TUE @ IITM 2016

THEMATIC UNIT OF EXCELLENCE

Thematic Unit of Excellence (TUE) on water purification using nanotechnology at IIT Madras is an initiative of the Department of Science and Technology, conceived by the Nano Mission. This new laboratory has come up also using the financial support of IIT. We conduct research on various aspects of materials, in the context of clean water.


Optical microscopy is essential to characterise organised assemblies.

PREFACE

This brochure showcases the activities of a research centre at IIT Madras. Some of you many not have seen our previous brochures and therefore, let me give you a brief introduction to our activities.

The Thematic Unit of Excellence (TUE) on Water Purification using Nanotechnology is an initiative of the Department of Science and Technology under the Nano Mission. Creation of this unit firstly is a recognition of our continuous efforts in the area and secondly is a demonstration of the DST's commitment to one of the most important areas where solutions of advanced science and technology are needed. This unit coexists with the DST Unit of Nanoscience, another initiative of the Nano Mission.

The TUE at IITM looks at a number of areas such as nanomaterials, photocatalysis, dedrimers, porous concrete, membranes, capacitive deionisation, electrospun fibres and solar desalination as solutions for water purification. Several associated aspects such as water quantity monitoring, modelling, prototype development, performance evaluation, field trials and technology transfer are under its purview. Conduct of discussion meetings, conferences, dissemination of information through various media, national and international collaborations and capacity building through short term projects and refresher courses are other areas of activity.

All of these will be possible only with team effort. Besides me, Professors Sarit Kumar Das, Ligy Philip, Edamana Prasad, Manu Santhanam, C. Vijayan and K. Srinivasa Reddy are participating in this effort. There are several Indian and international collaborators. In several areas our work has delivered technologies, besides publications and patents. In some areas, we have made our mark and in several others we have taken the first few baby steps.

The institute has recognised the importance of the activity and a new physical structure has come up. We have created several new facilities in it. One of the highlights of 2016 was the inauguration of the centre. The other excitement was the announcement of venture funding for our start-up company.

What we could accomplish in the last year is showcased here. This was possible due to the support of our coworkers, collaborators and funding agencies. I thank each one of them. There is a need for more people to join this effort and in the coming years, we hope that the nucleus created will be expanded further.

The content is pictorial in nature and in case you wish to know more, please contact us. We are aware that much more effort is needed to accomplish our goal.

Prof. T. Pradeep
January 19, 2017
pradeep@iitm.ac.in

Safety in the laboratory is an important aspect we care about.

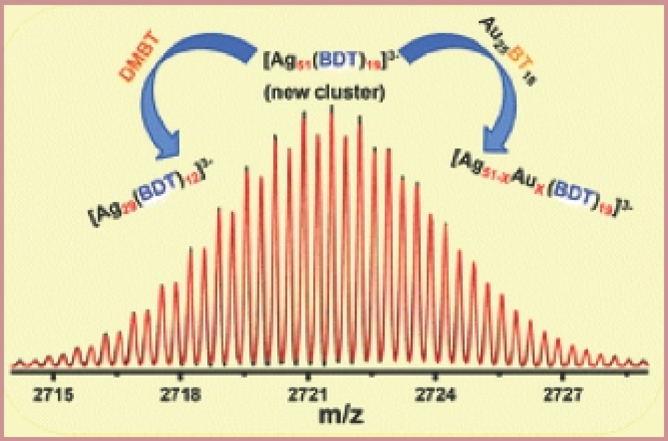
CONTENTS

Our new wet laboratory is equipped with all the tools needed for synthesis.

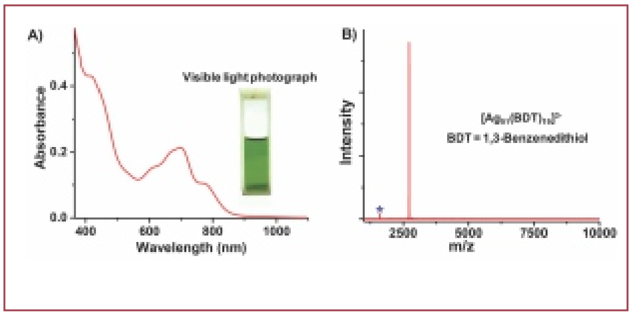
Atanu Ghosh, Debasmita Ghosh, Esma Khatun, Papri Chakraborty and T. Pradeep;

Nanoscale, 9 (2017) 1068 – 1077 [DOI: 10.1039/C6NR07692K]

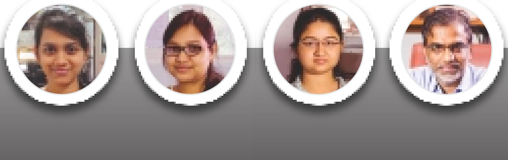
Unusual reactivity of dithiol protected clusters in comparison to monothiol protected clusters: Studies using $Ag_{51}(BDT)_{19}(TPP)_3$ and $Ag_{29}(BDT)_{12}(TPP)_4$



We report the synthesis and unique reactivity of a new green dithiol protected cluster (DTPC), $Ag_{51}(BDT)_{19}(TPP)_3$ (BDT and TPP are 1,3-benzenedithiol and triphenylphosphine, respectively). The cluster composition was confirmed by electrospray ionization (ESI) and matrix-assisted laser desorption ionization (MALDI) mass spectrometric studies as well as by other supporting data. Surprisingly, the chemical reactivity between this DTPC and $Au_{25}(SR)_{18}$ involves only metal ion exchange in $Au_{25}(SR)_{18}$ without any ligand exchange, while reactions between monothiol protected clusters (MTPCs) show both metal and ligand exchange, an example being the reaction between $Ag_{25}DMBT_{18}$ and $Au_{25}PET_{18}$ (where DMBT and PET are 2,4-dimethylbenzenethiol and phenylethanethiol, respectively). The conclusions have been confirmed by the reaction of another DTPC, $Ag_{29}(BDT)_{12}(TPP)_4$ with $Au_{25}BT_{18}$ (where BT corresponds to butanethiol) in which only metal exchange happens in $Au_{25}BT_{18}$. We also show the conversion of $Ag_{51}(BDT)_{19}(TPP)_3$ to $Ag_{29}(BDT)_{12}(TPP)_4$ in the presence of a second monothiol, DMBT which does not get integrated into the product cluster. This is completely different from the previous understanding wherein the reaction between MTPCs and a second thiol leads to either mixed thiol protected clusters with the same core composition or a completely new cluster core protected with the second thiol. The present study exposes a new avenue of research for monolayer protected clusters, which in turn will give additional impetus to explore the chemistry of DTPCs.



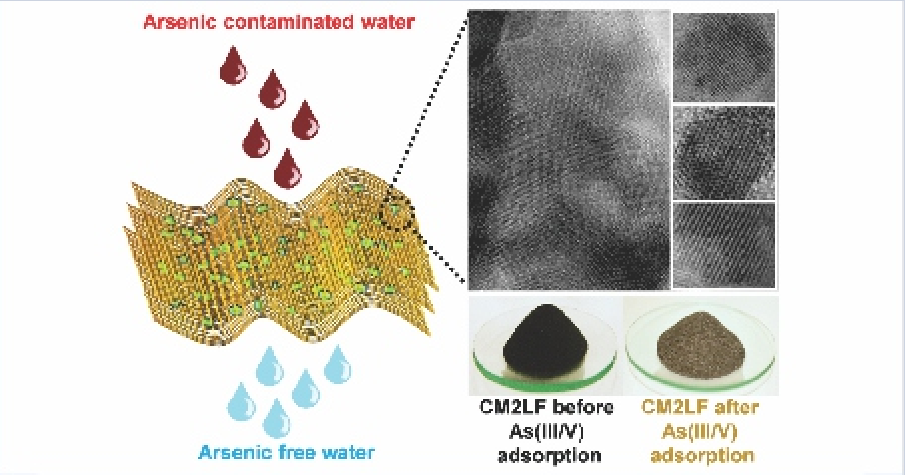
A) UV-vis spectrum of the purified cluster in DMF. The spectrum has step like features which are characteristic of small clusters. Inset: Visible light photograph of the cluster solution. B) ESI MS spectrum of the purified cluster in negative mode, in the region of *m/z* 1400 – 5000. The main peak at *m/z* 2721.56 is corresponding to $[Ag_{51}(BDT)_{19}]^{3-}$. PPh_3 attached peaks on cluster surface are marked with black asterisks. Peak at *m/z* 1603 is marked with blue asterisk which is due to presence of small quantity of $[Ag_{29}(BDT)_{12}]^{3-}$ cluster as side product.

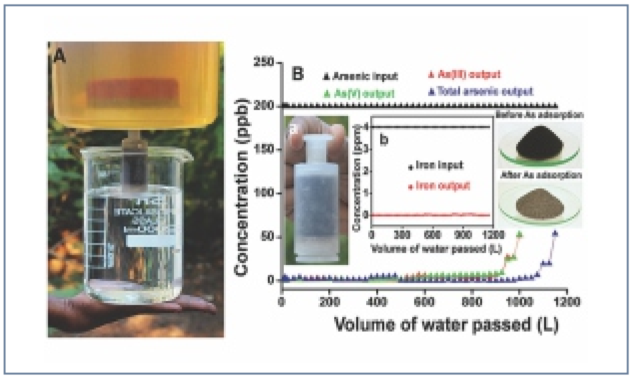


Anil Kumar Avula, Anirban Som, Paolo Longo, Chennu Sudhakar, Radha Gobinda Bhuin, Soujit Sen Gupta, Anshup, Mohan Udhaya Sankar, Amrita Chaudhary, Ramesh Kumar and T. Pradeep; *Adv. Mat., (2017) 1604260 [DOI: 10.1002/adma. 201604260]*

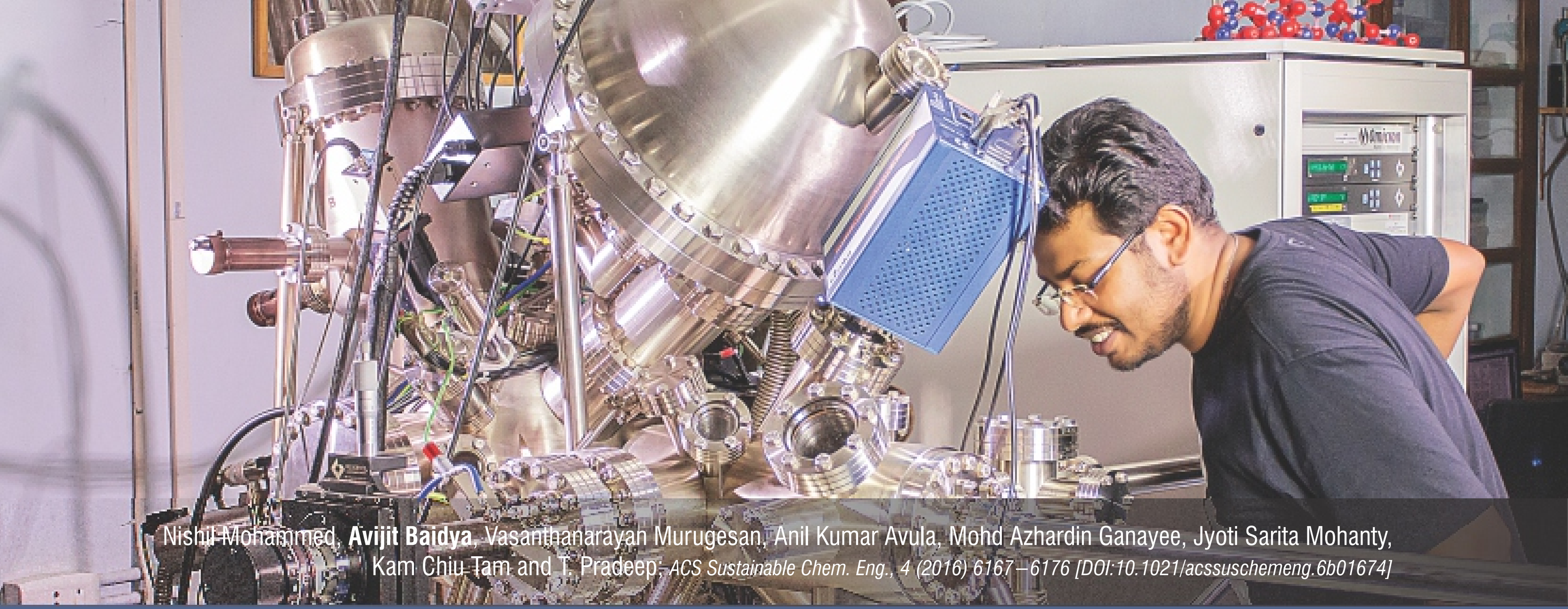
Confined metastable 2-line ferrihydrite for affordable point-of-use arsenic free drinking water

Arsenic-free drinking water, independent of electrical power and piped water supply, is possible only through advanced and affordable materials with large uptake capacities. Confined metastable 2-line ferrihydrite, stable at ambient temperature, shows continuous arsenic uptake in the presence of other complex species in natural drinking water and an affordable water purification device has been made using the same.



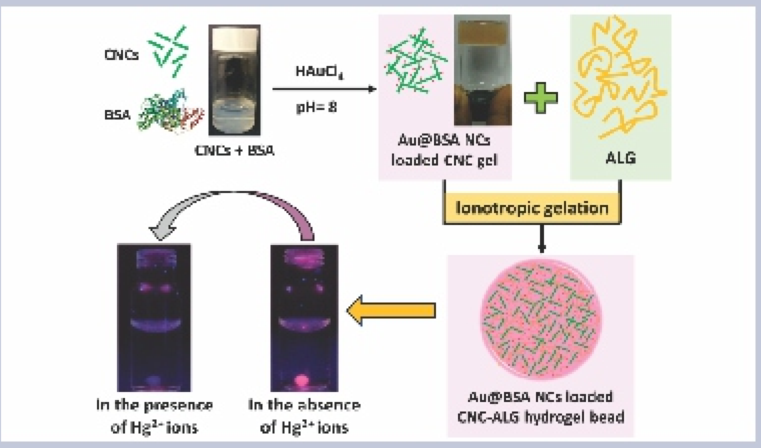


A) Set-up used for filtration containing arsenic (As(III +V)) and iron (Fe(II +III)) contaminated water using a cartridge with the reported material, along with a porous clay pre filter. B) Arsenic concentration in the water using a 60 g cartridge with the input as shown in A), inset (a) is the cartridge having 20 g adsorbent, inset (b) is iron output for the same input. The photographs of granular CM2LF before (black) and after (brown) As adsorption are in the inset.

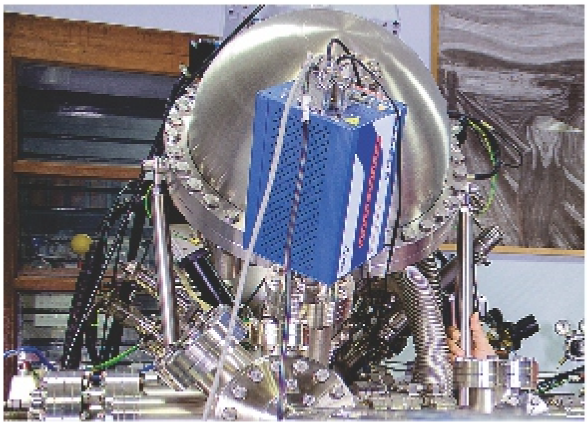


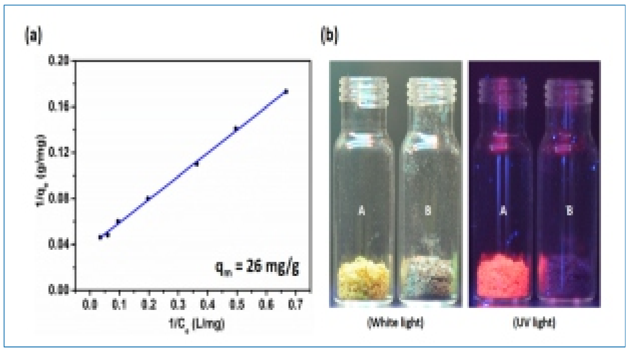
Nishil Mohammed, **Avijit Baidya**, Vasanthanarayan Murugesan, Anil Kumar Avula, Mohd Azhardin Ganayee, Jyoti Sarita Mohanty, Kam Chiu Tam and T. Pradeep, *ACS Sustainable Chem. Eng., 4 (2016) 6167–6176 [DOI:10.1021/acssuschemeng.6b01674]*

Diffusion controlled simultaneous sensing and scavenging of heavy metal ions in water using atomically precise cluster-cellulose nanocrystal composites

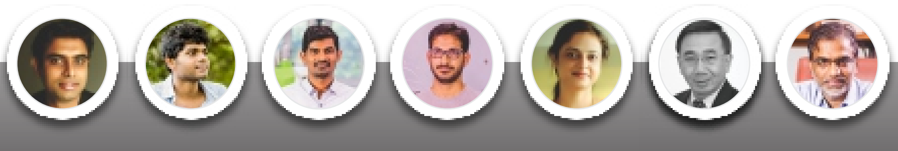


Development of a system that can simultaneously sense and scavenge toxic heavy metal ions at low concentrations is an ideal solution for in-situ monitoring and purification of contaminated water. In this paper, we report on the synthesis and application of a novel system, luminescent atomically precise cluster-cellulose nanocrystal composite namely bovine serum albumin protected gold nanoclusters (Au@BSA NCs) loaded cellulose nanocrystal - alginate hydrogel beads, that can simultaneously sense and scavenge heavy metal ions, specifically mercury ions in water. Characterization of the system performed using scanning electron microscopy coupled with energy dispersive spectroscopy and X-ray photoelectron spectroscopy elucidated the physical and chemical characteristics of the system. Additionally, we proposed a new method to visualize the diffusion phenomenon and calculated the effective diffusion coefficient of heavy metal ions in hydrogel beads by monitoring the fluorescence quenching dynamics of Au@BSA NCs upon binding with mercury ions. Finally, practical applications of this nanocomposite were demonstrated using batch adsorption experiments as well as using a dip pen device loaded with the hydrogel beads for in-situ monitoring of heavy metal ions in water.



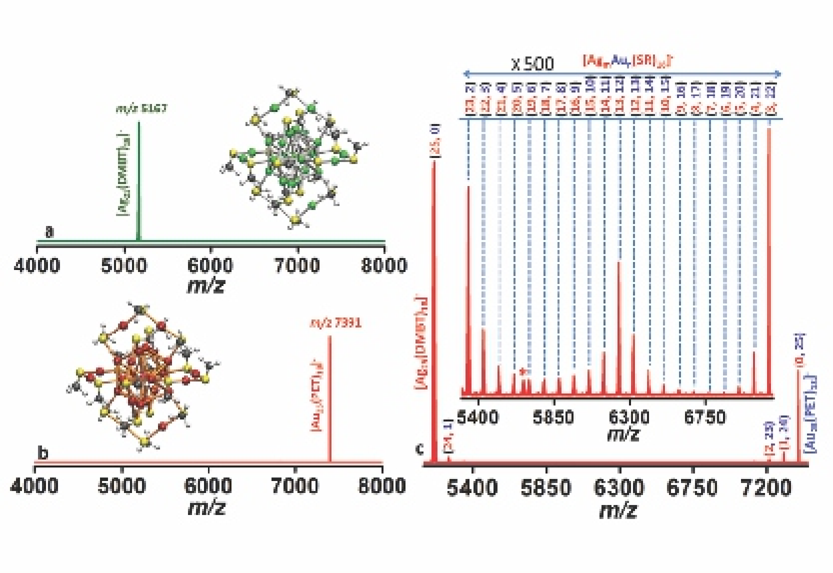


a) Equilibrium Hg2+ batch adsorption data, fitted using linearized form of Langmuir adsorption isotherm. b) Photographs of the vials containing nanocomposite (A) before and (B) after adsorption of Hg2+ ions under white light and UV light.

