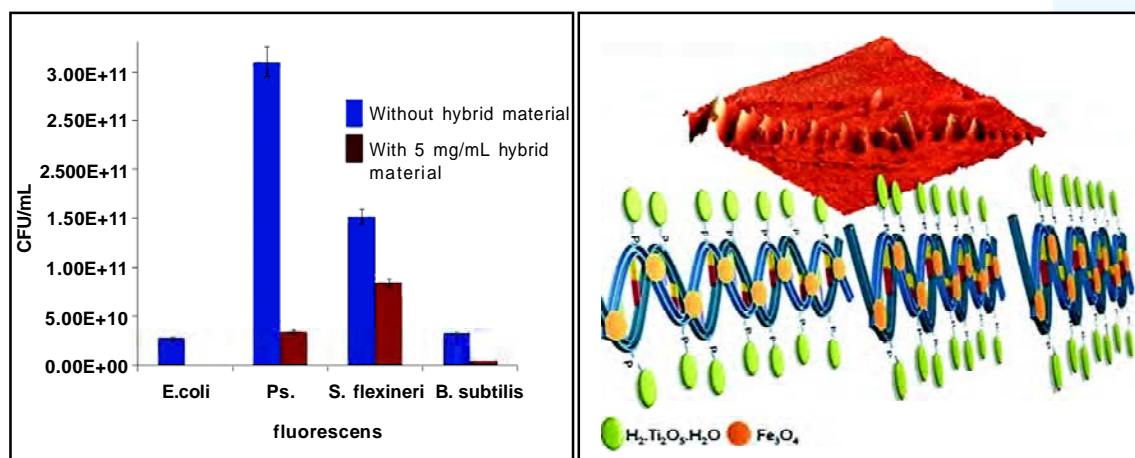


Fig. 5. (a) Bar diagram showing antibacterial property of the dual functionalized DNA; (b) Schematic outlay for the DNA based hybrid structure showing attachment of Fe and Ti sheets in the structure. The top inset picture is the atomic force microscopic (AFM) image of the hybrid, where Fe particles are seen to be orderly arranged.

comparison to the control sample in *E. coli* (Figure 5a).

Further, the LB containing only DNA did not inhibit growth of the bacterial colonies, which confirms that antibacterial activity was the signature of the hybrid material formed by the dual functionalization of the DNA. Microscopic images of all the bacteria culture showed distinct differences in the morphology of the colonies after treatment with the hybrid material. Visible cell rupture was observed in the gram stained bacterial colonies of all the bacteria. The AFM image of the bacterial colonies before and after treatment shows distinct change in the morphology of the bacterial colonies. The bacteria colony of *E. coli* showed thread-like morphology with height about 44 nm. After treatment with the hybrid material, perhaps due to the cell rupture the bacteria cells the morphology changed with the height about 500 nm (Figure 6). This type of material would be used in biomedicine for diagnostic applications and as biosensors.

In summary, we have established ionic

liquids and deep eutectic solvents as suitable alternatives to conventional solvent systems for the solubilization of a few biopolymers in substantial amounts. These new solvents are suitable for the preparation of functional new materials.

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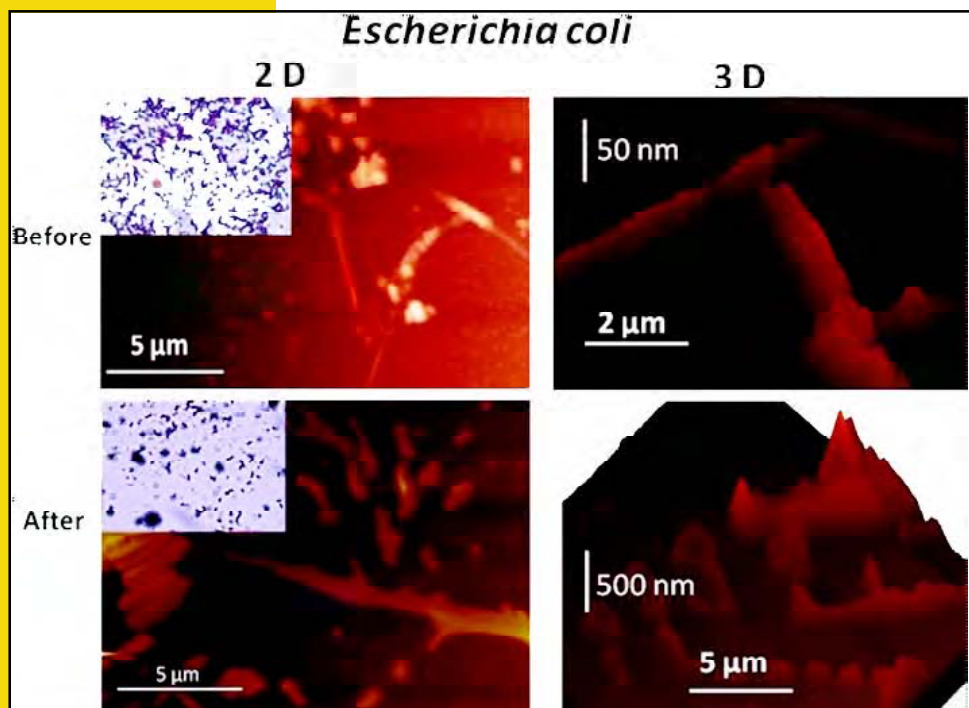


Fig. 6. AFM image of *E. coli* bacteria culture before and after treatment with the dual functionalized DNA nanocomposite, inset is the optical microscopic image of the bacteria culture at 100 X magnification.

