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Established in the year 1979 by the Assam Science Society and subsequently supported by the Assam government, IASST was adopted as an autonomous R&D institute by the Department of Science and Technology in March 2009. Research achievement during the year 2014 has been highlighted under its various programmes.

Keywords: Agarwood oil, biosurfactants, carbon dots, fuzzy topological space, optoelectronic devices.

THE Institute of Advanced Study in Science and Technology (IASST), Guwahati, was inaugurated by Nobel laureate Dorothy C. Hodgkin on 3 November 1979. IASST is engaged in multi-disciplinary research activities, both in fundamental and applied fields, spread across five programmes: basic and applied plasma physics, advanced materials science, mathematical and computational sciences, biodiversity and ecosystem research, and traditional knowledge-based drug development and delivery.

Basic and applied plasma physics

Plasma, formed by energizing gaseous phase of matter, is a soup of ions, electrons and neutrals. Plasma is not only abundant in the universe naturally, but also produced in the laboratory to study the theoretical basis of natural phenomena and also for plasma-based material technologies. Basic plasma research in IASST covers waves, instabilities and related phenomena in multicomponent plasma and dusty plasma. In a multicomponent plasma with critical density of negative ions, large amplitude Peregrine solitons were observed as prototype of rogue wave in ocean. Dust acoustic solitons involving dynamics of micron-sized charged particles and their interaction were also investigated in a laboratory dusty plasma[1]. Soliton, a special type of nonlinear wave, was used in the laboratory study as a model to describe behaviour of ocean tsunami waves.

Advanced materials science programme

In advanced materials science, research has been carried out on the development of optoelectronic devices[2–4], sensors[5], electrodes for hydrogen fuel cell[6] and nanomaterials for various applications[7–11].

Development of optoelectronic devices using plasma nanotechnology

Advanced optoelectronic devices from nanomaterials synthesized using plasma-based process were developed. These include thin/ultrathin films of conducting polymer alone or its nanocomposites with metal/metal oxide nanoparticles or some inorganic nanocrystals produced by solvent-free as well as water-free plasma-based processes requiring significantly less number of steps. The main focus is on the fabrication of flexible organic and hybrid photodetectors using nanomaterials developed using plasma process (Figure 1). The bulk heterojunction as well as plasmonic photodetectors exhibited enhanced photo-response, fast on/off switching and exceptional stability at ambient conditions[2,3]. Directly grown carbon nanotubes (CNTs) on transparent conducting oxide (TCO) substrates have also been utilized to prepare hybrid photodetectors which show enhanced sensitivity at low light intensities[4]. Directly grown CNTs on TCO substrate can be utilized as a fruitful application towards the fabrication of hybrid photodetectors using PPani and TiO_2 as photoactive materials, thereby avoiding the lift-off process of CNTs, unlike the traditional methods. Our research also emphasizes on understanding the basic material properties and charge transport properties for the development of advanced devices. The proposed plasma-based method provides a green and dry technology where the self-assembly of molecules, that is, the spontaneous association of atomic or molecular building blocks under plasma environment, emerges as a successful strategy to form well-defined structural and morphological units of nanometre dimensions.

Advanced functional materials based on carbon dots

New classes of carbon nanomaterials that have been recently discovered are carbon dots (CDs). These have attracted enormous attention due to their application in optoelectronic devices, biomedical imaging, biological labelling and drug delivery. These photoluminescent materials are chemically stable, environmentally and

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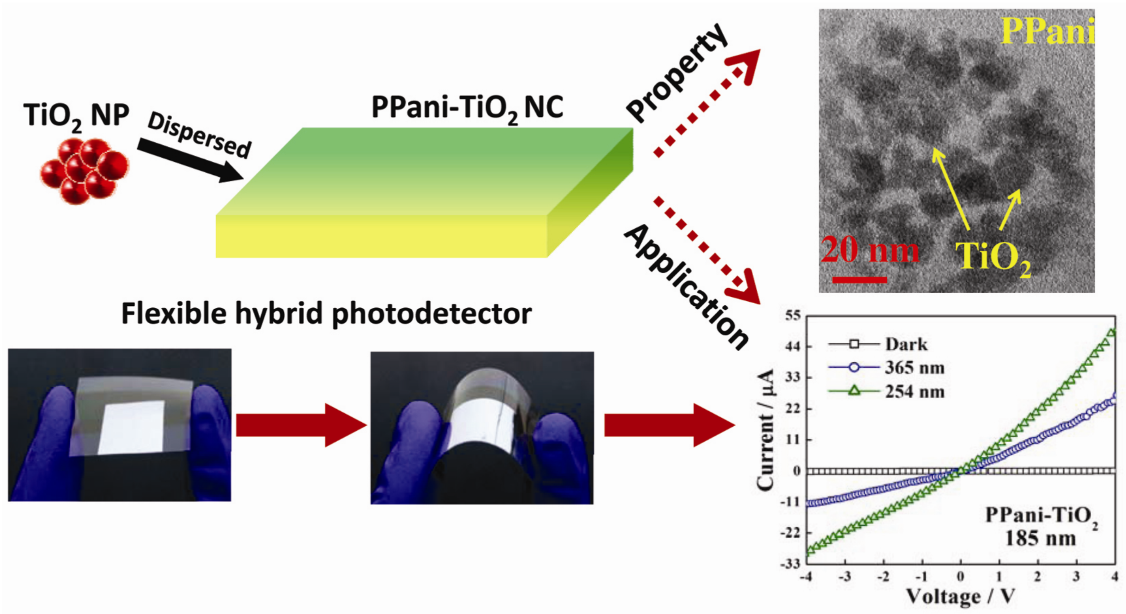