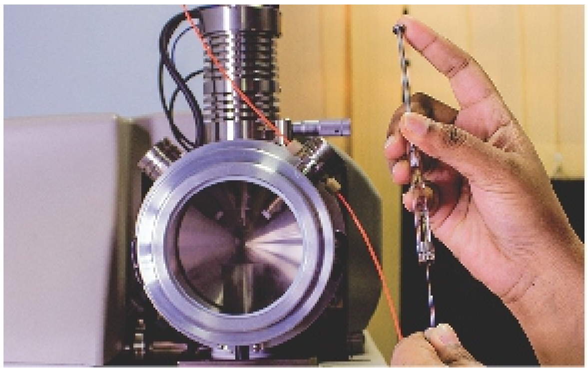


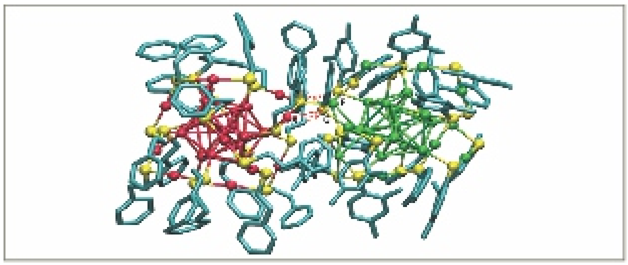
K. R. Krishnadas, Ananya Baksi, Atanu Ghosh, Ganapati Natarajan and T. Pradeep;
Nat. Commun., 7 (2016) 13447 [DOI: 10.1038/ncomms13447]

Structure-conserving spontaneous transformations between nanoparticles

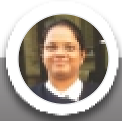


Electrospray ionization mass spectra (ESI MS) of $Ag_{25}(DMBT)_{18}$ (a) $Au_{25}(PET)_{18}$ (b) and a mixture of the two at a Ag_{25}:Au_{25} molar ratio of 0.3:1.0 measured within 2 min after mixing (c). The peak labels in (c) shown as numbers in red (m) and blue (n) in parentheses give the numbers of Ag and Au atoms, respectively, in the alloy clusters of formula, $Ag_m Au_n (SR)_{18}$. Schematic structures of **I** and **II** (with the R group as $-CH_3$, not the real ligands) are also shown. Color codes for the atoms in the inset pictures: red (Au), green (Ag), yellow (sulfur), black (carbon), white (hydrogen). The inset in (c) is the expanded region of the same mass spectrum between m/z 5300 to 7150. Fig. 1c and its inset shows that entire range (n=1-24) of alloy clusters, $Ag_m Au_n (SR)_{18}$ ($m+n=25$), are formed. The peak labeled with '*' in (c) is due to an unassigned dianionic species. DMBT is 2,4-dimethylbenzenethiol and PET is 2-phenylethanethiol.



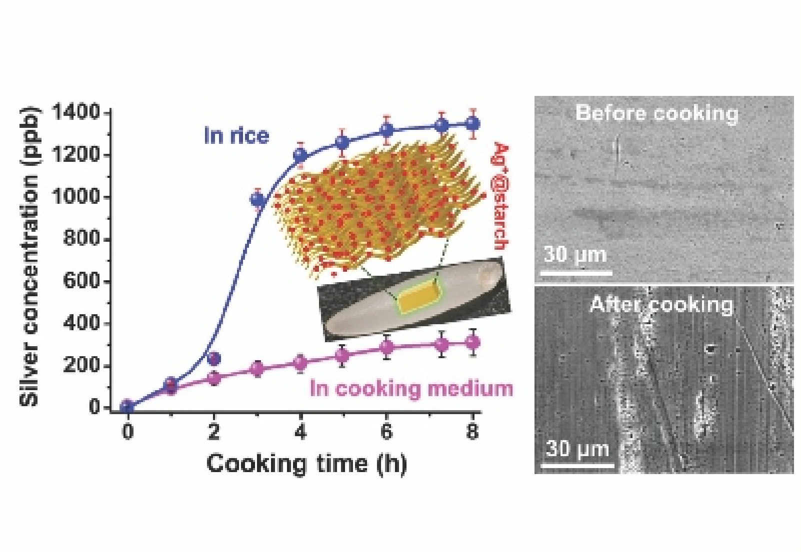


The geometry of $[Ag_{25}Au_{25}(DMBT)_{18}(PET)_{18}]^{2-}$ adduct (with II on the left and I on the right) obtained from DFT-optimization of the structure obtained from a force-field-based molecular docking simulation. The hydrogen atoms are omitted from the ligands for clarity. Color code for the atoms: Au (red), Ag (green), S (yellow), C (blue). DMBT is 2,4-dimethylbenzenethiol and PET is 2-phenylethanethiol.

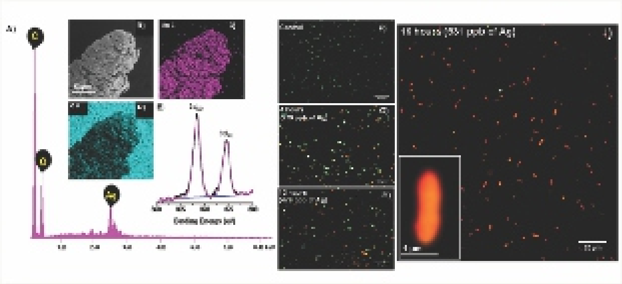



Soujit Sen Gupta, Ananya Baksi, Vidhya Subramanian and T. Pradeep;
ACS Sustain. Chem. Eng., 4 (2016) 4781–4787 [DOI: 10.1021/acssuschemeng.6b00980]

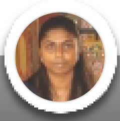
Cooking induced corrosion of metals



Uptake of metal ions into rice occurs while it is being cooked in metal vessels, leading to corrosion of the utensils. This study deals with silver, copper, and aluminium uptake during cooking in respective vessels, with a special emphasis on silver. The metal uptake is routed through solution, enhanced in the presence of specific anions like carbonate, and attenuated when the rice is polished. The concentration of silver in rice increases with the time of cooking with a concomitant decrease in the concentrations of Fe and Zn, suggesting a substitution mechanism for metal ion uptake. The results for some common rice varieties of use across the Indian subcontinent are presented. Similar behaviour was observed for cooking in copper and aluminium vessels. Among the three metals studied, aluminium showed reduced uptake. Studies have been done to probe the interaction of metal ions with glucose and sucrose, and efficient complex formation was detected with all these ions, implying that starch can also form complexes with them. The cooking practices used in this study are reminiscent of local customs and practices that were chosen deliberately to relate to the true implications of these results.

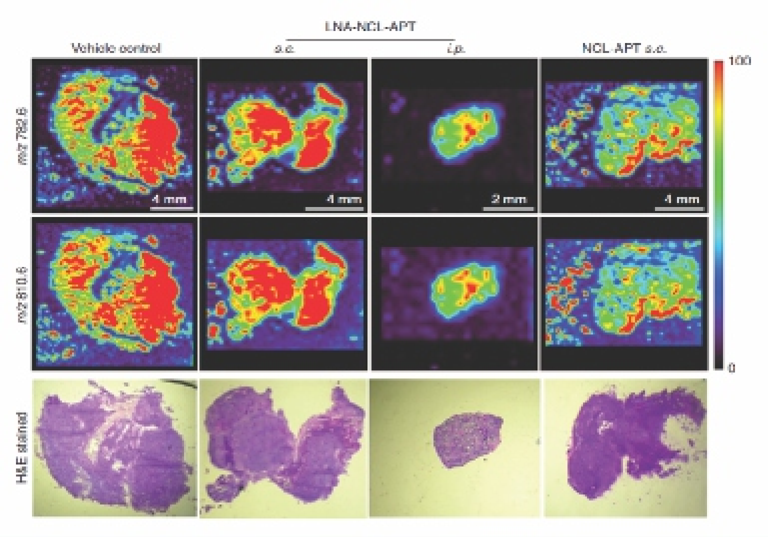


A) SEM/EDS of a rice grain when cooked in silver vessel showing the presence of silver. B) SEM image of the cooked (after drying) rice. C and D) Elemental mapping of silver and carbon. E) Monovalent form of Ag in the rice was confirmed from Ag 3d XPS. F-I) Fluorescence image of E. *coli* MTCC 739 showing the antibacterial activity of water kept in a silver vessel. One bacterium is expanded in the inset of I.

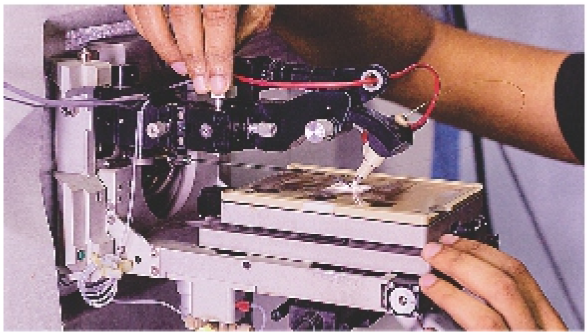



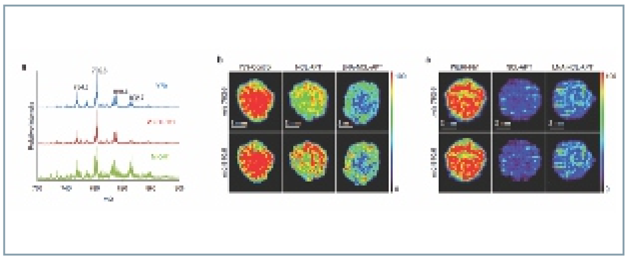

Nithya Subramanian, **Amitava Srimany,** Jagat R. Kanwar, Rupinder K. Kanwar, Balachandran Akilandeswari, Pukhraj Rishi, Vikas Khetan, Madavan Vasudevan, T. Pradeep and Subramanian Krishnakumar; *Mol. Ther. Nucleic Acids, 5 (2016) e358 [DOI: 10.1038/mtna.2016.70]*

Nucleolin-aptamer therapy in retinoblastoma: molecular changes and mass spectrometry-based imaging



Retinoblastoma (RB) is an intraocular childhood tumor which, if left untreated, leads to blindness and mortality. Nucleolin (NCL) protein which is differentially expressed on the tumor cell surface, binds ligands and regulates carcinogenesis and angiogenesis. We found that NCL is over expressed in RB tumor tissues and cell lines compared to normal retina. We study the effect of nucleolin-aptamer (NCL-APT) to reduce proliferation in RB tumor cells. Aptamer treatment on the RB cell lines (Y79 and WERI-Rb1) led to significant inhibition of cell proliferation. Locked nucleic acid (LNA) Modified NCL-APT administered subcutaneously (s.c.) near tumor or intraperitoneally (i.p.) in Y79 xenografted nude mice resulted in 26 and 65% of tumor growth inhibition, respectively. Downregulation of inhibitor of apoptosis proteins, tumor miRNA-18a, altered serum cytokines, and serum miRNA-18a levels were observed upon NCL-APT treatment. Desorption electrospray ionization mass spectrometry (DESI MS)-based imaging of cell lines and tumor tissues revealed changes in phosphatidylcholines levels upon treatment. Thus, our study provides proof of concept illustrating NCL-APT-based targeted therapeutic strategy and use of DESI MS-based lipid imaging in monitoring therapeutic responses in RB.

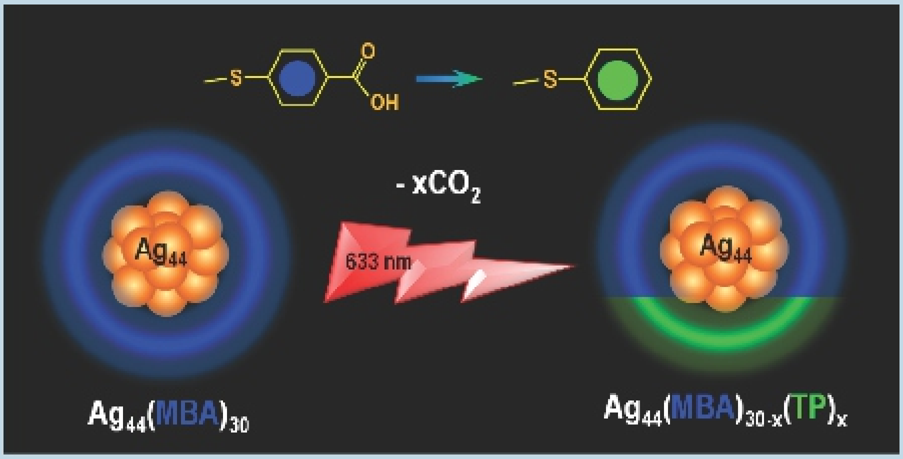




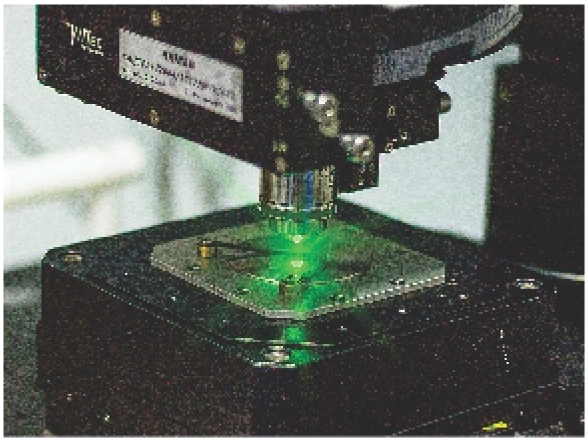
DESI MS imaging of aptamer treated RB cell lines. (a) DESI-MS spectra of Y79, WERI-Rb1 and MIO-M1 cells grown in cell. Cells were washed with 1XPBS twice and spotted on Whatmann membrane and imaged using methanol as solvent using positive mode and data acquired from 50 to 2,000 Daltons. Changes in the lipid expression accompanying the treatment with nucleolin aptamer in RB cell line, Y79 (b) WERI-Rb1 (c).

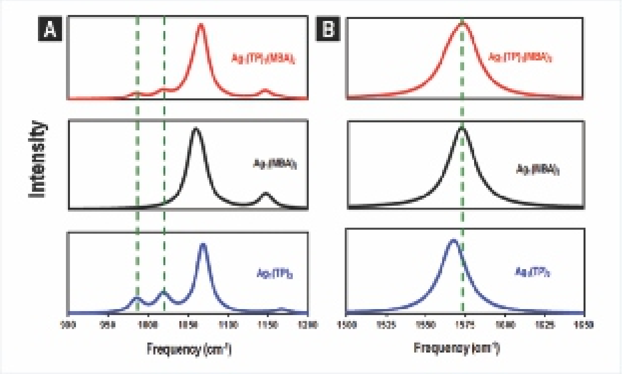
Indranath Chakraborty, **Anirban Som**, Tuhina Adit Maark, Biswajit Mondal, Depanjan Sarkar and T. Pradeep;
J. Phys. Chem. C., 120 (2016) 15471–15479 [DOI: 10.1021/acs.jpcc.6b04769]

Towards a janus cluster: Regiospecific decarboxylation of $Ag_{44}(4\text{-}MBA)_{30}$@Ag nanoparticles

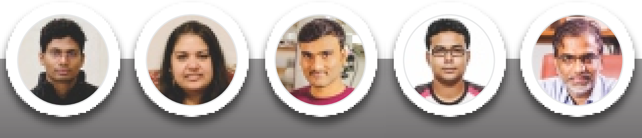


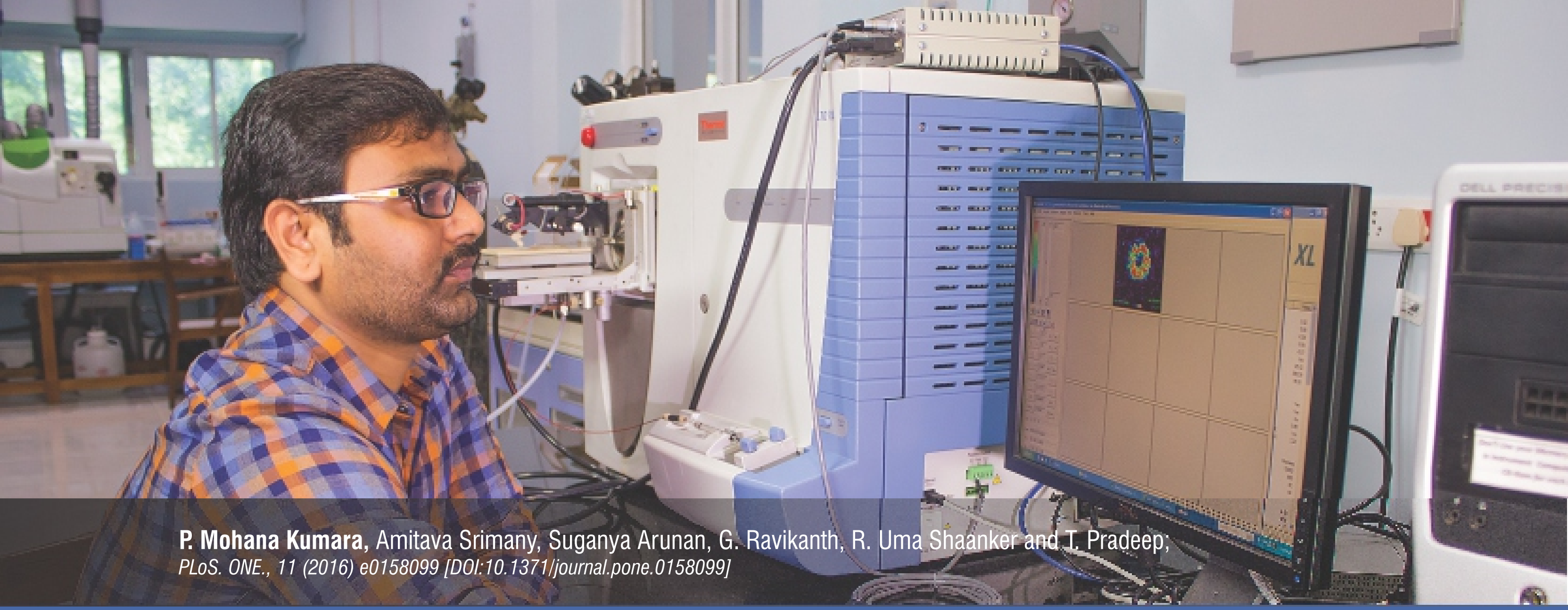
Ligand shell structure of the aspicule, $Ag_{44}(4\text{-}MBA)_{30}$ (MBA-mercaptobenzoic acid, in the thiolate form) was modified in a precise, site-specific manner. Laser irradiation at 633 nm of a monolayer assembly of plasmonic Ag nanoparticles (NPs) covered with $Ag_{44}(4\text{-}MBA)_{30}$ clusters leads to decarboxylation of 4-MBA ligands forming thiophenolate (TP) ligands. While the molecular identity and integrity of aspicules post laser irradiation were confirmed by ESI MS, time dependent SERS spectra and computational studies suggest that the phenomenon of decarboxylation is limited to the 4-MBA ligands facing the NP surface. This creates modified Ag_{44} clusters, with 4-MBA ligands on one side and TP ligands on the other, giving them a two-faced (Janus) ligand structure. The ligand distribution of such clusters gets equilibrated in solution. We show that such selective transformation can be used to create molecular patterns. Janus clusters may be important in chemistry at biphasic interfaces.