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## CSIR-CBRI Signs MoU with University of Petroleum Studies, Dehradun



The MoU being signed between CSIR-CBRI and UPES

A memorandum of understanding was signed between CSIR-Central Building Research Institute, Roorkee and University of Petroleum and Energy Studies, Dehradun on 11 February 2014. The MoU details the modalities and general conditions regarding collaboration between CBRI and UPES for enhancing availability of highly qualified manpower in the area of civil engineering, building science and

technology, engineering geology, architecture and planning and other areas of engineering.

The MoU is aimed at encouraging academic interaction between CBRI scientists and UPES faculty members and students with provisions to share their respective important R&D facilities.

The duration of MoU initially shall be a period of five years from the effective date.

## CSIR-IICT Signs MoU for Research on New Cancer Drugs

The CSIR-Indian Institute of Chemical Technology (IICT), Hyderabad has signed an MoU with Dortmund University, North Rhine-Westphalia, Germany for research in cancer drugs. The MoU will help in developing cancer drugs, said IICT chief scientist



Dr S Chandrasekhar. Dortmund University is closely working with the Max-Planck's Drug Discovery and Development Centre, Germany in stem cell research.

**Conference****Eighth Asia-Pacific Conference on Wind Engineering (APCWE-VIII) at CSIR-SERC**

The Eighth Asia-Pacific Conference on Wind Engineering (APCWE-VIII) was successfully organised by the CSIR-Structural Engineering Research Centre (SERC) at Chennai, during 10-14 December 2013, under the Chairmanship of Prof. Nagesh R. Iyer, Director, CSIR-SERC.



Prof. Kishor C. Mehta delivering valedictory address

The conference has its legacy starting with the first event held at Roorkee, India (1985), moving to Beijing, China (1989), Hong Kong, China (1993), Gold Coast, Australia (1997), Tokyo, Japan (2001), Seoul, Korea (2005) and Taipei, Taiwan (2009). The conference is convened every four years and CSIR-SERC had the privilege of hosting the event in India after 28 years.

The Patron of the conference was Prof. Samir K. Brahmachari, the then Director General, CSIR, and Secretary, DSIR, Government of India.

The conference was held at Hotel Green Park, Chennai. There were 298 registered participants including 124 students representing 16 countries.

The conference was inaugurated by the Chief Guest, Honourable Member, National Disaster Mitigation Authority (NDMA) Shri Bhattacharjee.

Prof. Nagesh R. Iyer, Chairman, APCWE-VIII welcomed the participants and media personnel and briefed the gathering

about the significance of the conference. He emphasised the fact that the world is focussing on harnessing Wind Energy as well as mitigating the effects of cyclonic wind storms and other extreme wind events.

Shri Bhattacharjee delivered the inaugural address, wherein he mentioned about the role of modern technology in providing early warning systems during cyclones, which could greatly facilitate in reducing loss of human lives. He also stated that cyclone shelters constructed along the coastal regions had saved lives of lakhs of people even during the recent cyclone “Phailin” in India.

The inaugural function had Prof. Yukio Tamura, President, International Association for Wind Engineering (IAWE) and Prof. Prem Krishna, Founder President, Indian Society for Wind Engineering and Vice-President, Indian National Academy of Engineering (INAE) as guests of honour. Prof. Yukio Tamura briefed about various activities in the field of wind engineering at international level, while Prof. Prem Krishna discussed about the Past, Present and Future of Wind Engineering. The conference proceedings was released by the Chief Guest.

Out of 161 contributory papers, around 136 papers were presented in the conference in 25 technical sessions. There were 12 Keynote presentations and 4 invited presentations by eminent speakers from all over the world.

More contributory papers were presented under the theme of Low and high Rise Buildings (LHB) followed by Computational Fluid Dynamics (CFD) and Wind Energy (Weg). Nonetheless, Boundary Layer Wind Tunnel Testing (BLWT) and Wind Disaster Mitigation (WDM) themes also attracted good number of researchers.

The technical sessions were followed by the official valedictory function of the conference. The Chief Guest of the

valedictory function was Prof. Kishor C. Mehta, Director, Hazard Mitigation and Structural Engineering Program, National Science Foundation, USA. In his valedictory address, he emphasised three key aspects, viz, “resilience, adaptability and sustainability” to be considered by young researchers in their future as these three parameters would lead to better environment.

Prof. Nagesh R. Iyer, Chairman, APCWE-VIII, briefed about the intense knowledge sharing that took place during the conference, giving it a completely new dimension. He also mentioned that every presentation was being assessed for probable publication in the *Journal of Wind Energy* as well as *Journal of Structural Engineering*. This was a unique initiative taken by the organisers



**Release of Conference Proceedings**

of APCWE-VIII. He congratulated the organisers for the successful conduct of the event.