Figure 1. Flexible photodetector developed using plasma nanotechnology.

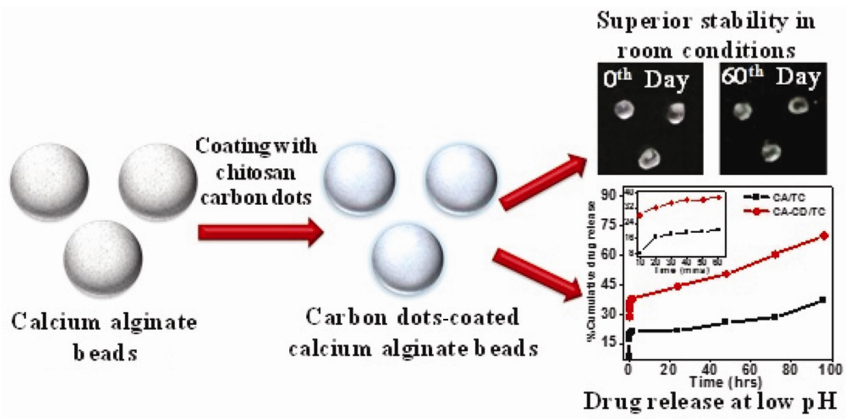

Figure 2. Carbon dots-coated calcium alginate beads which show stability up to 60 days under room temperature and higher drug release with time at pH 1.

biologically compatible compared to semiconductor quantum dots like CdS, CdSe, ZnS, etc. which have known toxicity and are potentially hazardous to the environment as they essentially contain heavy metals. The IASST research group was not only first to report the preparation of fluorescent CDs from chitosan gel[7], but also demonstrated the use of CD-coated biopolymer as optical sensor and in drug delivery application. Novel CD-coated alginate (CA-CD) beads were prepared, which exhibit superior stability and swelling properties. These beads show exceptional stability in ambient condition and are stable at normal pressure and atmosphere even after 60 days (Figure 2). The CA-CD beads were investigated for their use as pH-dependent sustained drug delivery vehicles taking tetracycline (TC) and TC associated β-cyclodextrin as model drug systems[8]. Interestingly, CA-CD beads showed better drug release profile than CA beads with maximum release obtained at pH 1, emphasizing their use in the gastrointestinal tract where pH is low. A host–guest-type inclusion complex of β-cyclodextrin : tetracycline showed greater drug loading efficiency, but its release was slower compared to TC. Hence, this type of β-cyclodextrin : drug inclusion complex can be effective in slower drug release rates applicable in slow and long-term drug administration.

We also demonstrated chitosan-based CDs rooted agarose hydrogel film as a hybrid solid sensing platform for the detection of heavy metal ions[9]. The fabrication of the solid sensing platform is centred on simple electrostatic interaction between the NH_3^+ group present in CDs and OH^- groups present in agarose. Simply on dipping the hydrogel film strip into heavy metal ion solution, in particular Cr^{6+}, Cu^{2+}, Fe^{3+}, Pb^{2+}, Mn^{2+} the strip displays colour change, viz. $Cr^{6+} \rightarrow$ yellow, $Cu^{2+} \rightarrow$ blue, $Fe^{3+} \rightarrow$ brown, $Pb^{2+} \rightarrow$ white and $Mn^{2+} \rightarrow$ tan brown. The optical detection limit of the respective metal ion is found to be 1 pM for Cr^{6+}, 0.5 μM for Cu^{2+} and 0.5 nM for Fe^{3+}, Pb^{2+} and Mn^{2+} by studying the changes in UV–visible reflectance spectrum of the hydrogel film. Moreover, the hydrogel film finds applicability as an efficient filtration membrane for separation of these quintet heavy metal ions. The strategic fundamental feature of this sensing platform is the successful capability of chitosan to form coloured chelates with transition metals. This proficient hybrid hydrogel solid sensing platform is thus most suitable to employ as an on-site operational, portable, cheap colorimetric–optical detector of heavy metal ions, with potential skill in their separation.