Theoretically calculated Raman spectra of model species, $Ag_1(TP)_1(4\text{-}MBA)_1$, $Ag_1(4\text{-}MBA)_2$ and $Ag_1(TP)_2$ in regions (A) 900-1200 cm^{-1} and (B) 1500-1650 cm^{-1}.

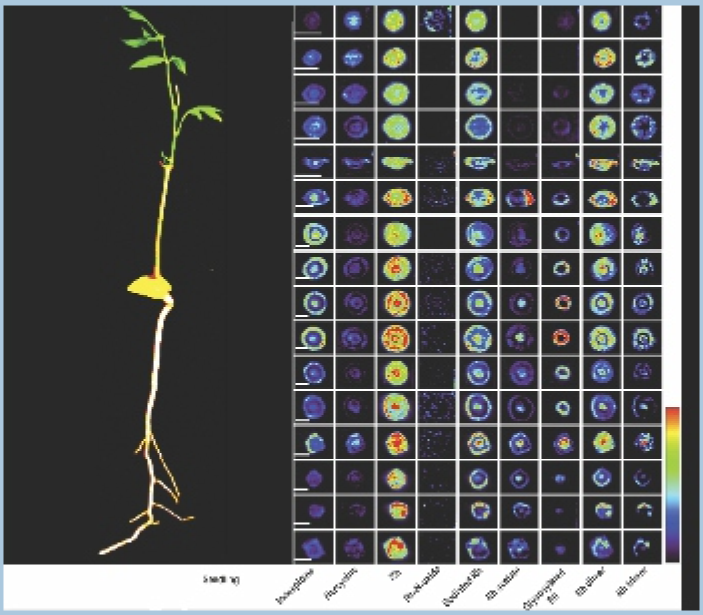


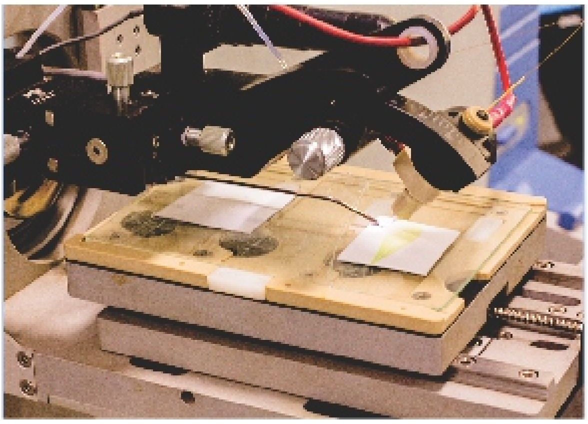


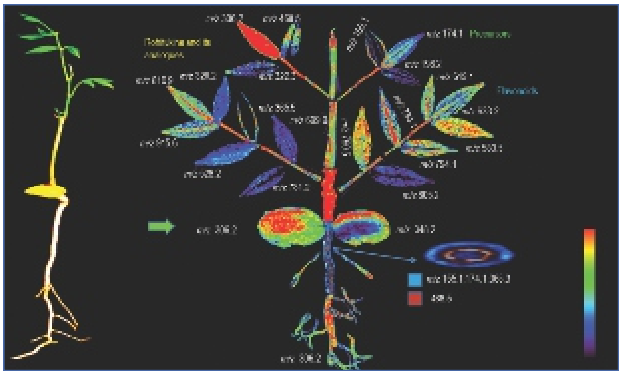
P. Mohana Kumara, Amitava Srimany, Suganya Arunan, G. Ravikanth, R. Uma Shaanker and T. Pradeep;
PLoS. ONE., 11 (2016) e0158099 [DOI:10.1371/journal.pone.0158099]

Desorption electrospray ionization (DESI) mass spectrometric imaging of the distribution of rohitukine in the seedling of *Dysoxylum binectariferum* Hook. f

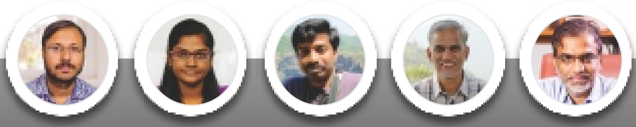
Ambient ionization mass spectrometric imaging of all parts of the seedling of *Dysoxylum binectariferum* Hook. f (Meliaceae) was performed to reconstruct the molecular distribution of rohitukine (Rh) and related compounds. The species accumulates Rh, a prominent chromone alkaloid, in its seeds, fruits, and stem bark. Rh possesses anti-inflammatory, anti-cancer, and immuno-modulatory properties. Desorption electrospray ionization mass spectrometry imaging (DESI MSI) and electrospray ionization (ESI) tandem mass spectrometry (MS/MS) analysis detected Rh as well as its glycosylated, acetylated, oxidized, and methoxylated analogues. Rh was predominantly distributed in the main roots, collar region of the stem, and young leaves. In the stem and roots, Rh was primarily restricted to the cortex region. The identities of the metabolites were assigned based on both the fragmentation patterns and exact mass analyses. We discuss these results, with specific reference to the possible pathways of Rh biosynthesis and translocation during seedling development in *D. binectariferum*.

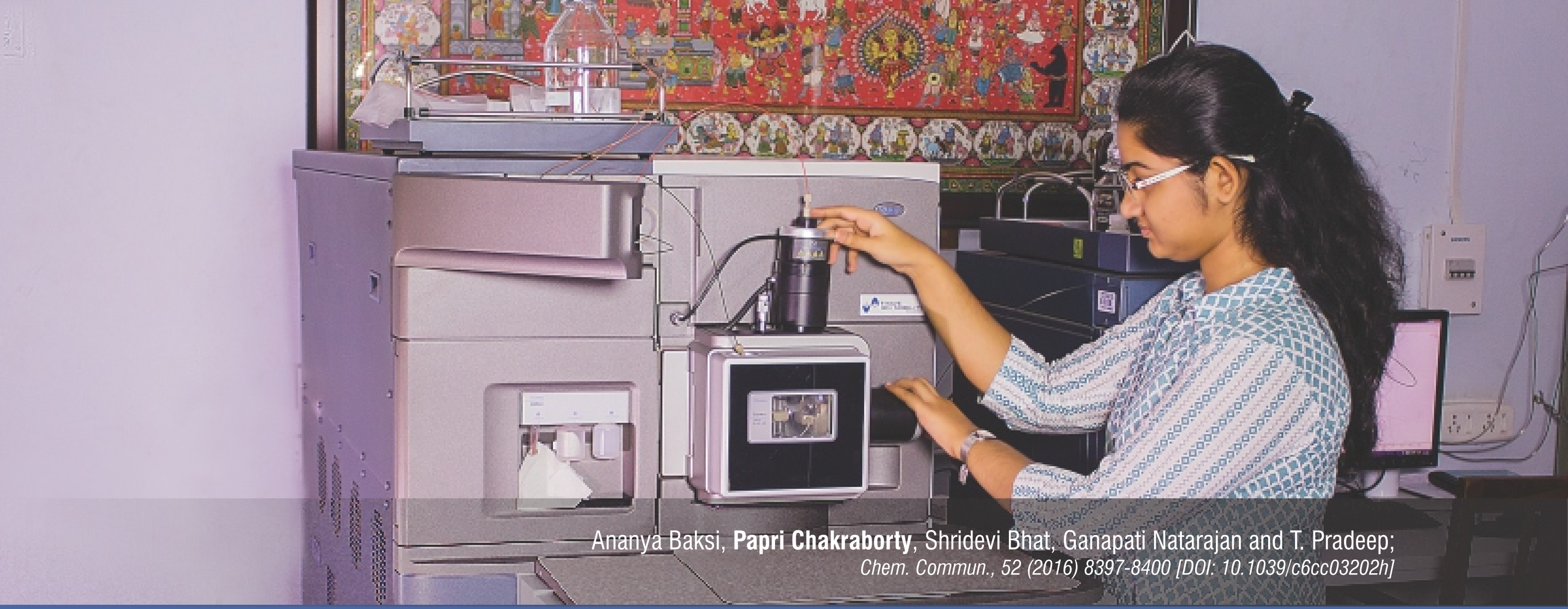






Reconstruction of spatial distribution of metabolites obtained from DESI MS imaging of different parts of a 10 months old seedling of *D. binectariferum*.

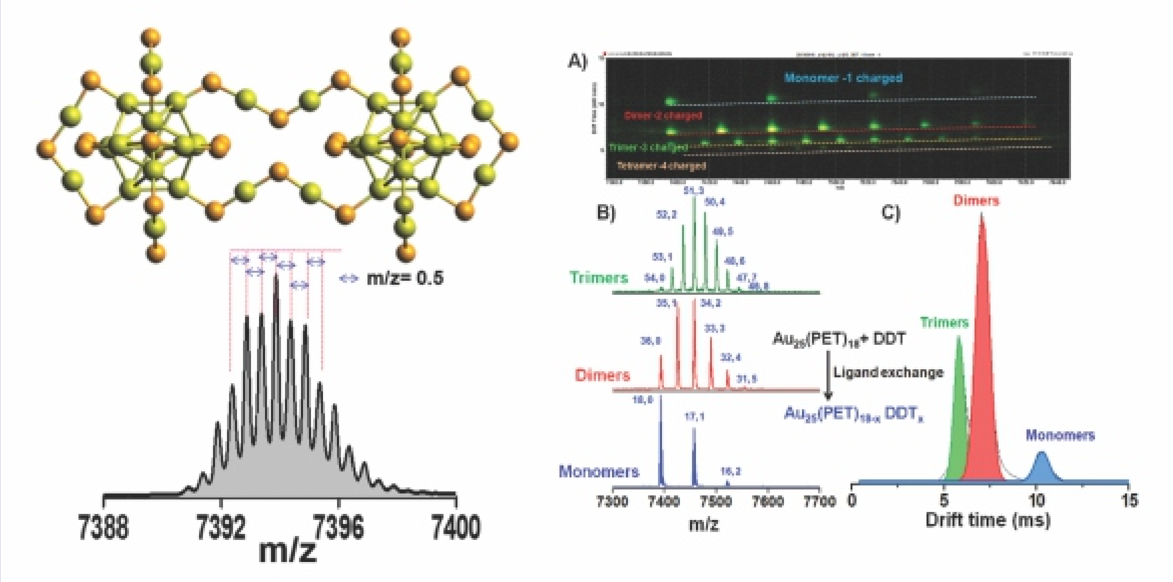




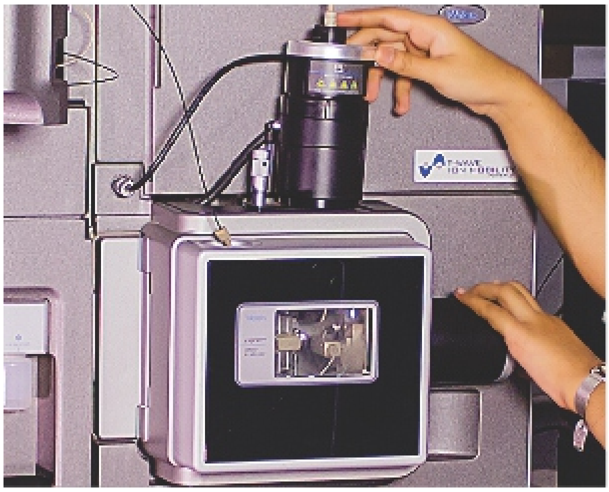
Ananya Baksi, **Papri Chakraborty**, Shridevi Bhat, Ganapati Natarajan and T. Pradeep;

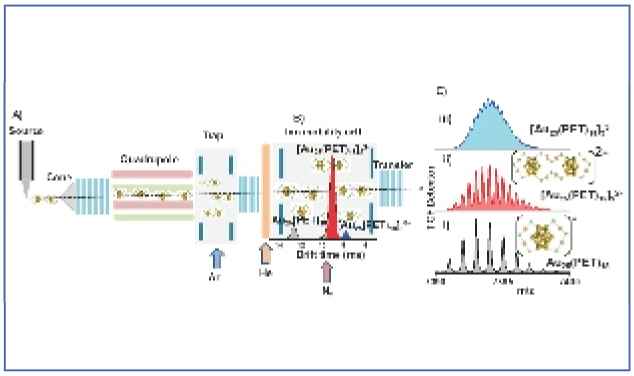
Chem. Commun., 52 (2016) 8397-8400 [DOI: 10.1039/c6cc03202h]

$[Au_{25}(SR)_{18}]_2^{2-}$: A noble metal cluster dimer in the gas phase

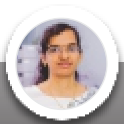


We present the first example of dimer formation in the monolayer protected atomically precise cluster system, $Au_{25}(SR)_{18}$, using ion mobility mass spectrometry. These transient species are shown to be important in explaining chemical reactivity between clusters.



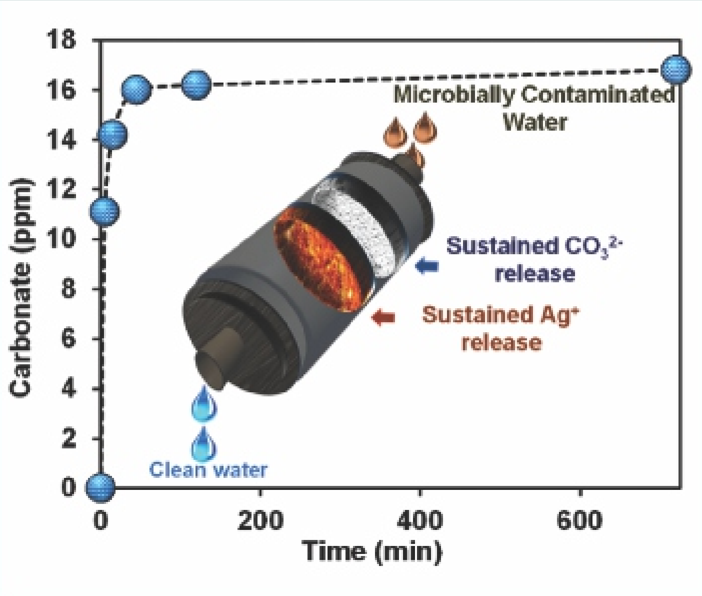


A) Schematic representation of the instrumental set-up where $Au_{25}(SR)_{18}$ cluster aggregates are created and B) subsequently separated by ion mobility mass spectrometry. C) Each of the peaks obtained from ion mobility are expanded. Peaks at 12.7, 10.8 and 7.8 ms in B correspond to $Au_{25}(PET)_{18}^-$, $[Au_{25}(PET)_{18}]_2^{2-}$, $[Au_{25}(PET)_{18}]_3^{3-}$, respectively as shown in i), ii) and iii). Representative structures are shown in the insets.

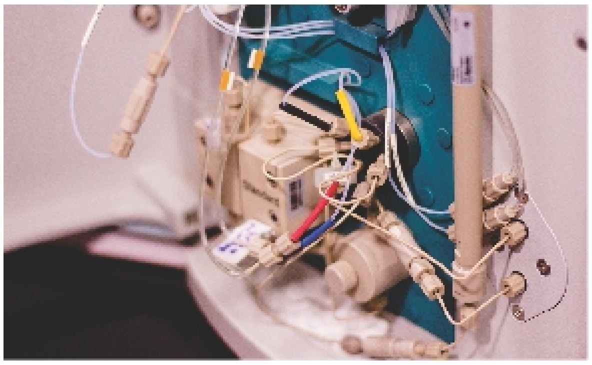



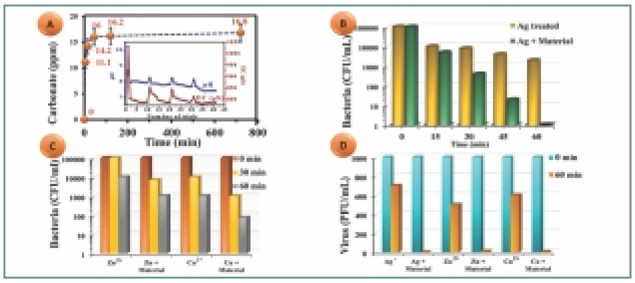
Jakka Ravindran Swathy, Nalenthiran Pugazhenthiran, Chennu Sudhakar, Anil Kumar Avula and T. Pradeep;
ACS Sustain. Chem. Eng., 4 (2016) 4043−4049 [DOI: 10.1021/acssuschemeng.6b00979]

Sparingly soluble constant carbonate releasing inert monolith for enhancement of antimicrobial silver action and sustainable utilization

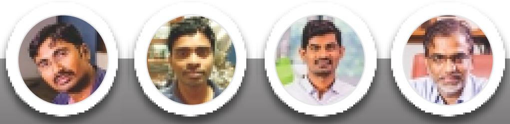


Silver, a metal with phenomenal commercial importance has been exploited in its ionic form in the field of water purification, with the objective of delivering microbially safe drinking water. Silver released at such concentrations is unrecoverable and has to be reduced to ensure sustainable utilization of the metal. We have shown that small concentrations of carbonate can effectively bring down the amount of silver ion used for microbial disinfection by half. Implementation of this finding requires constant carbonate releasing materials in natural water for an extended period. In this work, we describe a hybrid material with intrinsically high stability in water that is prepared using naturally abundant ingredients which releases carbonate constantly and in a controlled fashion. This composition in conjunction with reduced silver ion concentration delivers mircobially safe water, tested with *E. coli* and MS2 phage. Use of constant carbonate releasing material for antimicrobial applications can reduce the unrecoverable silver released into the environment by ∼1300 tons/year. We also show that the composition can be modified to release cations of choice without disturbing the CO$_3^{2-}$ release from the same. A sustained release of selective cations along with carbonate can supplement drinking water with the minerals of interest.



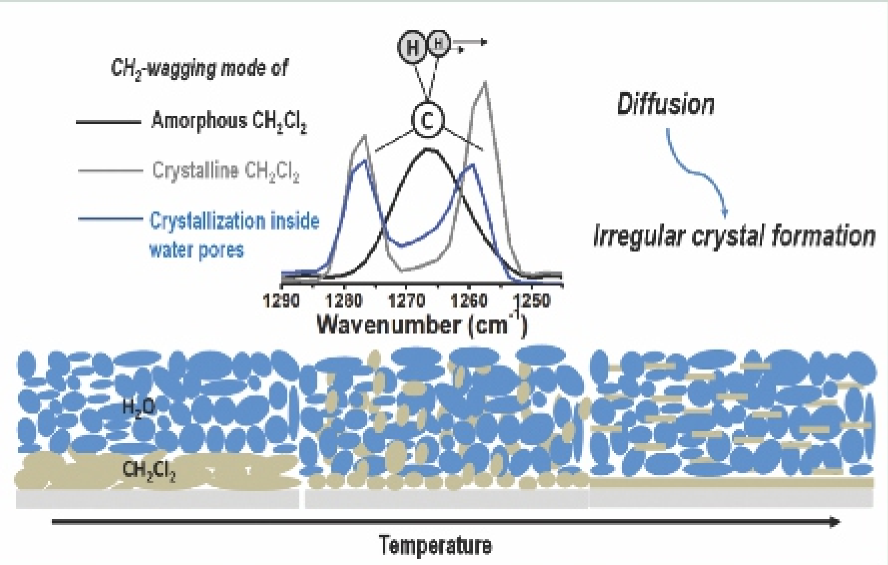


Kinetics of carbonate release from the monolith (C_{CO3}) for prolonged period of exposure to water. Inset shows the sustained release of carbonate in continuous flow of water (A). Carbonate-supported antibacterial activity of 50 ppb silver (B) and 1 ppm zinc and 500 ppb copper (C). Carbonate-supported antiviral activity of 50 ppb silver, 1 ppm zinc, and 500 ppb copper (D).