### **Meetings**

## **First Annual Meeting of Society of Biological Chemists–India (SBC-I) North East Chapter & Symposium on “Science Trends” held at CSIR-NEIST**

The first annual meeting and symposium of Society of Biological Chemists (India) North East Chapter was held at the CSIR-North East Institute of Science & Technology, Jorhat, Assam on 22 February 2014. The President of the Society Biological Chemists (India) along with the renowned Professors and Scientists from all the eight states of North East India attended the meeting.

The topics related to metagenomics, biomolecular aspects of cancer, Chronic Obstructive Pulmonary Disease (COPD), medicinal plants, crop improvement through genetic engineering, barcoding, implications of toxic heavy metals in health, microbe and plant based biomolecules, genomics in biodiversity from North East India and application of biotechnology research in Tea were discussed.

Dr. R.C. Boruah, President of SBC (I), North East Chapter gave a brief review about the history of SBC (I) and called it the longest surviving society of biological

chemists in India. He highlighted the symposium as a significant occasion for the Institute because it brought leading scientists of North East India onto an open forum.

Dr. B.G. Unni, Convenor of the Society of Biological Chemists, SBC (India) NE chapter talked about the history of the society’s North East chapter and also mentioned how its activities were sustained and strengthened over the years.

Prof. D. Chattopadhyay, President SBC (I) addressing the gathering stated that it was a historic moment for all as the meeting was held in the auditorium, which was built in the memory of the founder of SBC (I), North East Chapter and also appreciated the efforts taken by the chapter for having such a scientific gathering at Jorhat.

Dr. D. Ramaiah, Chairman of the Organising Committee expressed his happiness at having such a gathering from the states of NE India at CSIR NEIST, Jorhat. He also mentioned that the scientific

In his valedictory address, he emphasised three key aspects, viz, “resilience, adaptability and sustainability” to be considered by young researchers in their future as these three parameters would lead to better environment.

interactions with experts from the NE region will be very useful for taking collaborative projects utilizing the regional resources.

Two technical sessions were held immediately after the inaugural session and the first session was jointly chaired by Prof. D. Chattopadhyay Pro-Vice Chancellor Calcutta University and Prof. Anupam Chatterjee, Biotechnology & Bioinformatics, North Eastern Hill University Shillong, respectively.

Prof. D. Chattopadhyaya in his keynote lecture spoke on the subject related to the metagenomic analysis of petroleum hydrocarbon degrading microbial community. Their team has also initiated studies on a crude oil contaminated soil from North-East India. The resident microbial consortia operating on the petroleum hydrocarbon pollutants in the soil, a metagenomic approach were studied. 16S rRNA clone libraries were prepared for bacteria and archaea followed by capillary sequencing of the same.

Prof. Sankar Ghosh from the Assam University, Silchar gave a brief talk on Genomics in Biodiversity from North East India. His team has generated large-scale data on popular molecular markers from mitochondrial and chloroplast genome to assign the Genomics based DNA-Passport

and Genomic Diversity to explore the species identification and validation of diverse flora and fauna which includes different Indian fishes, catfishes, mahseer, ornamental fishes, testudines, endemic and economic animals, etc. The cancer genomics of head and neck (HNSCC), esophageal (ESCC), nasopharyngeal (NPC), colorectal (CRC) and breast cancers were also studied in view of identification of molecular markers based on Genomics.

Dr. B.G. Unni, Chief Scientist along with Tapan Dey, research scholar CSIR-NEIST Jorhat talked about the biochemical and molecular aspects related to Chronic Obstructive Pulmonary Disease and gave more stress on the increasing health risks due to occupational and environmental exposures to persistent environmental contaminants and heavy metal emissions. He also mentioned about the series of experiments conducted to evaluate the coal dust “exposure-response” relationship amongst the people residing very near to the open cast coal mine area.

Prof. A.K. Mukherjee from Tezpur Central University discussed more details about snake venom, molecular aspects of snake venom and also cardiovascular drug development from microbial resources of NE India.



A group photo of the participants at the SBC-I NE Chapter meeting in Jorhat

Dr. B.K. Sarma, Director, DBT Centre, Assam Agricultural University discussed about the crop improvement programme using genetic engineering research at Assam Agricultural University. He also talked about the introduction of insect resistance gene(s) into chickpea using gene technology. Apart from the findings, his group also generated transgenic lines in pigeon pea using Bt genes to confer protection against pod borers.

The second technical session was jointly chaired by Dr. B.G. Unni, Chief Scientist & Area Coordinator (Biological Sciences) and Prof. A.K. Mukherjee, Professor of Molecular Biology & Biotechnology respectively.

While Dr. Samir Sil of Tripura University talked about anticancer and immunomodulatory activity of *P. javanica*, Dr. Ajaikumar B. Kunnumakkara of IIT, Guwahati talked about the alternate methods for accelerating cancer drug discovery & development. Dr. Thiyam Ramsing Singh, Ramalingaswamy Fellow of Manipur University gave a lecture on Fanconi Anemia Pathway (FA) and Interstrand Cross links (ICL) pathway repair, implication in cancer therapy.

Dr. Mahuya Sengupta from the Assam Central University talked about immunobiological and health implications of toxic heavy metals in human infertility. Dr. D.N. Das of Rajiv Gandhi University, Arunachal Pradesh about application of biotechnology in fish. Meanwhile, Dr. P.K. Bhardwaj from the Regional Centre of IBSD, Sikkim gave a brief talk on understanding the molecular dynamism of endophytism in medicinal plants. Dr. Tanoy Bandhopadhyay, Scientist from Tocklai Research Association spoke about the applications of biotechnology based research in tea and the various research activities undertaken at Tocklai Research Institute.