Nanoparticles for treatment of MRSA-infected burn wound

Methicillin-resistant *Staphylococcus aureus* (MRSA)-infected burn wounds lead to invasive disease. Chloramphenicol, a broad-spectrum antibiotic is considered a potential drug due to its effectiveness against a large number of resistant bacterial isolates. This is because of its low-level use in the past owing to its hydrophobicity, toxicity and fast degradation. However, these limitations have been overcome by developing a novel chloramphenicol loaded with poly-ε-caprolactone pluronic composite nanoparticulate (CAM-PCL-P NP) drug delivery system for enhanced therapeutic index. CAM-PCL-P NP is proposed as a novel anti-MRSA candidate for clinical applications.

Muga silk-based biomaterials

Muga silk has been found to be a potential biomaterial in tissue engineering applications, particularly as a scaffold-based 3D model for cartilage tissue repair[10]. Plasma-treated muga silk was found to be a superior suture material with anti-microbial property for quick healing of wounds following surgical operation[11].

Mathematical and computational sciences

A new type of mixed fuzzy topological space has been introduced and the concept of fuzzy δ-I-continuity between mixed fuzzy ideal topological spaces has been defined. Its different properties have been investigated, including every fuzzy regularly I-open set is fuzzy δ-I-open and every fuzzy δ-I-open set is the union of a family of fuzzy regularly I-open sets[12]. In computational materials science, research has been carried out on the phonon spectrum of stoichiometric Heusler alloy Ni2FeGa[13].

Biodiversity and ecosystem research

Activity within this programme includes limited survey of diversity of fish, amphibia, aquatic invertebrates such as mites and insects, endemic muga silk worm and microorganisms in natural forests, specific niches such as guts of ethnic people of NE India, and rhizospheres and roots interior of high-value crops.

New species of oribatid mites

So far a total of 120 fish species belonging to 9 orders, 28 families and 67 genera have been recorded from aquatic ecosystems of NE India. Recently, three new species of the oribatid mites, namely *Pergalumna paraclericata*, *P. minipora* and *P. paracattienica* (Galumnidae) have been reported from moss growing on rocks in Arunachal Pradesh[14].

Nigrospora leaf blight on tea caused by Nigrospora sphaerica in India

It has been reported that *N. sphaerica* is frequently encountered as a secondary invader or as a saprophyte on many plant species and also as a causative organism of foliar disease on several hosts worldwide, e.g. leaf spots on Chinese wisteria, and leaf blight on *Curcuma* in China. At IASST, we reported that *N. sphaerica* infects tea plants causing Nigrospora leaf blight[15].

Biosurfactants from bacterial strains

Bacterial isolates from hydrocarbon polluted ecosystem were screened for their ability to control hydrogeneous pollutants and also to explore the bacterial metabolites, mainly biosurfactants. A bacterial consortium was developed which could degrade more than 80% of hydrocarbon under *in vitro* condition within four weeks of its application. Several bacterial strains of hydrocarbon-polluted fields of Assam were found to produce rhamnolipids, which have potential use in agriculture as biocontrol agents against fungal diseases of crops[16]. Rhamnolipids produced by the bacterial strains *Pseudomonas aeruginosa* SS14 and JS29 were tested against *Fusarium* wilt disease of *Pisum sativum* caused by *Fusarium oxysporum* f. sp. *pisi* and early blight of *Solanum lycopersicum* caused by *Alternaria solani* in *in vitro* and *in planta* studies. Rhamnolipid produced by *P. aeruginosa* SS14 caused complete suppression of *Fusarium* wilt disease symptoms when sprayed at 25 mg l^{-1} and those by *P. aeruginosa* JS29 caused complete suppression of early blight disease symptoms at 1.5 g l^{-1}. These rhamnolipids were also found effective against these diseases under field conditions.

Figure 3. Production of agarwood oil compounds by (***a***) artificial inoculation of plants in the field and (***b***) *in vitro* techniques.

Augmentation of Assam agarwood production

Fragrant agarwood oil production is a traditional industry which originated in NE India, and is famous in the global flavour and fragrance industry for its premium quality. Agarwood oil is produced in the plants of *Aquilaria malaccensis* on fungal infection. The plants have become extinct in the wild and therefore, currently the demand for agarwood oil is met from plants grown in the homestead gardens and commercial plantations. However, with regard to fungal infection only <10% plants generally get infected. For biotechnological interventions in the process, we used fungal strain(s) and artificial induction of agarwood formation in the field and produced oil in cell cultures by elicitation or biochemical pathway engineering to benefit the industry (Figure 3)[17]. We have pioneered studies taking cue from the centuries old traditions of Assam agarwood production and using latest tools of metabolomics to understand biomolecular linkages that exist in the production process. We have been able to successfully apply GC/MS-based data coupled with multivariate statistical tools to differentiate and classify Assam agarwood oils of various grades available in the market[18]. A similar metabolite profiling approach has also been adopted to screen fungi.

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