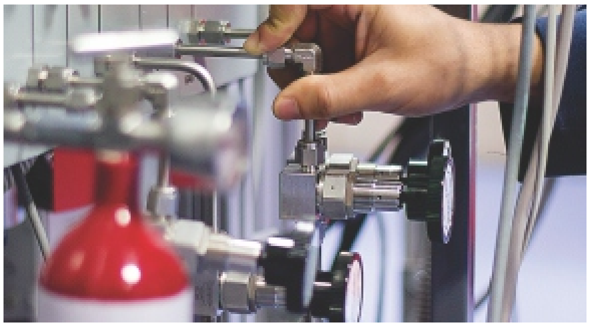


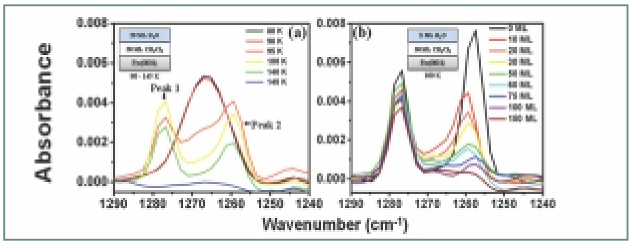
Radha Gobinda Bhuin, Rabin Rajan J. Methikkalam, Soumabha Bag and T. Pradeep;
J. Phys. Chem. C., 120 (2016) 13474 -13484 [DOI: 10.1021/acs.jpcc.6b00436]

Diffusion and crystallization of dichloromethane within the pores of amorphous solid water

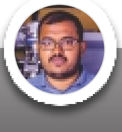


Dichloromethane thin films deposited on Ru(0001) at low temperatures (~80 K) or lower undergo a phase transition at ~95 K, manifested by the splitting of its wagging mode at 1265 cm^{-1}, due to factor group splitting. This splitting occurs at relatively higher temperatures (~100 K) when amorphous solid water (ASW) is deposited over it, with a significant reduction in intensity of the high wavenumber component (of the split peaks). Control experiments showed that the intensity of the higher wavenumber peak is dependent on the thickness of the water overlayer. It is proposed that diffusion of CH_2Cl_2 into ASW occurs and it crystallizes within the pores of ASW, which increases the transition temperature. However, the dimensions of the CH_2Cl_2 crystallites get smaller with increasing thickness of ASW with concomitant change in the intensity of the factor-group split peak. Control experiments support this suggestion. We propose that the peak intensities can be correlated with the porosity of the ice film. Diffusion of CH_2Cl_2 has been supported by low energy Cs^+ scattering and temperature programmed desorption spectroscopies.

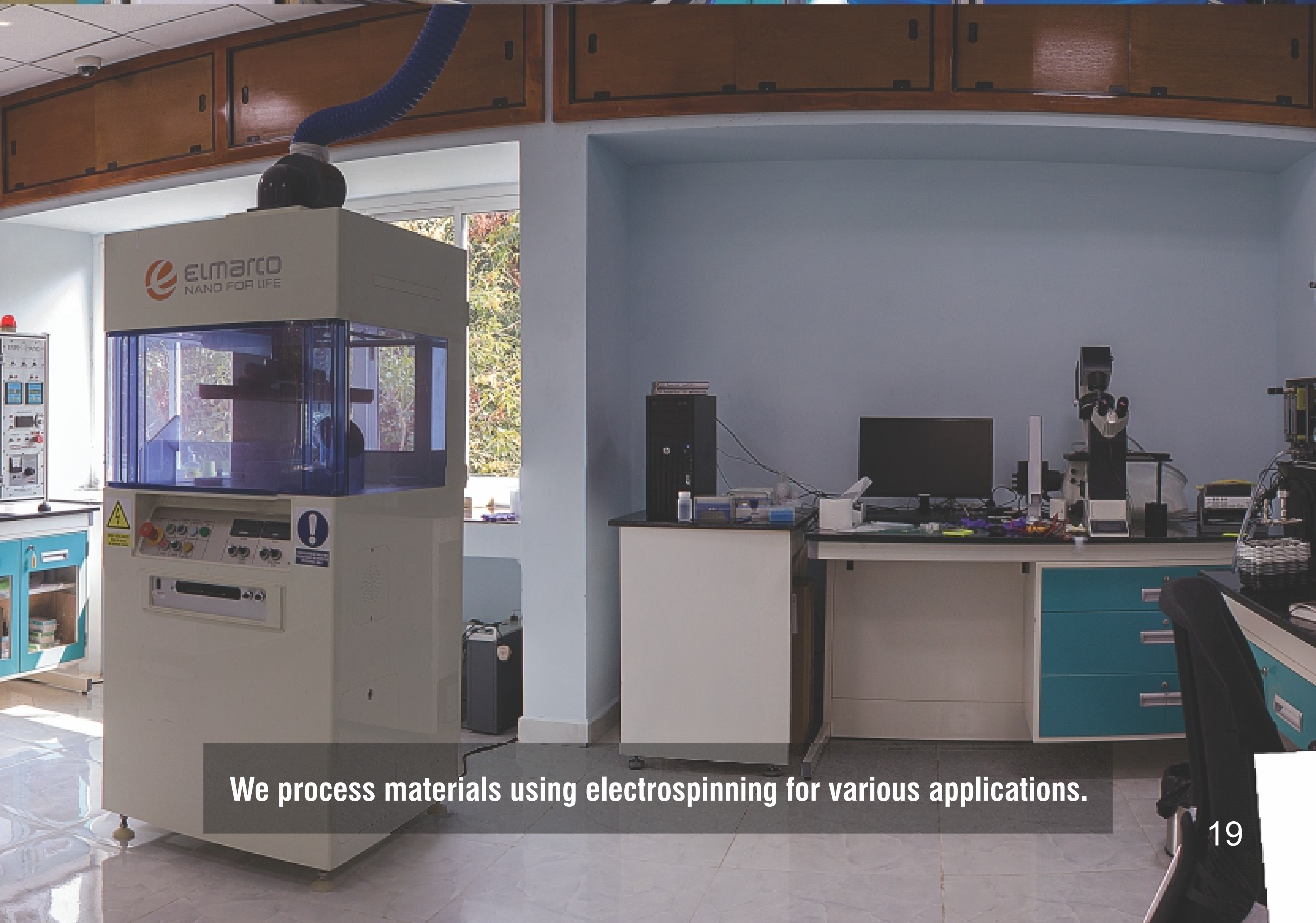




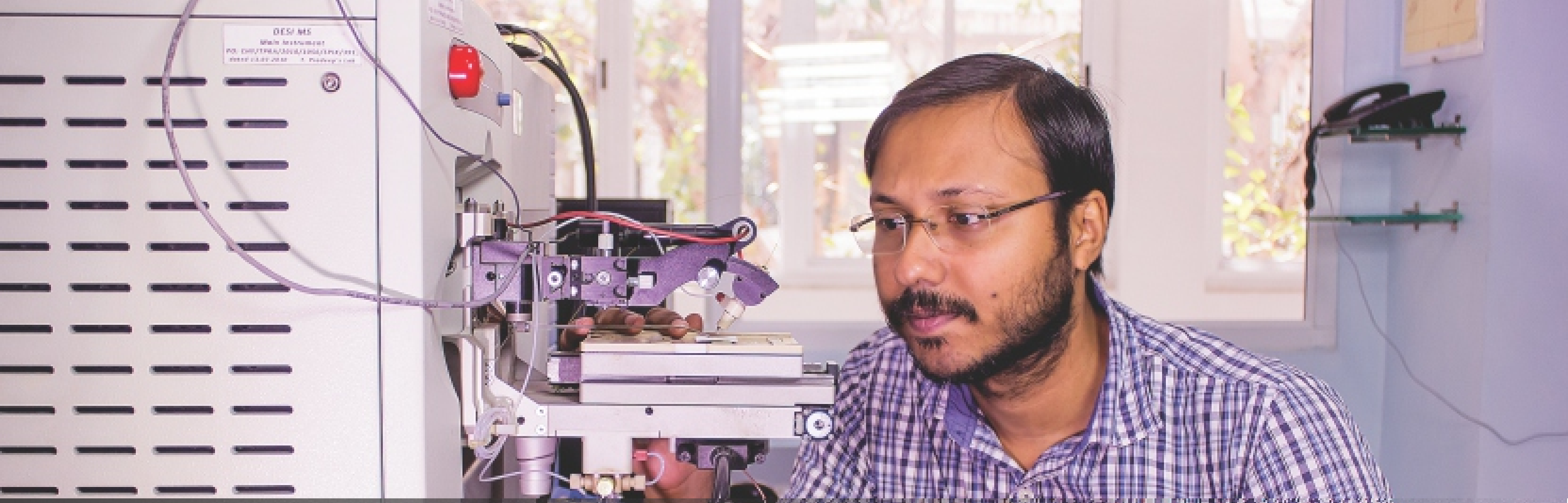
RAIR spectra: a) -CH_2 wagging mode of 50 ML CH_2Cl_2 for 20 ML water overlayer coverage at different temperatures. b) The same as a function of overlayer coverages of ASW at 100 K. Inset shows the schematic of the surface. Both CH_2Cl_2 and H_2O were deposited at 80 K on Ru(0001) surface.



We characterise the transport properties of all kinds of membranes.



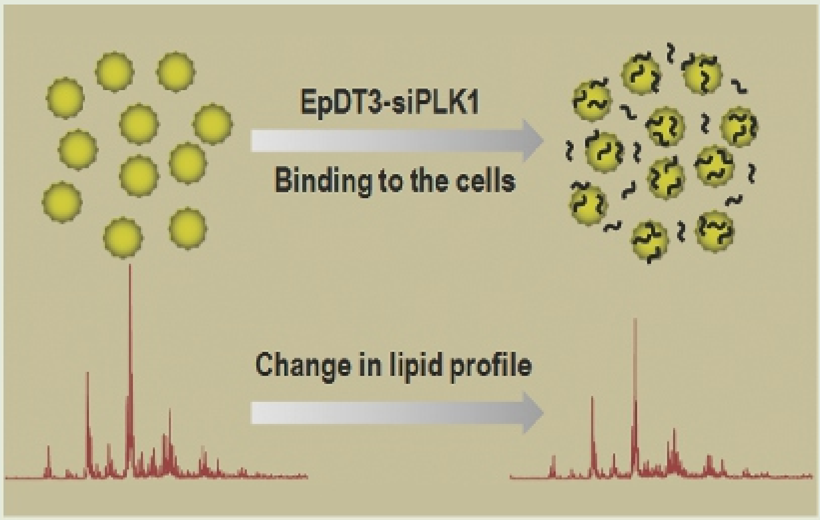
We process materials using electrospinning for various applications.



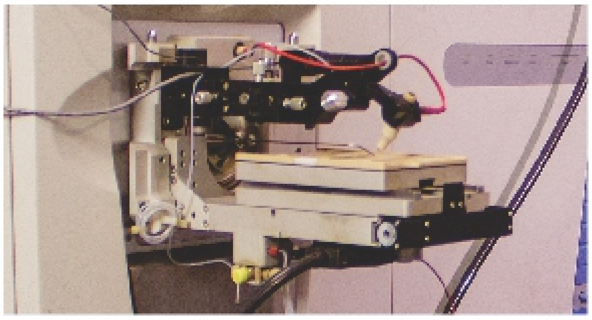
Balasubramanyam Jayashree, **Amitava Srimany**, Srinidhi Jayaraman, Anjali Bhutra, Narayanan Janakiraman, Srujana Chitipothu, Subramanian Krishnakumar, Lakshmi Subhadra Baddireddi, Sailaja Elchuri and T. Pradeep,

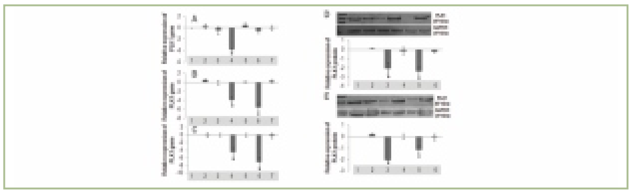
Anal. Bioanal. Chem., 408 (2016) 5623-5632 [DOI: 10.1007/s00216-016-9665-y]

Monitoring of changes in lipid profiles during PLK1 knockdown in cancer cells using DESI MS



The importance of the polo-like kinase 1 (PLK1) gene is increasing substantially both as a biomarker and as a target for highly specific cancer therapy. This is due to its involvement in multiple points of cell progression and carcinogenesis. PLK1 inhibitors' efficacy in treating human cancers has been limited due to the lack of a specific targeting strategy. Here, we describe a method of targeted downregulation of PLK1 in cancer cells and the concomitant rapid detection of surface lipidomic perturbations using desorption electrospray ionization mass spectrometry (DESI MS). The efficient delivery of siRNA targeting PLK1 gene selectively to the cancer cells is achieved by targeting overexpressed cell surface epithelial cell adhesion molecule (EpCAM) by the EpDT3 aptamer. The chimeric aptamer (EpDT3-siPLK1) showed the knockdown of PLK1 gene expression and PLK1 protein levels by quantitative PCR and western blotting, respectively. The abundant surface lipids, phosphatidylcholines (PCs), such as PC(32:1) (*m/z* 7546), PC(34:1) (*m/z* 782.6), and PC(36:2) (*m/z* 808.6), were highly expressed in MCF-7 and WERI-RB1 cancer cells compared to normal MIO-M1 cells and they were observed using DESI MS. These overexpressed cell surface lipids in the cancer cells were downregulated upon the treatment of EpDT3-siPLK1 chimera indicating a novel role of PLK1 to regulate surface lipid expression in addition to the efficient selective cancer targeting ability. Our results indicate that DESI MS has a potential ability to rapidly monitor aptamer-mediated cancer therapy and accelerate the drug discovery process.



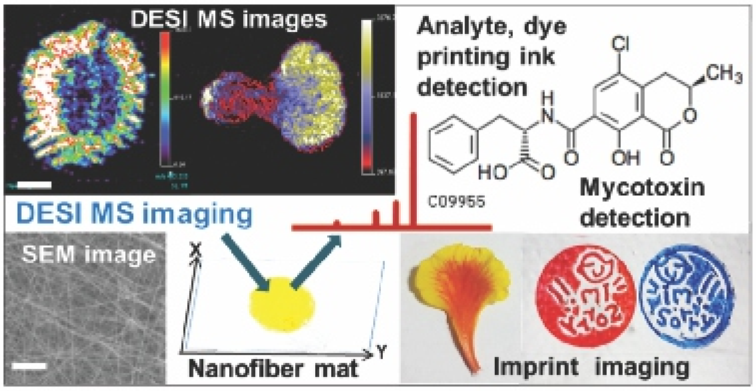


Expression of PLK1 gene in A) MIO-M1, B) MCF-7, and C) WERI-RB1 when they were untreated (1) and treated with EpDT3 (2), Scr-EpDT3 (3), siPLK1 (4), siScr (5), EpDT3-siPLK1 (6), and EpDT3-siScr (7). Expression of PLK1 protein in (D) MCF-7 and (E) WERI-RB1 when they were untreated (1) and treated with EpDT3 (2), siPLK1 (3), siScr (4), EpDT3-siPLK1 (5), and EpDT3-siScr (6). * P< 0.05 compared to untreated.

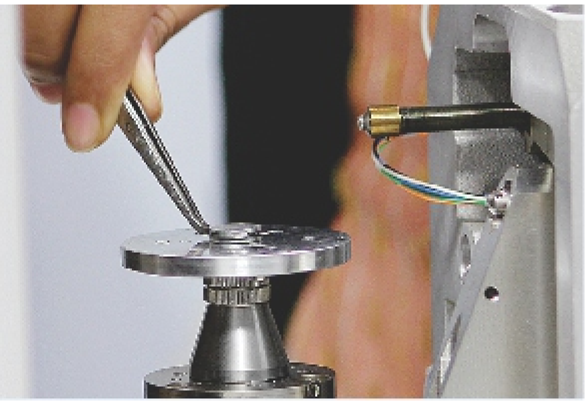
R. G. Hemalatha, **Mohd Azhardin Ganayee** and T. Pradeep;

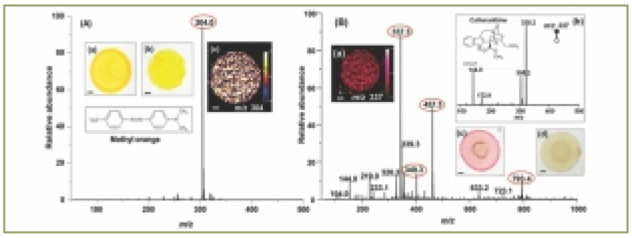
Anal. Chem., 88 (2016) 5710−5717 [DOI: 10.1021/acs.analchem.5b04520]

Electrospun nanofiber mats as “smart surfaces” for desorption electrospray ionization mass spectrometry (DESI MS) based analysis and imprint imaging

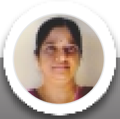


In this paper, desorption electrospray ionization mass spectrometry (DESI MS)-based molecular analysis and imprint imaging using electrospun nylon-6 nanofiber mats are demonstrated for various analytical contexts. Uniform mats of varying thicknesses composed of ∼200 nm diameter fibers were prepared using needleless electrospinning. Analytical applications requiring rapid understanding of the analytes in single drops, dyes, inks, and/or plant extracts incorporated directly into the nanofibers are discussed with illustrations. The possibility to imprint patterns made of printing inks, plant parts (such as petals, leaves, and slices of rhizomes), and fungal growth on fruits with their faithful reproductions on the nanofiber mats is illustrated with suitable examples. Metabolites were identified by tandem mass spectrometry data available in the literature and in databases. The results highlight the significance of electrospun nanofiber mats as smart surfaces to capture diverse classes of compounds for rapid detection or to imprint imaging under ambient conditions. Large surface area, appropriate chemical functionalities exposed, and easiness of desorption due to weaker interactions of the analyte species are the specific advantages of nanofibers for this application.





A) DESI MS spectrum eluted from a spot sample of methyl orange on a nylon nanofiber mat. (a) Photograph of the corresponding spot on a TLC-plate showing the spreading effect, forming a halo on the periphery. (b) Same sample spotted on a nylon nanofiber mat showing uniform spreading. (c) DESI MS image of a methyl orange peak at *m/z* 304. B) DESI MS spectrum of a Madagascar periwinkle flower extract spotted on an electrospun nylon nanofiber mat. DESI MS image (a) and tandem mass spectrum (b) of Catharanthine at *m/z* 337. TLC-plates showing the spreading (c) and fading effects (d) of the spot of the flower extract. The scale bar in all DESI MS images is 5 mm.