Finally, Dr. D. Ramaiah, Director and Dr. R.C. Boruah, Outstanding Scientist, thanked all the speakers for their presence and sharing the research activities undertaken by them in the area of molecular biology, biochemistry, biotechnology utilizing the regional resources. They said that the institute would extend all infrastructure facilities to undertake collaborative research works utilizing regional resources from NE region.



### Training Programmes/Workshops

## Training course on “Classical and Modern Methods in Plant Taxonomy and Biosystematics” inaugurated at CSIR-NBRI

There are only a few active centres in India where researchers are being trained in plant taxonomy and biosystematics. There is a constant declining trend in taxonomic research as well as taxonomists the world over. This concern has been expressed not only in India but the world over by eminent biologists.

Considering the increasing demand for more trained taxonomists to resolve the issues of biodiversity inventorying, conservation, monitoring and managements, it is important that taxonomy-based institutes in India take stock of the situation, and find



Dr. S.K. Jain delivering the inaugural lecture

out appropriate solutions by organizing training courses on various aspects of traditional and contemporary plant taxonomy and biosystematics. It is in this context that CSIR-National Botanical Research Institute, Lucknow organized a ten-day training course on “Classical and Modern Methods in Plant Taxonomy and Biosystematics” from 3-12 March 2014.



Training course material being released by Dr. S.K. Jain and Dr. C.S. Nautiyal

Dr. S.K. Jain, an eminent taxonomist and Former Director of the Botanical Survey of India, Kolkata was the Chief Guest of the Inaugural Function on 3 March 2014. During his inaugural speech, he emphasised the need and importance of plant taxonomy in the country.

The Director of CSIR-NBRI, Dr. C.S. Nautiyal in his welcome address encouraged the participants to utilize the opportunity of this training course to sharpen their skills in plant taxonomy. About 40 participants from various institutions, colleges, universities, and other departments representing 13 states like Andhra Pradesh, Assam, Haryana, Gujarat, Himachal Pradesh, Karnataka, Manipur, New Delhi, Sikkim, Tamil Nadu, Uttar Pradesh, Uttarakhand, and West Bengal participated in this training course.

The main aim of this training course was to inculcate interest in young students and faculties for plant taxonomy in the country. There were 30 lectures and a series of practical demonstrations in different groups of plants like Algae, Lichens, Bryophytes, Pteridophytes, Gymnosperms, Angio-sperms and Molecular Systematics, covering basic and applied aspects of plant systematics.

## RLA-2014 concludes at CSIR-NML

The third edition of Remaining Life Assessment (RLA-2014) concluded at CSIR-National Metallurgical Laboratory, Jamshedpur. During the course of the workshop burning issues namely Creep behaviour; Damage assessment of components used in power plant and petrochemical industries using different indigenous tools including NDE techniques; Plant failure analysis; Microstructural evolution in power plant materials during creep/service exposure; Electromagnetic techniques such as MagSys/MagStar; Portable Automated Ball Indentation (PABI) technique; Non-linear Ultrasonic device, and industrial case studies were also addressed.

The participants also visited the creep bay and interacted with the scientists. A

number of NDE tools and software databases, other technical facilities, etc. were also demonstrated to the visiting members.

During the valedictory session five group representatives from the participants presented their feedback on behalf of the team. The group covered areas like materials, components, operation conditions, facilities and services, partnership and collaboration, opportunities for further improvement, and enlightenment and focus on other critical components. Several plant safety measures and related issues were discussed.

Representatives from all the participating organizations namely, M/s Thermax Ltd., Pune; Sasan Power Ltd.; M/s TATA Power; M/s MRPL, Mangalore; M/s BPCL, Mumbai; M/s Mailam India Ltd., Pondicherry; M/s

CPRI, Nagpur; M/s Heavy Metal, Gujarat; M/s Essar Steel, Gujarat; M/s Bharat Forge, Pune; M/s NTPC, Noida; M/s TATA Steel; M/s Electrical Research & Development Association, Gujarat; M/s HAL, Koraput;

and M/s Kalyani Carpenter Special Steel Ltd. took part in the feedback session. The participants also requested to organize similar workshops with a longer duration as it served as an eye opener for many critical issues.



Glimpses of the event



## Diamond Jubilee Celebrations

# CSIR-NBRI Celebrates its Diamond Jubilee

CSIR-National Botanical Research Institute (NBRI), Lucknow where plant based research touches life through innovation, celebrated its Diamond Jubilee in 2013. The year witnessed a series of galvanizing and thought provoking lectures by luminaries from the field of research, academics and management.

A summary of these lectures, along with progress of the institute in various R&D areas during the past decade was compiled in the Diamond Jubilee Commemoration Volume, which was released by the Vice President of India Mr. M. Hamid Ansari at

Vigyan Bhawan, New Delhi on 22 February 2014. The book was released in the presence of Dr. Murlu Manohar Joshi, Member of Parliament & Ex-Minister of Science & Technology, Government of India and Dr. C.S. Nautiyal, Director, CSIR-NBRI, Lucknow.

The Diamond Jubilee Commemoration Volume presents an update of the plant science research programmes carried out at NBRI during 2003-2012. The book highlights the basic and applied research as well as the people-centric outreach programmes undertaken by different R&D Units of NBRI.

It also includes Diamond Jubilee Lectures, including the inaugural address by Dr A.P.J. Abdul Kalam, Former President of India, followed by 31 chapters outlining recent success stories of NBRI in the fields of exploration and documentation of plant diversity; prospecting plant diversity for new herbal products and for innovative technologies for bio-remediation of toxic metals and biodegradation of petroleum sludge and pesticides; bio-inoculant technologies for improved soil fertility and increased crop yields; metabolite engineering in medicinal and plants of other



CSIR-NBRI Diamond Jubilee Commemoration Volume being released by Vice President of India, Mr M. Hamid Ansari

economic interests; genetic improvement in plants through genetic engineering; development of new plant varieties and their agro-technologies, and several outreach programs.

### National Science Day Celebrations

## CSIR-Central Building Research Institute (CBRI), Roorkee

The CSIR-Central Building Research Institute (CBRI), Roorkee celebrated the National Science Day on 28 February 2014. On this

occasion, a poster competition was organised at the institute in the morning session for the young scientists, students and Project Fellows



Snippets of the function



of the institute. The young researchers presented their novel scientific ideas in the field of building science and disaster mitigation through posters.

The titles of the posters were Retractable Petals Building Envelope, Adaptable House for Flood-prone and Low-lying Areas, Buildings Inspired by Nature, Graphene and Spider Silk Composite Fibre, Magnetic Building, and Rain-electro Generator.

The competition was adjudicated by the Chief Guest of the function, Prof. D. Goldar, former Principal of Delhi College of Engineering, New Delhi and Prof. S.K. Bhattacharyya, Director, CSIR-CBRI. The

posters on themes Retractable Petals Building Envelope and Magnetic Building won the 1<sup>st</sup> and 2<sup>nd</sup> prize, respectively. The other four presentations got the consolation prize.

In the afternoon, Prof. S.K. Bhattacharyya expressed his views about the National Science Day and the significance of “Fostering Scientific Temper”, which was the theme of the year 2014. This was followed by the National Science Day lecture on “Elastic Wave Propagation in Transversely Impacted Beams” by Prof. D. Goldar. On this occasion, a documentary film on “Confined Masonry Construction” by CSIR-CBRI was also released.



## CSIR-Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow

The National Science Day was celebrated on 28 February 2014 at CSIR-Central Institute of Medicinal and Aromatic Plants (CSIR-CIMAP), Lucknow. A large number of scientists and students were present on the occasion.

Prof. R.C. Sobti, Vice Chancellor, Babasaheb Bhimrao Ambedkar University, Lucknow was the chief guest on the occasion. Prof. Sobti delivered the “Science Day” lecture on developing India as a knowledge society. Speaking on the occasion, he emphasized the need for strengthening science education at all levels. Prof. Sobti also exhorted the scientists and students to spare some time for thinking as thinking brings new ideas which lead to innovation in research.

Prof. Sobti also visited CIMAP’s Manav Upavan and interacted with the scientists.

In his welcome address Prof. Anil Kumar Tripathi, Director, CSIR-CIMAP said that after attaining leadership in menthol mint production, the Institute is in the process of selecting some other economically important medicinal and aromatic plants in which India can be a leader in the world. CIMAP is formulating the strategy for the furtherance of research and outreach programmes for enhancing the income of poor farmers.



Prof. Sobti delivering Science Day Lecture



Prof. Tripathi presenting memento to Prof. Sobti

The Institute remained open for general public including students on this occasion.

## CSIR-Institute of Himalayan Bioresource Technology (IHBT), Palampur

The National Science Day was celebrated with great enthusiasm at CSIR-IHBT, Palampur on 28 February 2014.

Mr. Avtar Singh Dindsa, CEO, Beauscape Farm, Sangrur (Punjab) and President of the Asia and Pacific Seed Association (APSA) delivered the Keynote lecture on “*Science for Every Farmer*”. He emphasized the importance of science in creating job opportunities in rural areas. He exhorted farmers of Himachal Pradesh to diversify agriculture instead of growing non-remunerative traditional crops. He

expected that the scientists and technologists in India would rise to the occasion and develop standard operation practices for enhancing per unit income of the farmers. Mr Dindsa suggested that the focus should be on exploring possibilities of growing niche crops for value-added diversification in agriculture. Mr. Singh also suggested studying market opportunities and demand with the focus on supply situation for which marketing federations need to be created.

Dr. P.S. Ahuja, Director, CSIR-IHBT felicitated Mr. Avtar Singh for taking Indian floriculture to new heights on the international forum. Dr. Ahuja suggested that the young generation scholars and researchers should be creative so as to become competent for creating jobs rather than seeking jobs.

Dr. Naresh Kumar, Dean (Academics) D.A.V. University, Jalandhar opined that our nation as a whole is lacking innovative attitude which will only come when the younger generation develop the habit of reading and travelling for the quest of knowledge.

Prof. S.K. Sharma, Emeritus Scientist and former Vice Chancellor of CSK-HPKV, Palampur presided over the function and highlighted the necessity and approach for fostering scientific temper in the country.