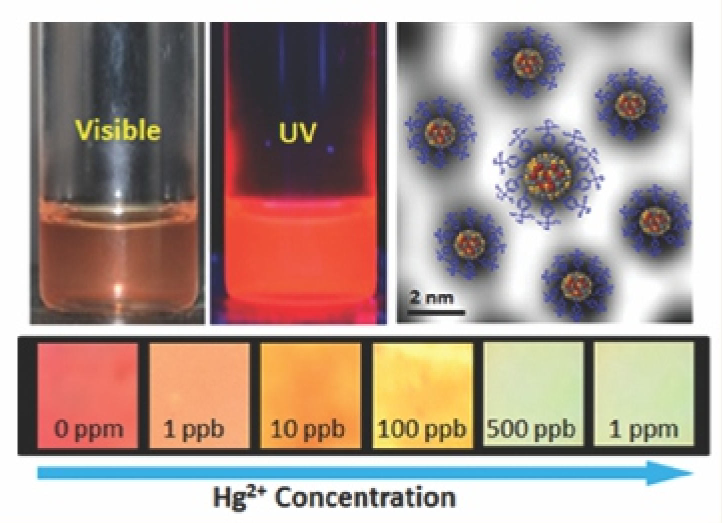


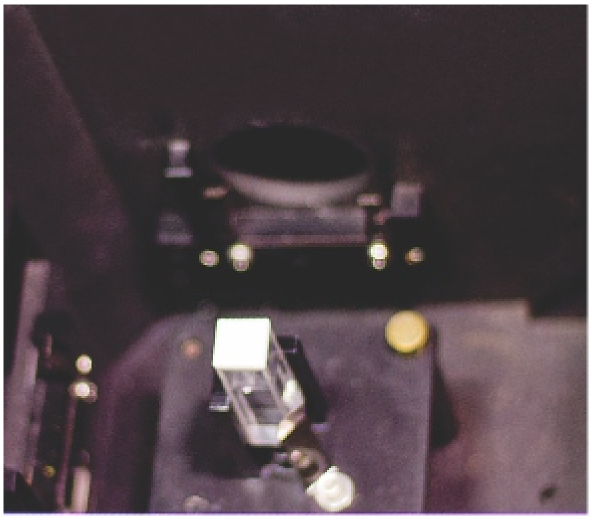
C. K. Manju, Indranath Chakraborty and T. Pradeep;
J. Mater. Chem. C., 4 (2016) 5572-5577 [DOI: 10.1039/c6tc01388k]

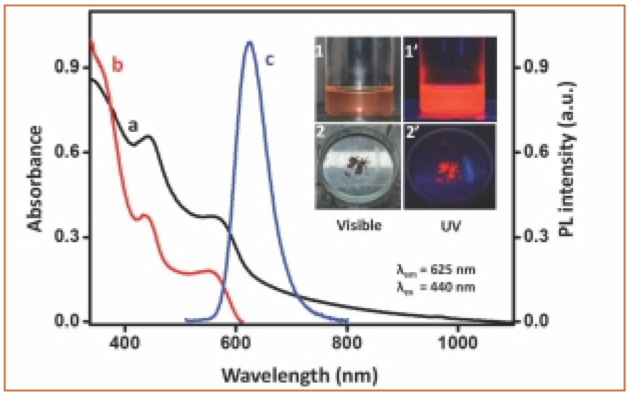
Highly luminescent monolayer protected $Ag_{56}Se_{13}S_{15}$ clusters

This article is part of themed collection: 2016 Journal of Materials Chemistry C Hot Papers

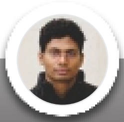
A highly luminescent (quantum yield 21%) mixed chalcogenide silver cluster, $Ag_{56}Se_{13}S_{15}$ cluster of Ag_2X stoichiometry, protected with 4-*tert*-butylbenzyl mercaptan ligand has been synthesized and characterized. Collective investigation from diverse tools of analyses such as mass pectrometry, elemental analysis, thermogravimetry and X-ray diffraction point to this composition. The cluster emits in the solution and in the solid state and has been deposited on oxide supports to get red emitting films. The specificity of cluster emission to mercuric ion, among a rage of heavy metal ions has been used to develop a sensor, which shows sensitivity down to 1 ppb. A pH paper-like visual detector has been developed by combining the Hg(II)-sensitive emission of the cluster and insensitive emission of fluorescein isothiocyanate. The test strip shows visual detection down to 1 ppb in real water samples.







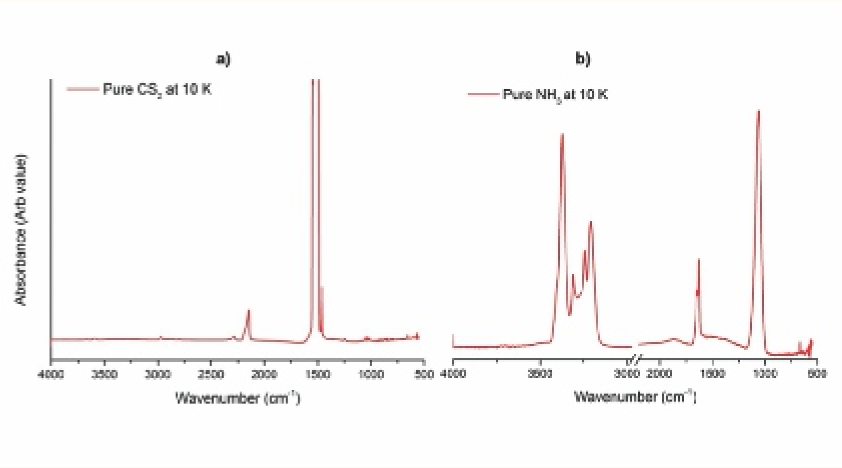
Comparison of UV-Visible spectrum (a) excitation spectrum (b) and emission spectrum (c) of cluster solution. Axis on the right is for traces (b) and (c). Cluster solution shows strong emission around 625 nm with three excitation maxima (359, 440 and 564 nm), all of which resulted in a single emission maximum. Inset shows the photograph of cluster under visible and UV light in solution state (1,1') and solid state (2,2'), respectively.



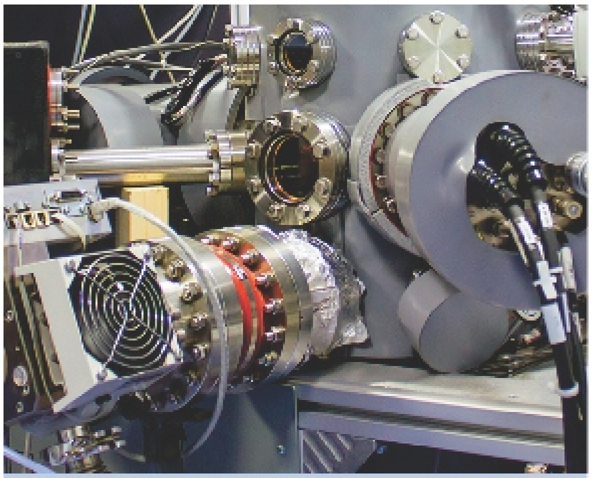
Rabin Rajan J. Methikkalam, S. Pavithraa, S. P. Murali Babu, H. Hill, Raja Sekhar, T. Pradeep and B. Sivaraman;

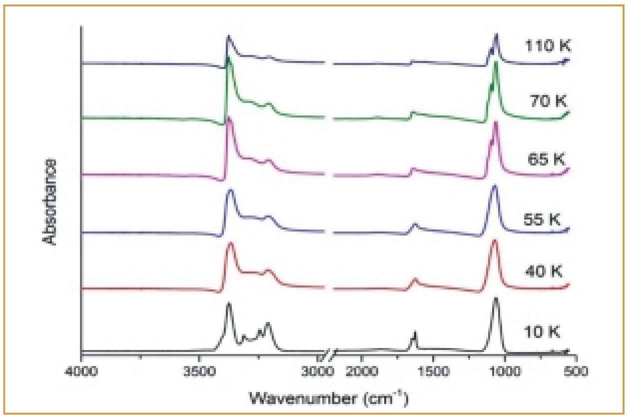
Adv. Space. Res., 58 (2016) 438–443 [DOI:10.1016/j.asr.2016.04.028]

Thio residue from thermal processing of cometary ices containing carbon disulfide and ammonia



We have carried out experimental investigation on binary ice mixture containing carbon disulfide (CS_2) and ammonia (NH_3) ices formed at 10 K. Icy films were formed in various combinations to investigate the reactivity of CS_2 and NH_3 molecules on cometary nucleus. In the case of NH_3 ices, deposition carried out at 10 K was found to contain NH_3 homo-dimers that was found to reorient upon annealing to 40 K. Phase transition was found to take place as the 10 K ice was warmed to higher temperatures and the phase transition temperature was found to be 5 K higher for the mixed ice in comparison to the layered deposits. Thermal processing of the mixed deposition of CS_2-NH_3ice was found to leave thio residue, which could be ammonium dithiocarbamate that was even found to be present at 340 K.





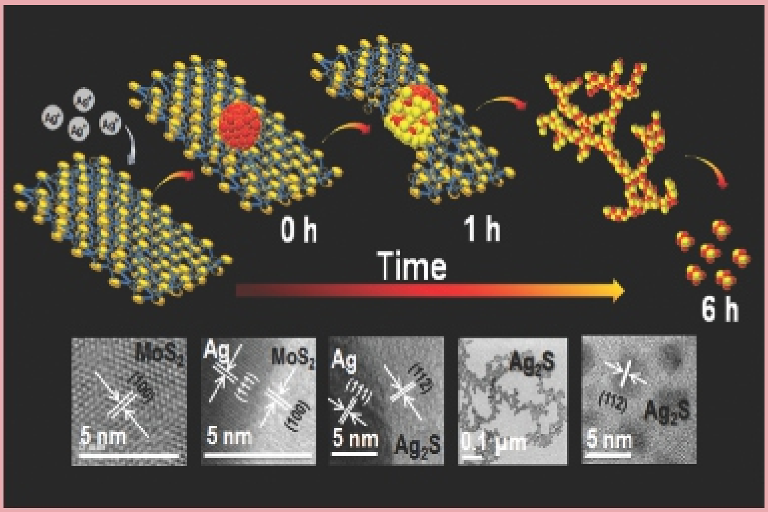
Temperature dependent infrared spectra of pure NH_3 with the presence of homo-dimers at 10 K which got reoriented when warmed to 40 K.

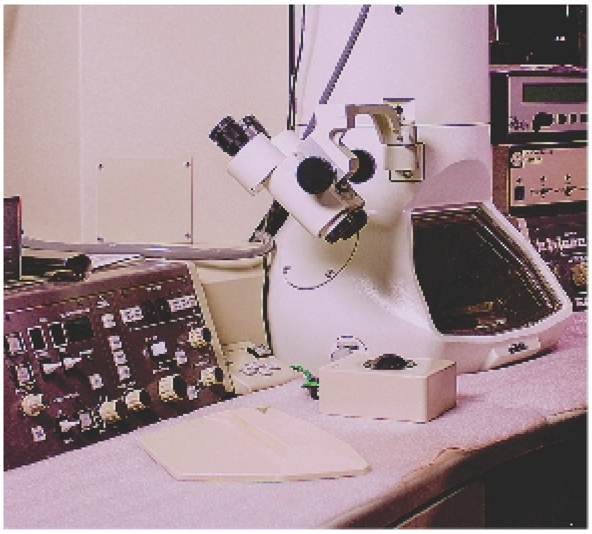


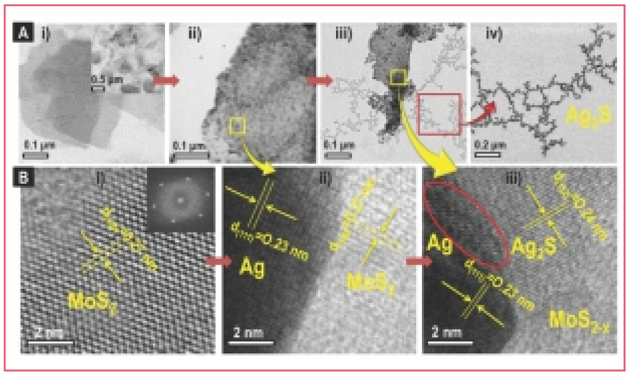

Biswajit Mondal, Anirban Som, Indranath Chakraborty, Ananya Baksi, Depanjan Sarkar and T. Pradeep;
Nanoscale, 8 (2016) 10282–10290 [DOI: 10.1039/c6nr00878j]

Unusual reactivity of MoS_2 nanosheets

Reactivity of the 2D nanosheets of MoS_2 with silver ions in solution, leading to their spontaneous morphological and chemical transformations is reported. This unique reactivity of the nanoscale form of MoS_2 was in stark contrast form its bulk counterpart. While the gradual morphological transformation involving several steps have been captured with electron microscopy, precise chemical identification of the species involved was achieved through electron spectroscopy and mass spectrometry. Energetics of the system investigated supports the observed chemical transformation. Reaction with mercury and gold ions show similar and dissimilar reaction products, respectively and points to the stability of metal-sulphur bond in determining the chemical compositions of the final products.







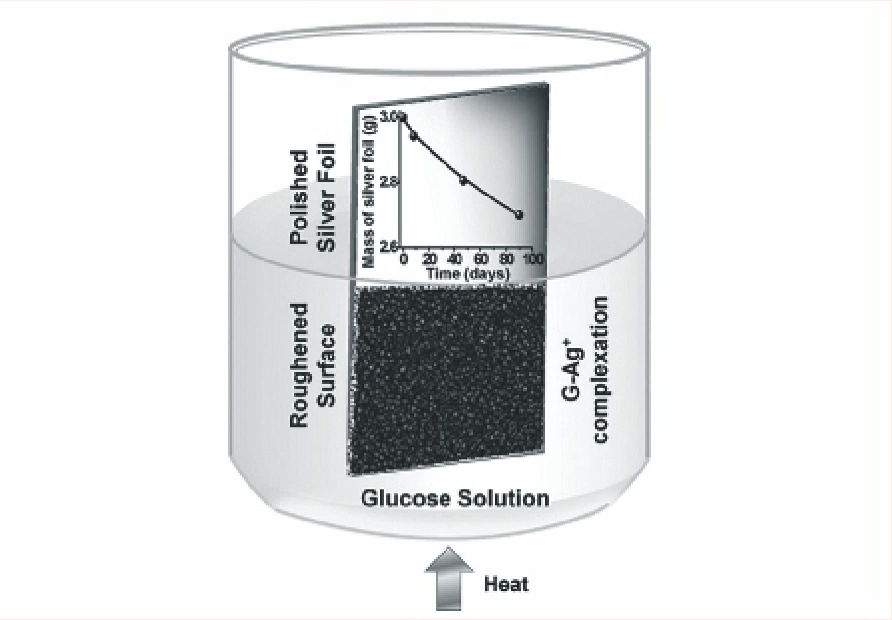
A) TEM images from different stages of the reaction; (i) exfoliated MoS_2 NSs, (ii) Ag NPs decorated NSs, (iii) Ag-reacted NSs where network of Ag_2S structures can be seen protruding out from the NS edges and (iv) a closer view of the branched morphology of Ag_2S network. B) HRTEM images confirming the structures as shown in Scheme 1 (i) structure of a MoS_2 NS (corresponding FFT pattern is shown in the inset; lattice plane is marked); (ii) expanded view of an Ag NP on the MoS_2 sheet (characteristic lattice planes are marked) and (iii) an Ag-Ag_2S NP on NS. This represents the initial stage of the transformation of Ag into Ag_2S by extraction and capture of sulphur from the NSs. Scale bars are indicated on all images.

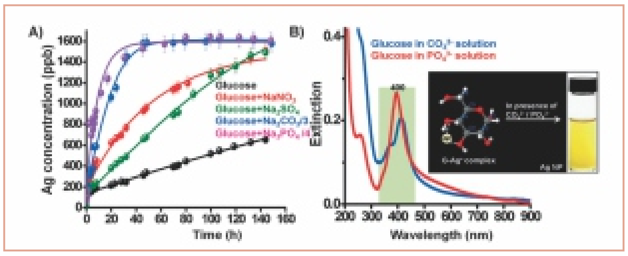
Ananya Baksi, Mounika Gandi, Swathi Chaudhari, Soumabha Bag, Soujit Sen Gupta and T. Pradeep;

Angew. Chem. Int. Ed., 55 (2016) 7777 –7781 [DOI: 10.1002/anie.201510122]

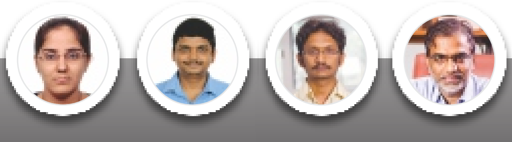
Extraction of silver by glucose

Unprecedented silver ion leaching, in the range of 0.7 ppm was seen when metallic silver was heated in water at 70 °C in presence of simple carbohydrates, such as glucose, making it a green method of silver extraction. Extraction was facilitated by the presence of anions, such as carbonate and phosphate. Studies confirm a two-step mechanism of silver release, first forming silver ions at the metal surface and later complexation of ionic silver with glucose; such complexes have been detected by mass spectrometry. Extraction leads to microscopic roughening of the surface making it Raman active with an enhancement factor of 5×10^8.



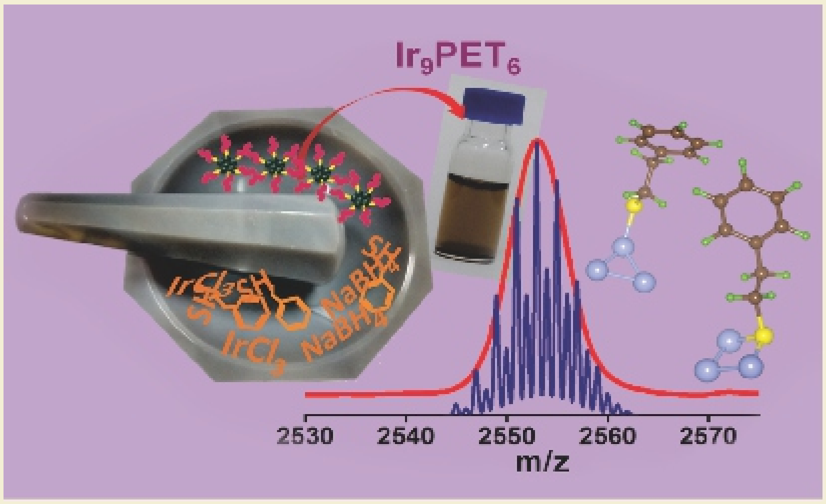


A) Effect of foreign anions on silver leaching from silver foil, in presence of glucose. In all cases, sodium salts of different anions namely, nitrate, sulfate, carbonate, and phosphate (50 ppm each, keeping glucose concentration the same) have been added. All of them enhance silver concentration in the solution while carbonate and phosphate have maximum enhancing capacity (4667 and 6554 ppb, respectively). The traces with carbonate and phosphate have been divided by 3 and 4, respectively. B) In presence of carbonate and phosphate, Ag nanoparticles form which was confirmed by UV/Vis spectroscopy with a characteristic plasmon band at 400 nm. Inset of (B) shows a schematic of the conversion of complexes into NPs and the photograph shows the product.

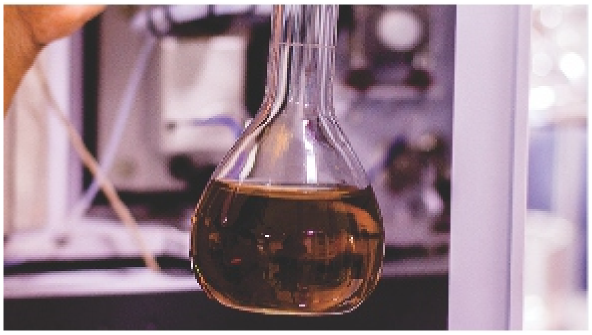


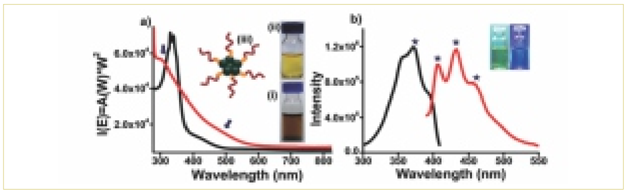
Shridevi Bhat, Indranath Chakraborty, Tuhina Adit Maark, Anuradha Mitra, Goutham De and T. Pradeep;
RSC Adv., 6 (2016) 26679–26688 [DOI: 10.1039/c5ra27972k]

Atomically precise and monolayer protected iridium clusters in solution

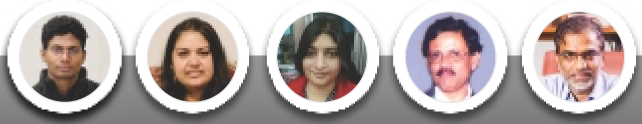


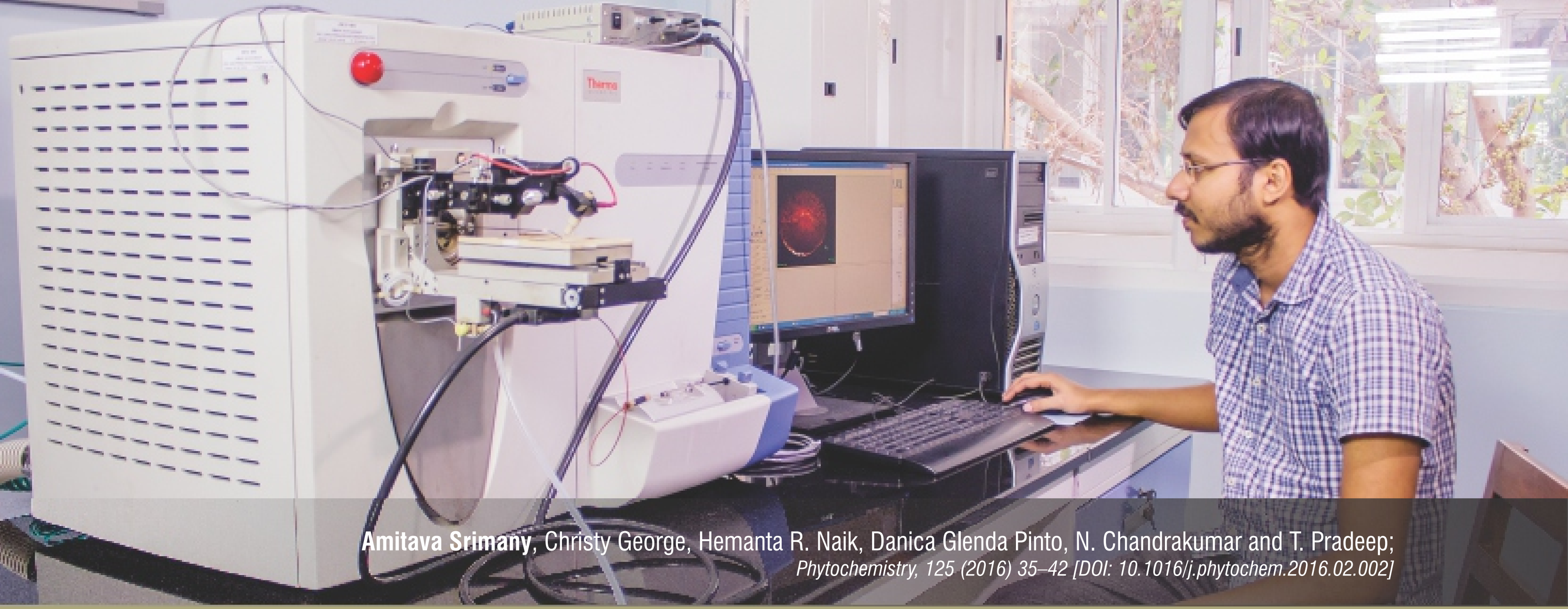
The first atomically precise and monolayer protected iridium cluster in solution, Ir_9PET_6 (PET-2-phenyethanethiol) was synthesized via a solid state method. The absence of plasmonic band at ~350 nm, expected in the UV/Vis spectra for spherical Ir particles of 10 nm size indicated that the synthesized clusters are smaller than this dimension. Small angle X-ray scattering (SAXS) showed that the cluster has a particle size of ~2 nm in solution which was confirmed by transmission electron microscopy (TEM). The blue emission of the cluster is much weaker than many noble metal clusters investigated so far. X-ray photoelectron spectroscopy (XPS) measurements showed that all Ir atoms of the cluster are close to the zero oxidation state. The characteristic S-H vibrational peak of PET at 2560 cm^{-1} was absent in the FT-IR spectrum of the cluster indicating RS-Ir bond formation. Molecular formula of the cluster, Ir_9PET_6 was assigned based on the most significant peak at *m/z* 2553 in the matrix assisted laser desorption ionization mass spectrum (MALDI MS), measured at the threshold laser intensity. Density functional theory calculations on small Ir@SCH_3 and Ir@PET clusters and comparison of the predictions with the IR and ^{1}H-NMR spectra of Ir_9PET_6 suggested that the PET ligands have two distinct structural arrangements and are likely to be present as bridging thiolates -(Ir-SR-Ir)- and singly attached thiolates -(Ir-SR).





a) UV/Vis spectra of the Ir_9PET_6 in THF (red trace) and Ir-PET thiolates in ethanol (black trace). Inset shows (i) photograph of the THF solution of the cluster having greenish brown color and (ii) photograph of Ir-PET thiolates in ethanol having yellow color and (iii) is a schematic representation of the cluster (color codes: olive - Ir, yellow - S and red - hydrocarbon chain of the thiol, in this case the phenylethyl groups), b) photoluminescence data of the cluster. Black trace shows the excitation spectrum and red trace corresponds to the emission spectrum (excited at 370 nm) showing peaks at 404, 432 and 460 nm as indicated by asterisks. Inset shows the photographs of the cluster under visible (left) and UV (right) irradiation.

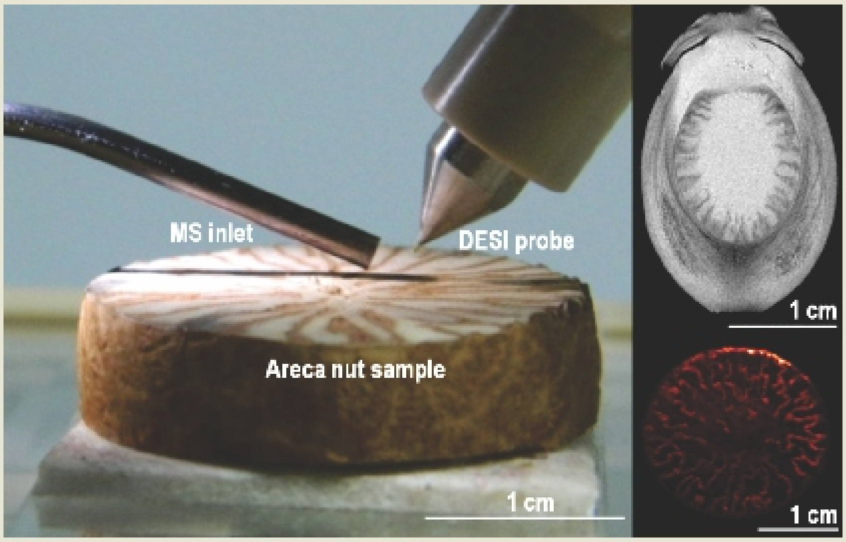




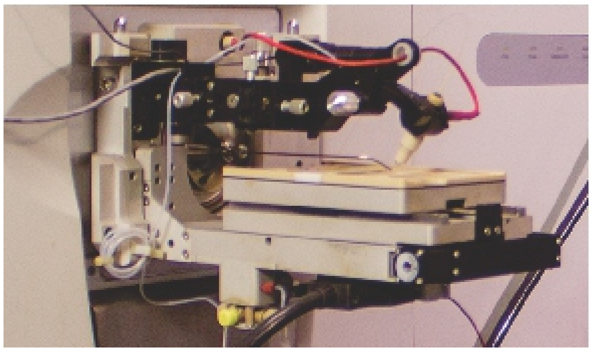
Amitava Srimany, Christy George, Hemanta R. Naik, Danica Glenda Pinto, N. Chandrakumar and T. Pradeep;

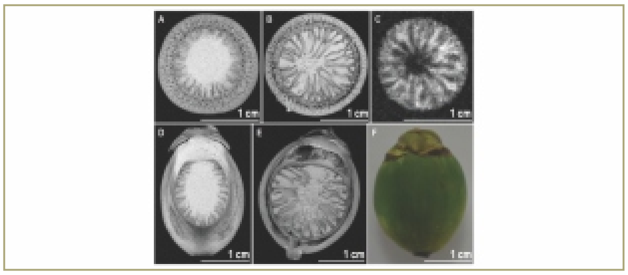
Phytochemistry, 125 (2016) 35–42 [DOI: 10.1016/j.phytochem.2016.02.002]

Developmental patterning and segregation of alkaloids in areca nut (seed of Areca catechu) revealed by magnetic resonance and mass spectrometry imaging

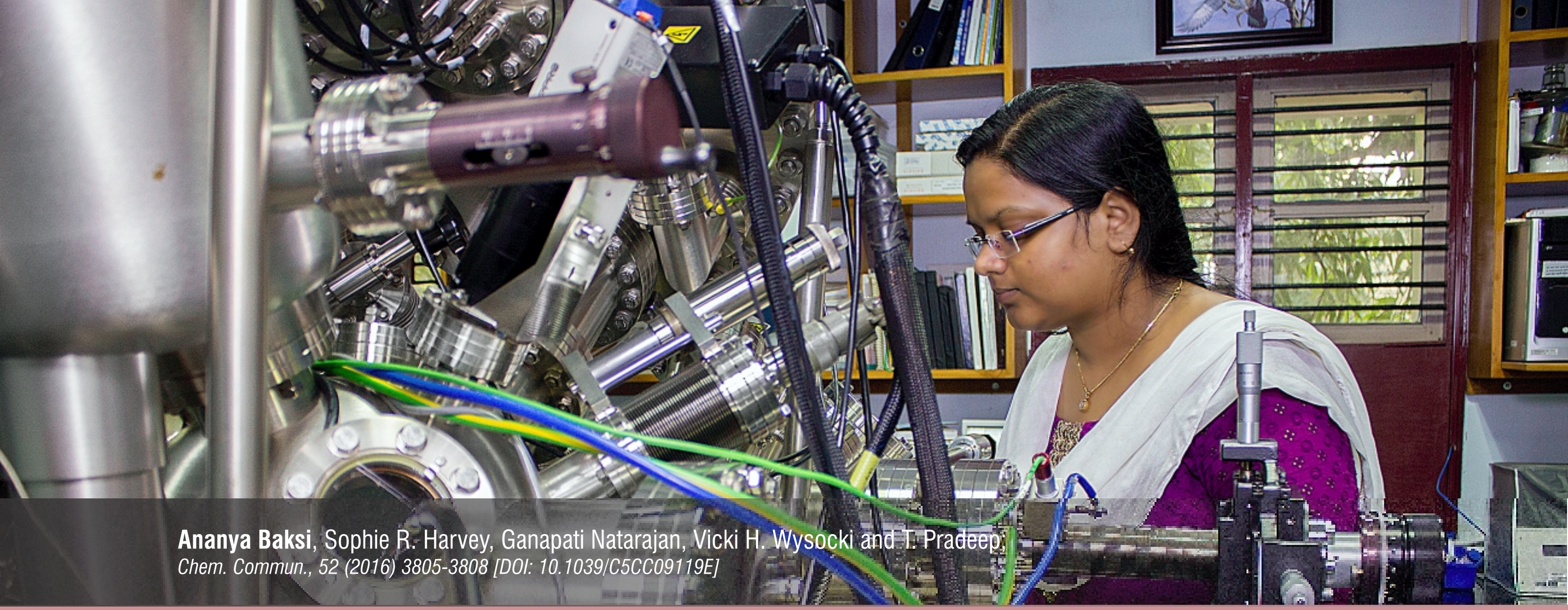


Areca nut (seed of *Areca catechu*) is consumed by people from different parts of Asia, including India. The four major alkaloids present in areca nut are arecoline, arecaidine, guvacoline and guvacine. Upon cutting, the nut reveals two kinds of regions; white and brown. In our present study, we have monitored the formation of these two regions within the nut during maturation, using the non-invasive techniques of magnetic resonance imaging (MRI) and volume localized magnetic resonance spectroscopy (MRS). Electrospray ionization mass spectrometry (ESI MS) and desorption electrospray ionization mass spectrometry (DESI MS) imaging have been used to study the associated change in the alkaloid contents of these two regions during the growth of the nut. Our study reveals that white and brown regions start forming within the nut when the liquid within starts solidifying. At the final stage of maturity, arecoline, arecaidine and guvacoline get segregated in the brown region whereas guvacine gets to the white region of the nut. The transport of molecules with maturity and corresponding pattern formation are expected to be associated with a multitude of physiochemical changes.



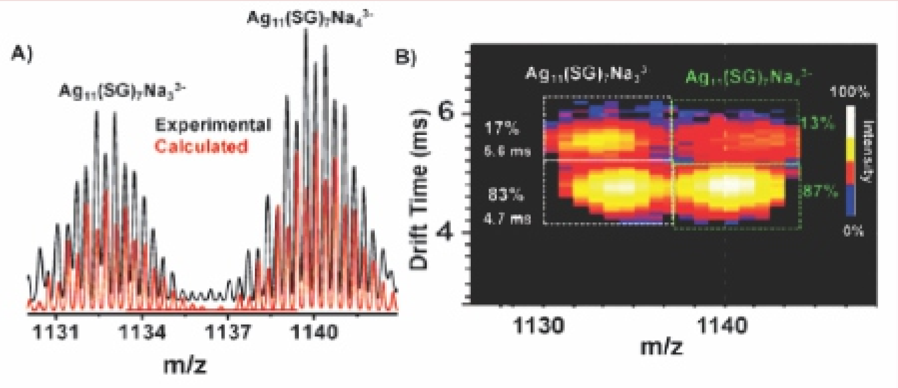


MRI images of areca nut samples of three different maturity stages. Axial view: (A) Stage 1 sample, (B) stage 2 sample, (C) stage 3 sample. Coronal view: (D) stage 1 sample, and (E) stage 2 sample. (F) Photographic image of a stage 2 areca nut sample.

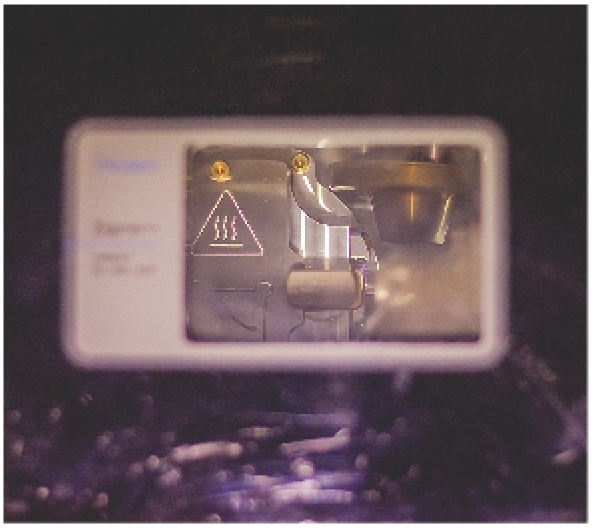


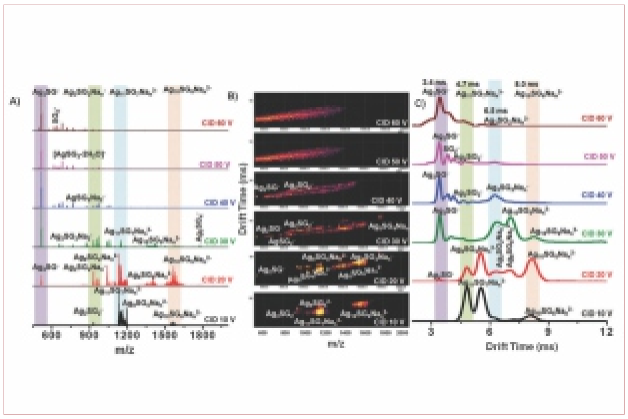
Ananya Baksi, Sophie R. Harvey, Ganapati Natarajan, Vicki H. Wysocki and T. Pradeep,
Chem. Commun., 52 (2016) 3805-3808 [DOI: 10.1039/C5CC09119E]

Possible isomers in ligand protected Ag_{11} cluster ions identified by ion mobility mass spectrometry and fragmented by surface induced dissociation

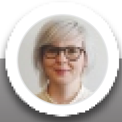


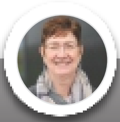
This communication reports the identification of gas phase isomers in monolayer-protected silver clusters. Two different isomers of $Ag_{11}(SG)_7^{-}$ (SG-gulathione thiolate) with different drift times have been detected using combined electrospray ionization (ESI) and ion mobility (IM) mass spectrometry (MS). Surface induced dissociation (SID) of the 3^{-} charge state of such clusters shows charge stripping to give the 1^{-} charged ion with some sodium attachment, in addition to fragmentation. SID and collision induced dissociation (CID) for $Ag_{11}(SG)_7^{-}$ suggest different pathways being accessed with each method. SID was introduced for the first time for the study of monolayer-protected clusters.





(A) CID of $Ag_{11}(SG)_7Na_n^{3-}$ with major products labeled. Corresponding drift time plots of ion mobility drift time versus *m/z* are shown in (B) and the respective peaks are labeled. Corresponding drift time profiles are shown in (C). Each of these plot of ion drift time versus *m/z* and the mass spectra are shown separately in Fig. S2–S5 (ESI†). Major fragments are marked with highlight.



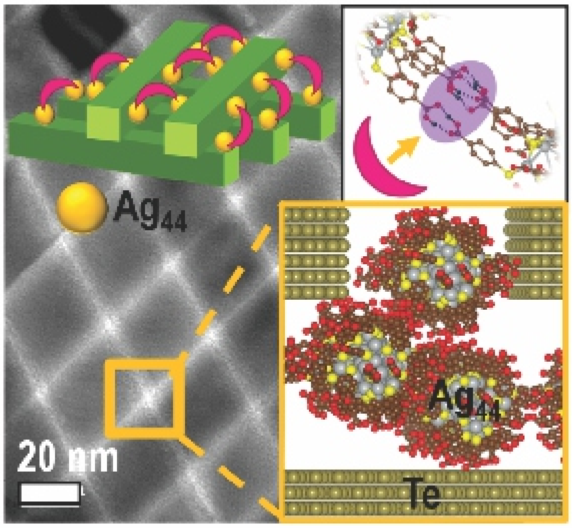


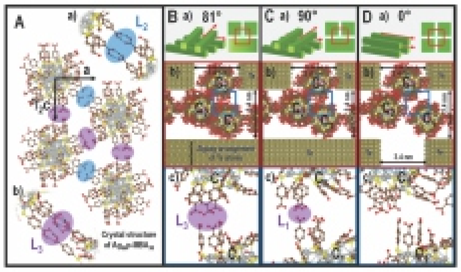
Anirban Som, Indranath Chakraborty, Tuhina Adit Maark, Shridevi Bhat and T. Pradeep;

Adv. Mater., 28 (2016) 2827-2833 [DOI: 10.1002/adma.201505775]

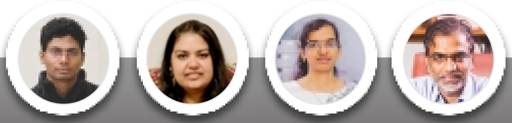
Cluster mediated crossed bilayer precision assemblies of 1D nanowires

Highly organized crossed bilayer assemblies of NWs are made directly from the solution state using directed hydrogen bonding between the protecting ligand shells of atomically precise cluster molecules. Layers of QCs remain sandwiched between two neighboring NWs and keep them apart at a distance, dictated by the core-size of the cluster, while orientation of ligands in space dictates interlayer geometry.