The function was attended by students from S.C.V.B., Govt. Degree College, Palampur and distinguished guests from CSK-HPKV, State officials, eminent citizens, Press and Media.



A view of the dais



Dr. P.S. Ahuja felicitating Mr. Avtar Singh Dindsa

## CSIR-Indian Institute of Toxicology Research (IITR), Lucknow

The CSIR-Indian Institute of Toxicology Research (IITR), Lucknow celebrated the National Science Day on 28 February 2014. The day was observed as an “Open Day” at the institute which threw open its gates to school/college students and citizenry of the city.

The celebrations began with a popular

science lecture entitled *Chemistry – A Discipline with Diverse Applications* delivered by Prof. T.K. Chandrashekar, Secretary, Science and Engineering Research Board, Department of Science and Technology, New Delhi. Prof. Chandrashekar described the wide applications of Chemistry in our

daily lives. He opined that Chemistry plays the role of a “Mother Subject” to the different scientific disciplines. It plays a vital role in living systems, industry, health care, pharmaceuticals, diagnostics and advanced materials to name a few. Some chemicals like nitroglycerine have interesting dual roles as an explosive and as a drug for treatment of angina.

The technology of Magnetic Resonance Imaging that draws heavily from Chemistry has received the highest scientific recognition, the Nobel Prize in the areas of Physics, Chemistry and Medicine, he said. He summed up his talk enumerating the contributions of Dr. Mahenderlal Sircar, Dr. Homi J. Bhabha, Dr. Vikram Sarabhai and Sir C.V. Raman.

Prof S.P. Gautam, Member, Madhya Pradesh Public Service Commission, presided

over the function. In his address, he emphasized the existence of a scientific temperament in our country from time immemorial. A very convincing parallel was drawn between the Sri Ramacharitra Manas and every day science. He also suggested areas for contribution by CSIR-IITR, in sync with the mandate of the institute such as releasing environmental pollution advisories, creation of a GPS-enabled Environment Information Service, etc.

Later in the afternoon, fifty undergraduate science students from Mahila Vidyalaya Degree College visited the institute and were shown a film on the R&D activities of IITR. They were also taken around a few laboratories viz. Food Toxicology, Analytical Chemistry and Nanomaterial Toxicology. The students had a one-to-one interaction with a few scientists.



## CSIR-National Botanical Research Institute (NBRI), Lucknow

The National Science Day was celebrated by the CSIR-National Botanical Research Institute on 28 February 2014. The day was observed as ‘Open Day’ when its various laboratories, viz., Exposition, Herbarium, Library, Botanic Garden, and R&D Laboratories were visited by a large number of students drawn from various local schools and colleges.

On this occasion, Prof. R.K. Khandal, Vice-Chancellor, Uttar Pradesh Technical University, I.E.T. Campus, Sitapur Road, Lucknow, was the Chief Guest of the function and delivered the National Science Day Lecture. Distinguished guests, Scientists, staff of CSIR-NBRI, researchers and a number of students were present on the occasion.

In his welcome address, Dr. C.S. Nautiyal, Director, CSIR-NBRI said that the Institute has made commendable progress in research in the past few years.

Prof. R.K. Khandal, in his lecture entitled ‘Nanomaterials for Advanced Applications’ said that nanomaterials, the building blocks of nanotechnology, are regarded as one of the



*Glimpses of National Science Day*



key materials of this century. The benefits derivable from nanotechnology and in turn from nanomaterials are as varied as the

challenges involved in achieving them. For the development of nanomaterials approaches would have to be novel; simple ways would have to be developed to create nanomaterials in a matter-of-fact way.

Since nanomaterials are often more than one-phase systems, creating huge interfaces, modification of surfaces, bringing in compatibility between completely different and diverse phases, size reduction through the free energies available from the systems, etc. are some of the target goals. Materials finding applications in most advanced devices and tools would have to be developed using such approaches. For this, synergistic combinations of materials of different kinds and characteristics would have to be developed. Composite materials having the dispersion of nanoparticles in the matrix of different types would be attempted.

The thought of creating hybrid materials would set in the minds of the scientists world over, whenever there would be the need for extraordinary materials having light-weight but heavy duty.

Using the basic concepts of nanoscience, different types of nanocomposites are being developed. Unique properties of nanocomposites include simulation of phenomena observed in nature such as color change with respect to surroundings (chameleon effect), superior adhesion to surfaces (gecko effect), photochemical conversion of solar energy (photosynthesis), capture and storage of solar energy (trees), high strength materials (spider web), etc. Such nanocomposites in turn have led to the development of devices such as invisibility cloak, metamaterials, combat wear, spider silk, specialty adhesives, coatings etc.

## CSIR-North East Institute of Science & Technology (CSIR-NEIST), Jorhat



Chief Guest Dr. K.M. Bujarbaruah, VC, AAU delivering the Science Day lecture. Also seen sitting is Dr. R.C. Boruah, In-charge, CSIR-NEIST

CSIR-North East Institute of Science & Technology (CSIR-NEIST), Jorhat celebrated the National Science Day 2014 at its premises on 28 February. Dr. K.M. Bujarbaruah, Vice Chancellor, Assam Agricultural University (AAU), Jorhat graced the function as the Chief

Guest.

Guest.