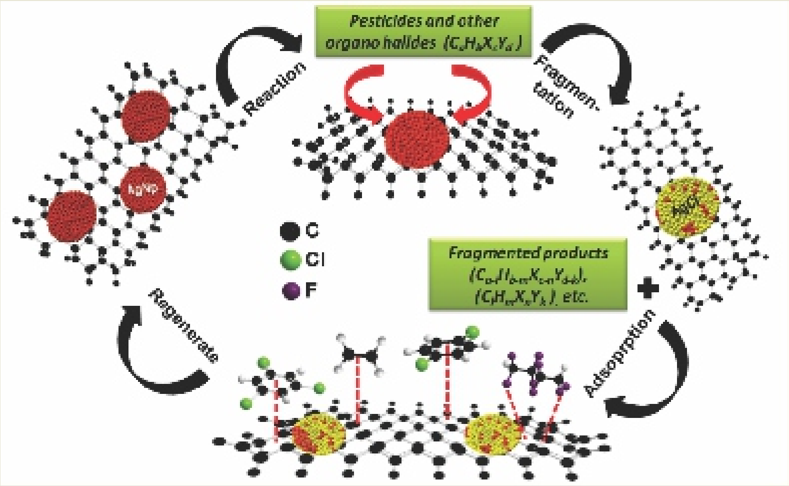
A) H-bonding between neighboring clusters in the $Ag_{44}(MBA)_{30}$ superlattice structure. Clusters remain H-bonded with the neighboring ones between L_2 (inset a) and L_3 type of ligand bundles. B) a, b and c represent the schematic representation of the 81° orthogonal bilayer assembly, a model of the marked region of the schematic in a) and zoomed view of the marked region in b), respectively. C and D represent other possible arrangements which are not energetically better. Clusters are assembled on Te surfaces kept at 3.4 nm, in three different planes labeled as C_1 to C_3.



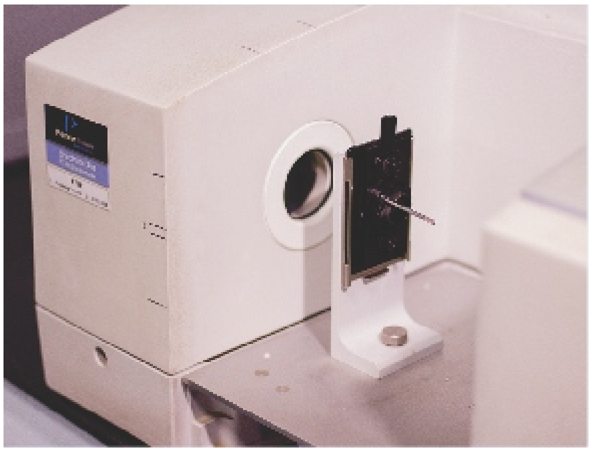
Dibyashree Koushik, **Soujit Sen Gupta**, Shihabudheen M. Maliyekkal and T. Pradeep;

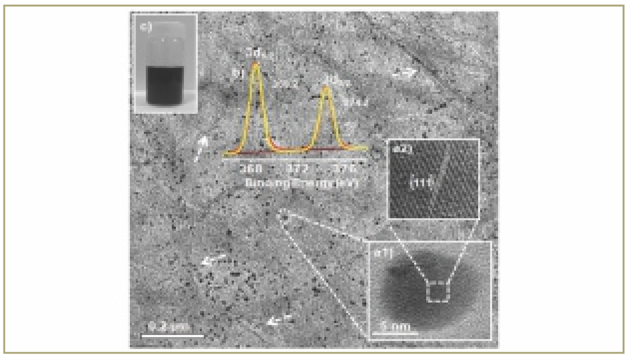
J. Haz. Mater., 308 (2016) 192-198 [DOI:10.1016/j.jhazmat.2016.01.004]

Rapid dehalogenation of pesticides and organics at the interface of reduced graphene oxide-silver nanocomposite



This paper reports dehalogenation of various organohalides, especially aliphatic halocarbons and pesticides at reduced graphene oxide–silver nanocomposite (RGO@Ag). Several pesticides as well as chlorinated and fluorinated alkyl halides were chosen for this purpose. The composite and the products of degradation were characterized thoroughly by means of various microscopic and spectroscopic techniques. A sequential two-step mechanism involving dehalogenation of the target pollutants by silver nanoparticles followed by adsorption of the degraded compounds onto RGO was revealed. The composite showed unusual adsorption capacity, as high as 1534 mg/g, which facilitated the complete removal of the pollutants. Irrespective of the pollutants tested, a pseudo-second-order rate equation best described the adsorption kinetics. The affinity of the composite manifested chemical differences. The high adsorption capacity and re-usability makes the composite an excellent substrate for purification of water.





TEM image of RGO@Ag composite; the folding of the RGO sheets is marked with white arrows. Insets: a1) HRTEM image of a single nanoparticle, a2) expanded portion from figure a1 showing a lattice spacing of 0.232 nm corresponding to the (111) lattice plane, b) deconvoluted XPS spectrum of Ag in the composite and c) photograph showing the dispersed nature of the composite.

OTHER PUBLICATIONS

- **Joyful Years with the Journal**: **Balancing the Editor–Professor Life**; T. Pradeep; *ACS Sustainable Chem. Eng., 4 (2016) 6252 [DOI: 10.1021 /acssuschemeng.6b02786].*
- **Direct observation of the formation pathway of [Mo132] keplerates**; Subharanjan Biswas, Dolores Melgar, Amitava Srimany, Antonio Rodríguez-Fortea, T. Pradeep, Carles Bo, Josep M. Poblet and Soumyajit Roy; *Inorg. Chem., 55 (2016) 8285-8291 [DOI: 10.1021/acs.inorgchem.5b02570].*
- **Bridging innovations in academic institutions to society**; T. Pradeep, Baldev Raj, V. Ramgopal Rao, Anil Kumar, Bodh Raj Mehta, G. U. Kulkarni, Tata Narasinga Rao, A. K. Ghosh, Satish Vasu Kailas, Kishore M. Paknikar, Mohan Kumar, S. G. Sreekanteswara Swamy, Anshup, Nitin Kale, Praveen Poddar, Radhica Sastry, Saket Kumar, Abhijeet Gaan, Krishnan Swaminathan, Prashanth Vaijayanth, Vijaya Lakshmi, Rajeev Kumar, D. R. Prasada Raju, Debapriya Dutta, Sanjay Bajpai, Soujit Sen Gupta, Devaraju; *Curr. Sci., 110 (2016) 482-486.*

BOOK CHAPTERS

- **Evolution of atomically precise clusters through the eye of mass spectrometry**; Shridevi Bhat, Indranath Chakraborty, Ananya Baksi, Raghu Pradeep Narayanan and T. Pradeep; *Nanoscience: Volume 3 Paul O'Brien (Ed.) and P John Thomas (Ed.), Royal Society of Chemistry, London, 3 (2016) 343–385 [DOI:10.1039/9781782623717-00343].*

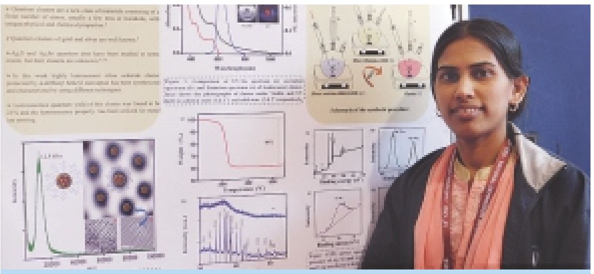
RESEARCH PROJECTS AT HAND

- Improve rubber to steel bonding in steel radial tyres through scientific under- standing, MRF Ltd. Rs. 130 lakhs (principal investigator).
- Soft ionization ion mobility mass spectrometry of atomically precise clusters of noble metals, Rs. 608 lakhs (principal investigator).
- Thematic Unit of Excellence (TUE) on water purification using nanotechnology at IIT Madras, DST, Rs. 1081 lakhs (principal investigator).
- Dust free glass, Saint-Gobain Research India Ltd. Rs. 36 lakhs (principal investigator with Prof. R. Nagarajan).
- Others such as JC Bose Fellowship, R&D Awards, technology development and instrument maintenance activities are managed as projects.

PROJECTS GRANTED IN 2016

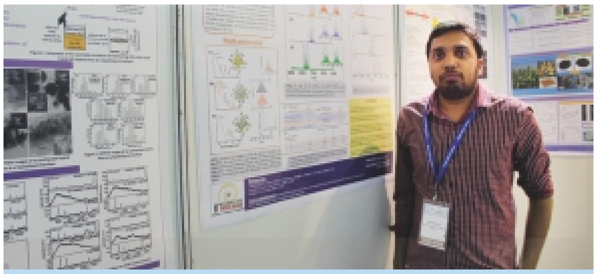
- Cluster composite nanofibre membranes for rapid, ultra-trace detection of waterborne contaminants, India-German Science and Technology Forum, Total funds Rs. 191.324 lakhs (principal investigator along with InnoNano Research Pvt. Ltd.).
- Arsenic free South 24 Parganas district, DST, Rs. 374.88 lakhs (principal investigator).
- Development of a novel combined arsenic filtration/monitoring system for community-scale water supplies, India-UK project supported by GITA, total funds Rs. 130 lakhs (principal investigator along with InnoNano Research Pvt. Ltd.).

STUDENTS' POSTER PRESENTATIONS

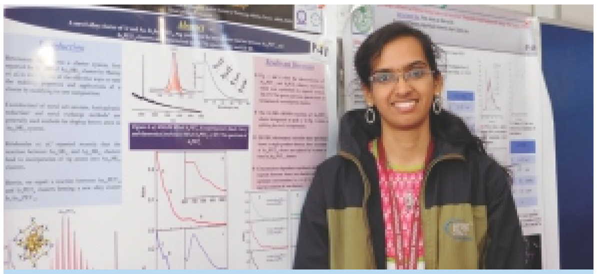


Highly luminescent silver selenide by **C. K. Manju** (18th Chemical Research Society of India Symposium, CRSI 2016, Panjab University) February 5-6, 2016.

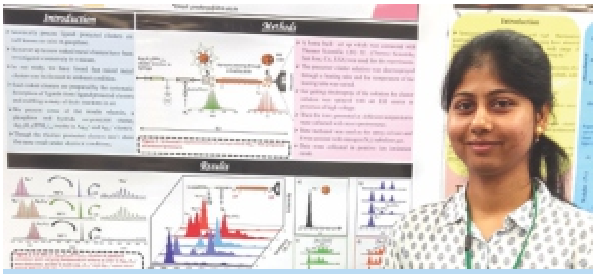
Metallic nanobrushes made using ambient droplet sprays by **Depanjan Sarkar** (8th Bangalore INDIA NANO conference, The Lalit Ashok, Bengaluru, 2016) March 4, 2016.



Inter-cluster reactions between $Au_{25}(SR)_{18}$ and $Ag_{44}(SR)_{30}$ by **K. R. Krishnadas** (8th Bangalore INDIA NANO conference, The Lalit Ashok, Bengaluru, 2016) March 4, 2016.

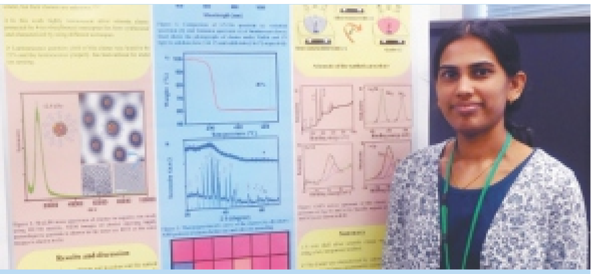


$Ir_3Au_{22}PET_{18}$: A new alloy cluster made by inter-cluster reaction by **Shridevi Bhat** (18th Chemical Research Society of India Symposium, CRSI 2016, Panjab University) February 5-6, 2016.



Naked clusters of noble metals in air formed from ligand protected clusters in solution by **Madhuri Jash** (JSPS-DST Asian Academic Seminar; Advanced Materials, Processes and Systems for Sustainable Development, 2016, The University of Tokyo, Japan) December 17, 2016.

Dissociation of gas phase ions of atomically precise silver clusters establishes their electronic stability by **Papri Chakraborty** (JSPS-DST Asian Academic Seminar; Advanced Materials, Processes and Systems for Sustainable Development, 2016, The University of Tokyo, Japan) December 17, 2016.



Highly luminescent monolayer protected $Ag_{56}Se_{13}S_{15}$ clusters by **C. K. Manju** (JSPS-DST Asian Academic Seminar; Advanced Materials, Processes and Systems for Sustainable Development, 2016, The University of Tokyo, Japan) December 17, 2016.

Unusual reactivity of dithiol protected clusters in comparison to monothiol protected clusters by **Atanu Ghosh** (JSPS-DST Asian Academic Seminar; Advanced Materials, Processes and Systems for Sustainable Development, 2016, The University of Tokyo, Japan) December 17, 2016.

Molecular Ionization at low voltage from one-dimensional nanostructures by **Rahul Narayanan** 64th ASMS (conference on Mass Spectrometry, Texas, USA) June 5-9, 2016.

AWARDS AND RECOGNITIONS

1

2

3

4

5

① DEPANJAN SARKAR

Nano Young Scientist Award 2016' for the young researchers in the field of nanotechnology by the Govt. of Karnataka
Malhotra Weikfield Foundation Nano Science Fellowship Award
March 4, 2016

② BEST EXHIBITOR AWARD

Category of innovative display at the 8th Bangalore India Nano conference,
The Lalit Ashok, Bangalore INDIA NANO conference, Bengaluru
March 4, 2016

③ AVIJIT BAIDYA

Best Presentation Award
Research Scholars Day ID
August 23, 2016

④ ATANU GHOSH

Best Posters Award
DST - JSPS Asian Academic Seminar - Japan
December 19, 2016

⑤ PAPRI CHAKRABORTY

Best Posters Award
DST - JSPS Asian Academic Seminar - Japan
December 19, 2016

● K. R. KRISHNADAS

Best Posters Award
8th Bangalore INDIA NANO conference,
The Lalit Ashok, Bengaluru
March 4, 2016

● DEPANJAN SARKAR

Institute Research Scholar Award
57th Institute day - IIT Madras
April 25, 2016

● C. K. MANJU

Royal Society of Chemistry's Best Poster Award
18th Chemical Research Society of Indian Symposium
Panjab University, Chandigarh
February 5, 2016

GRADUATION

Ph.D.

Anirban Som, Department of Chemistry, IIT Madras, 2016	Investigations into the reactivity of tellurium nanowires with ionic, molecular and metallic silver, 2016.
Rabin Rajan J. Methikkalam, Department of Chemistry, IIT Madras, 2016	Physico-chemical changes at icy surfaces of relevance to astrochemical processes, 2016.
K. R. Krishnadas, Department of Chemistry, IIT Madras, 2016	Chemical reactions of atomically precise noble metal clusters, 2016.
Soujit Sengupta, Department of Chemistry, IIT Madras, 2016	Graphenic materials for affordable clean water, 2016.

M.Sc.

Anindita Mahapatra	Department of Chemistry, IIT Madras, 2016
Bibhuti Bhusan Rath	Department of Chemistry, IIT Madras, 2016
Esma Khatun	Department of Chemistry, IIT Madras, 2016
Pallab Basuri	Department of Chemistry, IIT Madras, 2016
Tripti Ahuja	Department of Chemistry, IIT Madras, 2016

ALUMNI NEWS

- Radha Gobinda Bhuin, received SERB overseas postdoctoral fellowship 2016.
- Radha Gobinda Bhuin, joined Friedrich Alexander Universität Erlangen Nürnberg (Hans- Peter Steinrück's research group) as a postdoc researcher.
- G. Velmurugan, Postdoctoral Fellow, Cancer and Genetics Research Centre, College of Medicine, University of Florida, Gainesville, Florida, USA.
- Udayabhaskararao Thumu, Post-Doctoral Fellow Nanophotonics Group, Prof. Dan Oron, Dept of Physics of Complex Systems, Weizmann Institute of Science Rehovot, Israel.
- Balanagulu Busupalli (Bala), postdoctoral fellow in the 'Origins of Life Initiative' at Harvard University.
- M. S. Bootharaju, Postdoctoral fellow, C/o Prof. Jean Marie Basset KAUST Catalysis Center (KCC) King Abdullah University of Science and Technology, Thuwal 239556900, Saudi Arabia.
- Soumabha Bag, Posdoctoral fellow, Institute of Nanotechnology, Karlsruhe Institute of Technology, Germany.
- Ananya Baksi, Posdoctoral fellow, Institute of Nanotechnology, Karlsruhe Institute of Technology, Germany.
- Akshaya Kumar Samal, Postdoctoral Researcher KAUST Catalysis Center, King Abdullah University of Science & Technology, Thuwal 239556900, Saudi Arabia.
- Jeba Singh David, Mass spectrometry specialist, Agilent Partner Laboratory, Gulf Bio Analytical Dubai, UAE.
- Aniruddha Molla, Postdoctoral Researcher, BK21 Plus (Korea Research Foundation) C/o Prof. Jin Suk Chung School of Chemical Eng. & Bioeng, University of Ulsan.
- T. S. Sreeprasad, NASA space grant: to develop 2D polymerbased solar cells.
- T. S. Sreeprasad, A seed funding to work on nextgen, nanomaterial based energy generators.
- T. S. Sreeprasad, Industrial funding to develop novel wash down coating for gear.

PATENTS

- **Cellulose nanocrystal templated iron oxyhydroxide based adsorbent for arsenic removal from water and a device thereof**; T. Pradeep, Avijit Baidya, Bibhuti Bhusan Rath and A. Anil Kumar; *201641027660*, August 12, 2016.
- **Method of synthesis of atomically precise metal cluster-cellulose nanocrystal composite for diffusion controlled simultaneous sensing and scavenging of heavy metal ions in water;** T. Pradeep, Nishil Muhammed, Avijit Baidya, A. Anil Kumar and Michael K. C. Tam; *201641031815,* September 19, 2016.
- **Structure and topology conserving transformations between two archetypal nanoparticles**; T. Pradeep, K. R. Krishnadas, Atanu Ghosh, Ananya Baksi and Gana Natarajan; *201641034921,* October 13, 2016.
- **Method to produce unprotected naked clusters of metals of precise composition in air without mass selection**; *201641035574*, October 18, 2016.
- **Inbuilt water purification device for storage containers**; *Design patent. 287785*, October 18, 2016.
- **Domestic water purification unit**; *Design patent. 288810*, November 24, 2016.
- **Cellulose microstructures templated nanocomposites with enhanced arsenic removal capacity and a purifier thereof**; *IDF No.1433*, December 29, 2016.
- **Patterned metallic nanobrushes for capture of atmospheric humidity***; IDF No.1492,* December 29, 2016.
- **Chitosan reinforced mixed oxidze nanocomposite for fluoride removal from water and a device thereof***; IDF No.1499,* December 29, 2016.

PATENTS GRANTED

- **On-line water purifier for hand pumps, Design application**; *Patent No. 271059,* filed on April 6, 2015, granted on July 12, 2016.
- **A method to produce supported noble metal nanoparticles in commercial quantities for drinking water purification**; T. Pradeep filed along with Aquamall Water Solutions Ltd.; *Patent No. 277112*, filed on August 22, 2007, granted on November 10, 2016.
- **Coated mesoflowers for molecular detection and smart barcode materials;** P. R. Sajanlal and T. Pradeep; *Patent No. US20160077010 A1,* filed on April 30, 2014, granted on March 17, 2016.
- **Multielement and multiproperty tagging**; P. R. Sajanlal and T. Pradeep; *Patent No. JP5931725* (B2), filed on August 2010, granted on June 8, 2016.