Delivering the National Science Day lecture on *Negating the impact of climate change in agriculture*, Dr. Bujarbaruah said that the Intergovernmental Panel on Climate Change has reaffirmed that climate is changing. He began by talking about what is meant by climate change and climate variability and their adverse impacts. He said according to Maplecroft's Climate Change Vulnerability Index (CCVI), economy of India is at high risk and will be highly affected with the country placed at the 20<sup>th</sup> rank with Bangladesh being the country to be most affected placed at 1<sup>st</sup> rank. He further emphasized that it is time now to shift focus to mitigation measures to

negate the climate change impacts. He talked about initiatives of AAU to combat climate change like bio-prospecting of rice gene to identify the heat-tolerant genes, soil analysis to identify the lacking nutrients which may aid in improving crop productivity, adoption of precision watering and SRI (System of Rice Intensification) to improve productivity. He said it is the need of the hour to rejuvenate the natural resources. He further talked about measures like identification of acid-tolerant gene in microbes which may help as the soil in Assam is mostly acidic, smart farming for small farmers, roof-top cultivation, gene identification in animals for heat and cold temperature tolerance, fish breeding in green house conditions, etc. which may help in combating and negating the impact of climate change.

In the presidential remark, Dr. R.C. Boruah, In-charge, CSIR-NEIST extended his appreciation for the informative lecture delivered by the Chief Guest and briefly highlighted the significance of the day.

The day was also observed as 'Open Day' where a large number of students, teachers and general public visited different R&D departments of the laboratory.

## CSIR-National Metallurgical Laboratory (NML), Jamshedpur



The CSIR-National Metallurgical Laboratory (NML), Jamshedpur celebrated the National Science Day with more than 200 students and 70 teachers from eminent East and West Singhbhum based schools and colleges participating. These included Women's College, Jamshedpur; Aditya Institute of Technology, Jamshedpur; Kerala Samajam Model School, Sakchi; KPS, Burmamines; and Buddha Academy School for Excellence.

A documentary film on Sir C.V. Raman was shown to the participants. The National Science Day is celebrated every year to mark the discovery of the Raman Effect.

Welcoming the gathering, Dr. S. Prakash, NML, Advisor Management said the aim of the National Science day is to enlarge the domain of science ensuring scientific temperament and most importantly creating a conducive environment to attract young minds to have a feel of pride in Indian science.

Prof. B.K. Mathur from the Indian Institute of Technology (IIT), Kharagpur delivered the key lecture on “Roles Teachers Play”. Prof. Mathur said that though teachers are appointed on the basis of their academic records, teaching is a profession of transfer of knowledge. According to Prof. Mathur, there are several characteristics of a teacher. According to him, a teacher should be a good writer, a Manager, a Developer, a Salesperson, a Professional, a Subject expert, a Techno Wizard, and a Counselor. Further, using humor in the classroom a teacher could keep his pupils attentive. Teachers should master the art of planning, coordinating, commanding, controlling, organizing, guiding, coaching and facilitating a topic, he said.

The Chief Guest also visited the laboratory and interacted with the working scientists.

### Flower Show

## Chrysanthemum and Coleus Show at CSIR-NBRI, Lucknow

A two-day Annual Chrysanthemum and Coleus Show was organized by the CSIR-National Botanical Research Institute (NBRI), Lucknow during 7-8 December 2013.

In the Central Lawn, the fresh and dainty Coleus after the dew bath overnight displayed multi-coloured foliage. Besides this, cut flowers and special flower arrangements were also organized in a huge enclosure. The sight of different varieties of flowers elated the visitors comprising every age group. Children enjoyed the flower show along with parents. The main idea to organize the flower show is to promote the floriculture industry and to develop awareness about floriculture. In all, 78 exhibitors participated with 789 entries this year.

The prize distribution function was organized at the open-air theater of the Institute, amidst the swing blooms of vast



A view of the flower show

array of Chrysanthemum and splendid varieties of Coleus scattering colour and joy in the atmosphere. Dr. Harsharan Das, IAS, Principal Secretary, Science and Technology, Govt. of U.P. and Shri Rajan Shukla, IAS, Principal Secretary, Coordination, U.P., were

the Guests of Honour and distributed the prizes to the winners. The function was also graced by Mrs. Neelam Shukla and Mrs. Manju Nautiyal, who joined in distributing the prizes.

A total of 349 prizes (106 First, 110 Second and 133 Commendation) in addition to 22 running challenge cups/shields/trophies were awarded to the successful competitors. HAL, Lucknow occupied the first position by winning a total of 31 prizes (16 First, 7 Second and 8 Commendation) followed by Headquarter, Central Command, Lucknow who stood second by winning a total of 28 prizes (12 First, 8 Second and 8 Commendation). Tata Motors Ltd., Lucknow occupied the third position by winning 19 prizes (4 First, 4 Second and 11 Commendation).

On this occasion, Dr. C.S. Nautiyal, Director, CSIR-NBRI, Lucknow, while welcoming the Guests of Honour said that NBRI has been organizing flower shows

every year since the last four decades. NBRI has been developing a number of new varieties of flowers for the benefit of the public. Till now the Institute has developed 80 new varieties of Chrysanthemum and conserved 225 types of germplasm.

Dr. Harsharan Das, in his address, congratulated CSIR-NBRI for its contributions in the field of floriculture, especially in developing several varieties of chrysanthemum. Appreciating the development of floriculture in Uttar Pradesh, he said that still a lot needs to be done in this sector if it has to compete in the international market.

Mr. Rajan Shukla commended the efforts of NBRI in organizing this flower show and said that such types of shows help in promoting awareness among the public so that they can upgrade their skills in this field. He also underlined the need to take care of the economic prospects of floriculture as well as medicinal and aromatic plants.



## Appointments

### Dr. Amod Kumar takes over as Acting Director of CSIR-CSIO

Dr. Amod Kumar, Chief Scientist has taken over as Acting Director of the CSIR-Central Scientific Instruments Organisation (CSIO), Chandigarh.

Dr. Amod Kumar did his B.E. (Hons.) in Electrical and Electronics Engineering from Birla Institute of Technology and Science, Pilani; M.E. in Electronics from Punjab University, Chandigarh and Ph.D. in Biomedical Signal Processing from IIT Delhi. He has more than 34 years of experience in Research and Development of different instruments in the area of Process Control, Environmental Monitoring, Biomedical Engineering and Prosthetics.

Dr. Kumar is currently working as Chief Scientist in the Department of Biomedical Instrumentation. He has more than 40 publications in reputed national and international journals. He has worked at Technical University Berlin for one year on DAAD fellowship in 1987-88. He is Adjunct Professor, Bengal Engg & Science University besides a senior faculty member of Post Graduate programme of Academy of CSIR.

His areas of interest are Digital Signal Processing, Image Processing and Soft Computing.



## Honours & Awards

### Director, CSIR-NIO receives Dr. H.N. Siddique Memorial Lecture Award

Dr. S.W.A. Naqvi, Director, CSIR-National Institute of Oceanography (NIO), Goa was conferred with the Dr. H.N. Siddique Memorial Lecture Award at the 50<sup>th</sup> Annual Convention of Indian Geophysical Union (IGU) held at National Geophysical Research Institute, Hyderabad from 8-11 January 2014. On this occasion, Dr. Naqvi delivered a lecture on *Ocean Iron Fertilization: An update based on LOHAFEX*.

The award is instituted by IGU to honour scientists who have made outstanding contributions in the field of Earth System Science. The award includes a gold medal and citation.

Dr. Naqvi joined NIO in 1976 and has carried out pioneering research on biogeochemical processes in aquatic low-oxygen environments, especially microbially-mediated redox transformations of nitrogen such as denitrification in the seas around India and terrestrial freshwater ecosystems. He demarcated the zone of denitrification in the Arabian Sea, studied its variability in space and time, and determined its rate using several diverse physico-chemical, isotopic and enzymatic techniques. His work provided new insights into processes associated with

suboxic ecosystems, including high respiration rates and associated bacteria-produced nepheloid layers, and mechanisms of nitrous oxide production.

He also demonstrated that human activities are causing an increase of nitrous oxide emission from the oceans. He also successfully led LOHAFEX, the last Ocean Iron Fertilization Experiment, conclusively demonstrating that the potential of this technique for atmospheric Carbon dioxide sequestration is not very large. As per Google Scholar, to date, Dr. Naqvi's work has been cited 4090 times. He has an h-Index of 35 and an i10-index of 69.

Dr. Naqvi is the recipient of several prestigious awards such as the Young Scientist Award by CSIR (1987); Shanti Swaroop Bhatnagar Prize in Earth Sciences (1996); Vigyan Ratna by UP Government (2004); National Award for Ocean Science & Technology (2013) and PSN National Award for Excellence in Science and Technology (2013). He is a fellow of all three national science academies as well as of the Third World Academy of Sciences (TWAS).



Obituary

## Dr. B.R. Nijhawan, First Indian Director of CSIR-NML Passes Away

Dr. Balraj Nijhawan, the first Indian Director of the CSIR-National Metallurgical Laboratory (NML), Jamshedpur, passed away at the age of 98 on 6 April 2014 in Florida (USA).



Dr Balraj Nijhawan was a legend, a visionary and an inspirational leader who laid the foundation of R&D at NML. During his last visit to CSIR-NML, Jamshedpur, Dr. Nijhawan said, “I have been privileged and honored to have lived long enough to be a small part of the history of India, and to have been one of the members of this leading and prestigious international institution. To say that I am proud of my association is an understatement....I am humbled to have had the opportunity as a young man to have experienced the joy and inspiration of the founding fathers of India, and the founding visionaries of the laboratory. NML has been my life and joy.”

Dr. Nijhawan was known for his vision, especially pilot-scale research, for example on mineral processing, low shaft iron making furnace, ferro-alloys, manganese, aluminizing, etc., which helped towards establishing of new plants and/or industrial problem solving in India. His efforts fostered the Indian foundry industry. He developed alloys with the use of indigenously available metals including nickel-free austenitic stainless steels based on Cr, Mn and N systems.

Dr. Nijhawan had been internationally recognized for his work on armour plate development and armour failure and related fields and on control of austenitic grain size of steel. Several research publications, technical reports, patents, books, etc. will always remain to his credit. Many Honours and Awards including Padma Shri (1958) and Bhatnagar Prize (1964) had been conferred upon him.

Dr. S. Srikanth, Director and all the staff of NML condole the sad demise of their beloved guide and philosopher Dr. Nijhawan.

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