INCUBATION

- InnoNano Research Private Limited (a start-up company at IIT Madras). The company to use thirteen patents.
- Safewater Nano Pte. Ltd. The company is incorporated in Singapore, to take our water technologies to international markets, at a funding of $18 million.

AMRIT

AFFORDABLE
arsenic removal at less than 2 paise/litre

EASY INTEGRATION
with other solutions

EASY MAINTAINABILITY
simple backwash

ADAPTABLE
capacity from 1,000 to 20,000 litres/hour
in different models

INTRODUCING
The hand-pump model

Presence of arsenic and iron in drinking water affects water quality significantly. Damage to human health due to the presence of arsenic in water is well known. With the advent of nanotechnology, it is possible to address contaminants such as arsenic at affordable cost. A product, aptly titled AMRIT is presented here. AMRIT uses a composition based on iron oxyhydroxide to remove arsenic from water.

What it means in terms of performance and affordability? AMRIT composition can handle up to an input load of 5 ppm of arsenic and bring the output level below the typical detection limit (<1 ppb). Composition is at least 5-6 times more efficient than any other adsorbent available currently. Since the contact time required for removal is fairly low (less than 1 min), the composition is used in the size of 0.2 mm, thereby offering negligible pressure drop. This helps from several aspects: treatment cost reduces, filtration unit becomes smaller, filtration unit can be operated with minimum pressure, easily maintainable by local community and reduced sludge quantity.

Parameter	Input water quality	Output water quality
Turbidity	Up to 200 NTU	1 NTU (WHO norm, BIS norm: 5 NTU)
Iron	Up to 15 ppm	<0.3 ppm (WHO and BIS norms)
Arsenic	Up to 5 ppm	<0,010 ppm (WHO norm, BIS norm: <0.05 ppm)
Allowed TDS	Up to 2000 ppm	No reduction from input
pH	6 to 9	7 to 8

Product Name	**AMRIT** - **A**rsenic and **M**etal **R**emoval by **I**ndian **T**echnology.
Product description	An affordable domestic and community scale water purification unit for iron and arsenic removal.
Technical details	Iron and turbidity removal by physical filtration, arsenic removal by adsorption.
Product elements	Unit attached to hand-pumps with appropriate fittings.
Material of construction	MS and GI pipes. Food grade ingredient for adsorption.
Mode of operation	Hand-pump operated.
Electricity requirement	No electricity required for operation.
Feed water quality	Turbidity: up to 200 NTU Iron: up to 15 ppm Arsenic: up to 5 ppm Allowed TDS: up to 2,000 ppm
Output water quality	Turbidity: 1 NTU (WHO and BIS norms: 5 NTU) Iron: <0.3 ppm (WHO and BIS norms) Arsenic: <0.010 ppm (WHO and BIS norms: <0.05 ppm)
Rate of water filtration	Typically each stroke of the pump delivers 300 mL of water in 2 sec.
Replacement frequency	Yearly for arsenic removal media, 3-5 years for turbidity/iron removal media.
Expected life of the unit	5 years.
Adaptability	Easy integration with existing water purification technologies and products.

AMRIT was co-created by IIT Madras and InnoNano Research Pvt. Ltd., an IIT Madras incubated company. InnoNano Research was co-founded by professors and alumni of reputed Indian academic institutions.

AFFORDABLE
arsenic removal at less than
2 paise/litre

EASY INTEGRATION
with other solutions

EASY MAINTAINABILITY
surface rubbing by brush,
once a week

ADAPTABLE
capacity from
100 - 9,000 litres/day

Arsenic and Metal Removal by Indian Technology

AMRIT was co-created by IIT Madras and InnoNano Research Private Limited, an IIT Madras incubated company. InnoNano Research is co founded by Professors and Alumni of reputed Indian academic institutions

Presence of arsenic and iron in drinking water affects water quality significantly. Damage to human health due to the presence of arsenic in water is well-known. With the advent of nanotechnology, it is possible to address contaminants such as arsenic at affordable cost. A product, aptly titled AMRIT is presented here. AMRIT uses a composition based on iron oxyhydroxide to remove arsenic from water.

What is means in terms of performance and affordability? AMRIT composition can handled up to an input load of 5 ppm of arsenic and bring the output level below the typical detection limit (<1 ppb). Complition is at least 5-6 times more efficient than any other adsorbant available currently. Since the contact time required for removal is fairly low (less than 1 min), the composition is used in the size of 0.2 mm, thereby offering negligible pressure drop. This helps from several aspects: treatment cost reduces, filtration unit becomes smaller, filtration unit can be operated with minimum pressure, easily maintainable by local community and reduced sludge quantity.

The nanocomposite material

The arsenic filter assembly

InnoNano Research Pvt. Ltd

Registered Office: 7/30, II Main Road, Kastuibai Nagar,
Adyar, Chennai 600020
R&D Office: HSB 270, IIT Madras, Chennai 600036
Email: udhayasankarm@live.com
Phone: +91 9789037951

Parameter	Input water quantity	Output water quality
Turbidity	Up to 200 NTU	1 NTU (WHO norm: 5 NTU)
Iron	Up to 15 ppm	<0.3 ppm (WHO and BIS norms)
Arsenic	Up to 5 ppm	<0.010 ppm (WHO norm:<0.05 ppm)
Allowed TDS	Upto 2000 ppm	No reduction from input
pH	6 to 9 7 to 8	

Product Name	AMRIT - Arsenic Removal by Indian Technology
Product description	An affordable domestic and communty scale water purification unit for iron and arsenic removal
Technical details	Iron and turbidity removal by physical filtration, arsenic removal by adsorption
Product elements	One input water storage tank, one output water storage tank kept on a stand along with purification cartridges
Material of construction	Food grade polypropylene for plastic components. Food grade ingredient for adsorbents
Mode of operation	Manual pouring of water or through a pump, gravity flow to the output tank
Electricity requirement	No electricity required for operation, electricity may be used to operate the pump
Feed water quality	Turbidity: up to 200 NTU Iron: up to 15 ppm Arsenic: up to 5 ppm Allowed TDS: up to 2000 rpm
Output water quality	Turbidity: 1 NTU (WHO and BIS norms: 5 NTU) Iron: <0.3 ppm (WHO and BIS norms) Arsenic:<0.010 ppm (WHO norm, BIS norm: <0.005 ppm)
Rate of water filtration	50-100 mL/min (domestic model), 100-500 L/h (community model). 500 L/h (online model)
Replacement frequency	Yearly for arsenic removal media, 3-5 years for turbidity/iron removal media
Expected life of the unit	15 years
Adaptability	Easy integration with existing water purification technologies and products

AMRIT

A view of our stall at Bangalore INDIA NANO 2016.

Another view of our stall at Bangalore INDIA NANO 2016.

Vidhya is using a plasma chamber to fabricate devices.

Many of our measurements are done in ultrahigh vacuum environment.

VISITORS


With the Director and the InnoNano Team, August 01, 2015


With Sung Jae Kim, Pedro Alvarez, Peter Vikesland and Marc Andelman, March 04, 2016


With Sung Jae Kim and Wonseok Kim, Seoul National University, South Korea, February 03, 2016


With Mahesh Gupta, CEO of Kent, August 4, 2016

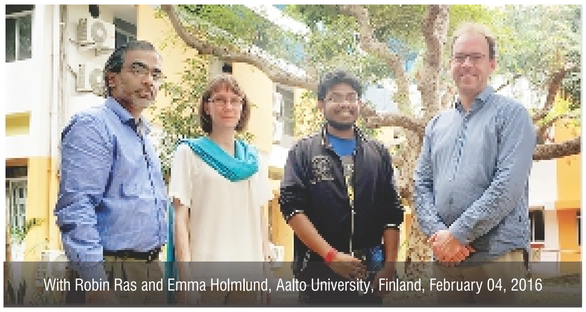
07/01/16	Prof. John Tharakan, Howard University, Washington, DC, USA
08/01/16	Dr. Akshaya K. Samal, KAUST, Saudi Arabia
09/01/16	Ms. Ranu Dutta, DST Young Scientist, Nanotechnology Center
11/01/16	Prof. C.N.R. Rao, JNCASR to inaugurate TUE
20/01/16	Mr. Kalyan Raman, Thermax Ltd., Pune
27/01/16	Ms. R. Pratibha Nalini, VIT, Chennai
29/01/16	Dr. A. Chakraborty, Indo-German Director, New Delhi
02/02/16	Dr. Ger Bergkamp, Executive Director, IWA, Amsterdam
02/02/16	Dr. Ganesh Pingare, Regional Director, Regional Office, Bangkok, Thailand
02/02/16	Dr. Sushmita Mandal, India Director, IWA, New Delhi
03/02/16	Mr. Wonseok Kim, Seoul National University, South Korea
04/02/16	Prof. Robin Ras, Aalto University, Finland
04/02/16	Dr. Emma Holmlund, Aalto University, Finland
05/02/16	Mr. Alabhya Singh and Dr. Arpita Singh, Dehradun
11/02/16	Prof. Suddhasatha Basu, IIT Delhi
13/02/16	Dr. Santhosh Chidangil, Head, Department of Atomic and Molecular Physics, Manipal University, Manipal
22/02/16	Dr. Paolo Longo, GATAN, USA
22/02/16	Dr. P. J. Reddy, Bangalore
26/02/16	Dr. Rajnish Uppal, VESTERGAARD, New Delhi
04/03/16	Prof. Akash Gulyani, Ph.D., Assistant Investigator, in STEM, Bangalore
05/03/16	Prof. Marc Andelman, CDI inventor, Worcester, United States
05/03/16	Mr. P. Senthil Nathan, Coimbatore
07/03/16	Prof. Sung Jae Kim, Seoul University, South Korea
08/03/16	Prof. Horst Hahn, KIT, Germany
08/03/16	Prof. Vasantha Kumari, B. S. Abdur Rahman University, Tamil Nadu
08/03/16	Dr. David Jenkins, Plymouth University, UK
18/03/16	Prof. Chittaranjan Ray, Director, Nebraska Water Center, USA
21/03/16	Mr. Subramanian, Blue Star, Chennai
31/03/16	Prof. B. V. R. Chowdari, Senior Executive Director, President's Office and Professor, School of Materials Science & Engineering, Singapore
31/03/16	Prof. Bo Liedberg, Dean, Interdisciplinary Graduate School, Singapore
02/04/16	Mr. Santhosh, IAS, Tamil Nadu Govt.
18/04/16	Prof. Micheal Tam, Waterloo Institute of Nanotechnology, Waterloo, Canada
18/04/16	Dr. Bhabendra Pradhan, Nanoholdings, USA
26/04/16	Prof. Masahiro Yoshimura, Tokyo Institute of Technology, Japan
04/05/16	Mr. Ajay Sharma, IAS, Punjab Govt.
09/05/16	Dr. Rajiv Sharma, DST, New Delhi
09/05/16	Prof. Satish Vasu Kailas, IISc Bangalore
10/05/16	Dr. T. N. V. V. Rao, Bangalore
12/05/16	Dr. Abhinav Trikha, IAS, Punjab Govt.

VISITORS


Navin Patnaik and M. Udhaya Sankar along with an AMRIT unit, July 20, 2016


With K. L. Chopra, former director of IIT Kharagpur, March 01, 2016

19/05/16	Prof. C. R. Raj, IIT Kharagpur
28/05/16	Dr. B. L. V Prasad, NCL Pune
07/06/16	Dr. Rajesh Parishwad, RSC, Bangalore
22/06/16	Prof. P. M. Ajayan, Rice University, USA
24/06/16	Mr. Madhav Narayan, Senior Director, Intel Technology India Pvt. Ltd.
04/07/16	Dr. Sanjiv Sambandan, IISc Bangalore, Bangalore
07/07/16	Ms. Seema Singh, Science Reporter, New Delhi
20/07/16	Dr. S. V. Eswaran, Emer. Sci. UNESCO-DBT Reg. Centre for Biotech., Haryana
04/08/16	Mr. Mahesh Gupta, Chairman & Managing Director, Kent RO Systems Ltd., Noida, Uttar Pradesh
05/08/16	Mr. G. N. Murari, Bosch India
16/08/16	Dr. Raghunath Reddy, DST, New Delhi
22/08/16	Vijay Sampath, Managing Director, AquaSphere Greentech Solutions Pvt. Ltd., Bangalore
22/08/16	Dr. Teruhisa Ueda, CEO – Shimadzu Corporation, Japan
22/08/16	Dr. R. R. Sonde, Thermax Ltd., Pune
13/09/16	Dr. Hassinen Jukka, Aalto University, Finland
13/09/16	Dr. Maija Vidqvist, Finland
13/09/16	Dr. Nikolaos Pahimanolis, Finland
26/09/16	Organo Corporation team from Japan
04/10/16	Mr. Priyabrata Roy, Bashudha Biotechnology Laboratory for Conservation, Centre for Interdisciplinary Studies, Kalikapur, Kolkata
11/10/16	Mr. M.M. Murugappan, Vice Chairman, Murugappan Group of Companies, Chennai
31/10/16	Mr. Erick Mobegi, Kenya
01/11/16	Dr. S. Krishnakumar, Sankara Nethralaya, Chennai
03/11/16	Prof. Arindam Banarjee, IACS, Kolkata
07/11/16	Prof. Ian. A. Nicholls, Linnaeus University, Sweden
10/11/16	BHEL Team, Trichy
14/11/16	Prof. Ronojoy Adhikari, IMSC, Chennai
14/11/16	Mr. Goutham and Guru, Saint Gobind, Chennai
18/11/16	Dr. Benny Antony, Arjuna Natural Extracts, Kerala
21/11/16	Dr. Muthu Murugesan, Bio Nano, UK
21/11/16	Dr. Floriant Doungmene, Bio Nano, UK
21/11/16	Dr. Christopher Johnson, Bio Nano, UK
25/11/16	Dr. Badrinath, Chairman, Emeritus, Sankar Nethralaya, Chennai
25/11/16	Dr. Subir Chakraborty, Exide, Kolkata
07/12/16	Dr. Srinivas Ramakrishnan, Ph.D candidate, Chidsey Research Group, Stanford University, USA
09/12/16	Mr. Vijay Sampath, Managing Director, AquaSphere Greentech Solutions Pvt. Ltd., Bangalore
09/12/16	Mr. Tullio Servida, CTO, Indropan Technologies, Italy
15/12/16	Mr. Suresh Oliver, GERIND Technology Pvt. Ltd., Chennai
24/12/16	Dr. Aniruddh Bahadur Yadav, Tirupati, Andhra Pradesh

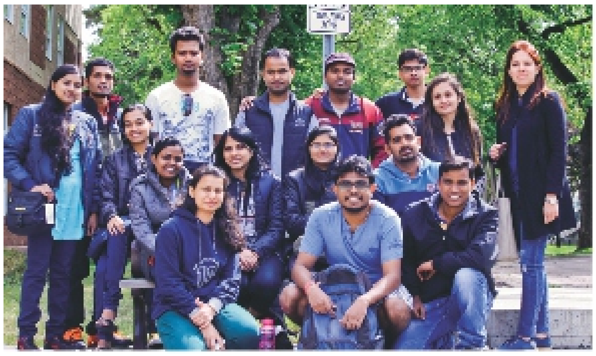

With Robin Ras and Emma Holmlund, Aalto University, Finland, February 04, 2016


With A. Q. Khan, Pulamanologist, September 4, 2016


With Sanjiv Sambandan, IISC, July 4, 2016


With Ashok Ganguly and Ramgopal Rao, August 17, 2016

STUDENTS’ VISITS OVERSEAS


IC IMPACT 2016, Canada


AIST, Japan


With Hannu Hakkinen, University of Jyvaskyla, Finland


With Kam Chiu Tam, University of Waterloo, Canada


With Robin Ras, Aalto University, Finland


With Robin Ras and Emma, Aalto University, Finland

FOREIGN STUDENTS’ VISITS


Nishil Mohammed with Avijit Baidya
University of Waterloo, Canada (Oct. 2015 - Apr. 2016)


Erick Mobegi with Anil Kumar Avula
Kenyatta University, Kenya (Nov. 2016 - Apr. 2017)

PROF. T. PRADEEP'S VISITS

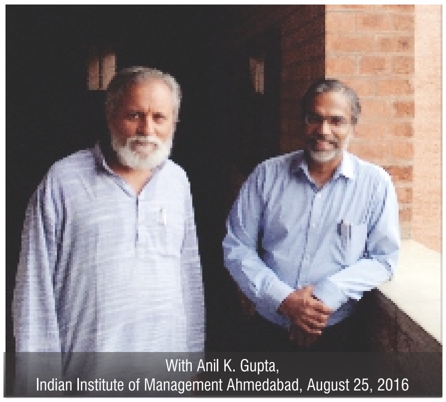

Asian Academic Seminar, Japan, December 16, 2016


Asian Academic Seminar, Japan, December 16, 2016

04/01/16	103rd Indian Science Congress, Mysore
16/01/16	Startup India Event, New Delhi
01/02/16	Indo-French Seminar, VIT, Chennai
03/02/16	MRF, Thiruvottiyur, Chennai
11/02/16	PSG College, Coimbatore
12/02/16	Colloquim speaker, IISER, Trivandrum
14/02/16	Amrita, Kochi, Kerala
17/02/16	Indian Institute of Science, Bangalore
18/02/16	Visiting Dr. David E. Reinser, Kolkata
29/02/16	ICONSAT, IISER, Pune
03/03/16	8th Bangalore India Nano, Bangalore
09/03/16	International Symposium on Clusters, Thiruvananthapuram, Kerala
22/03/16	Lecture,University of Calicut, Calicut, Kerala
11/04/16	IISc Bangalore and JNCASR (UGC Meeting), Bangalore
15/04/16	19th India-Japan Science Council, Bangalore
02/05/16	Inaugurating SET, as Chief Guest, Vellore, Tamil Nadu
25/05/16	Meeting with Philip Campbell, Editor-in-Chief of Nature, New Delhi
31/05/16	IWA Meeting, Jaipur
15/06/16	Nanyang Technological University, Singapore NTU, Singapore
23/06/16	Nano Mission Council, Bangalore
05/07/16	Hindu Senior Sec School, Chennai
13/07/16	3rd Meeting of the NATAG-Proof of Concept Committee, New Delhi
14/07/16	Lecture, IIST Trivandrum, Kerala
25/07/16	Sastra University, Tanjavur
26/07/16	Presentation on the Project Proposal, 23rd NMC, JNCSR, Bangalore
08/08/16	Green Chemistry Conference, B. S. Abdur Rahman University, Chennai
18/08/16	NIT Trichy
24/08/16	Students & Faculty Interaction at ILS & IET, Ahmedabad University
12/10/16	India Pistons Ltd., Chennai
18/10/16	DST Meeting, Bangalore
26/10/16	Meeting with Dr. P. B. Salim, IAS, Kolkata
22/11/16	IIT Bombay, Mumbai
23/11/16	Presentation on the Project Proposal, 24th NMC, JNCSR, Bangalore
24/11/16	Nanomedicine workshop, AIIMS, New Delhi
25/11/16	Convocation Ceremony as Chief Guest, Sankara Nethralaya, Chennai
29/11/16	PACN Congress 2016, Sustainable Water Resources for Africa, Kenya
03/12/16	4th NATAG meeting, IIT Bombay, Mumbai
16/12/16	Asian Academic Seminar, Tokyo, Japan

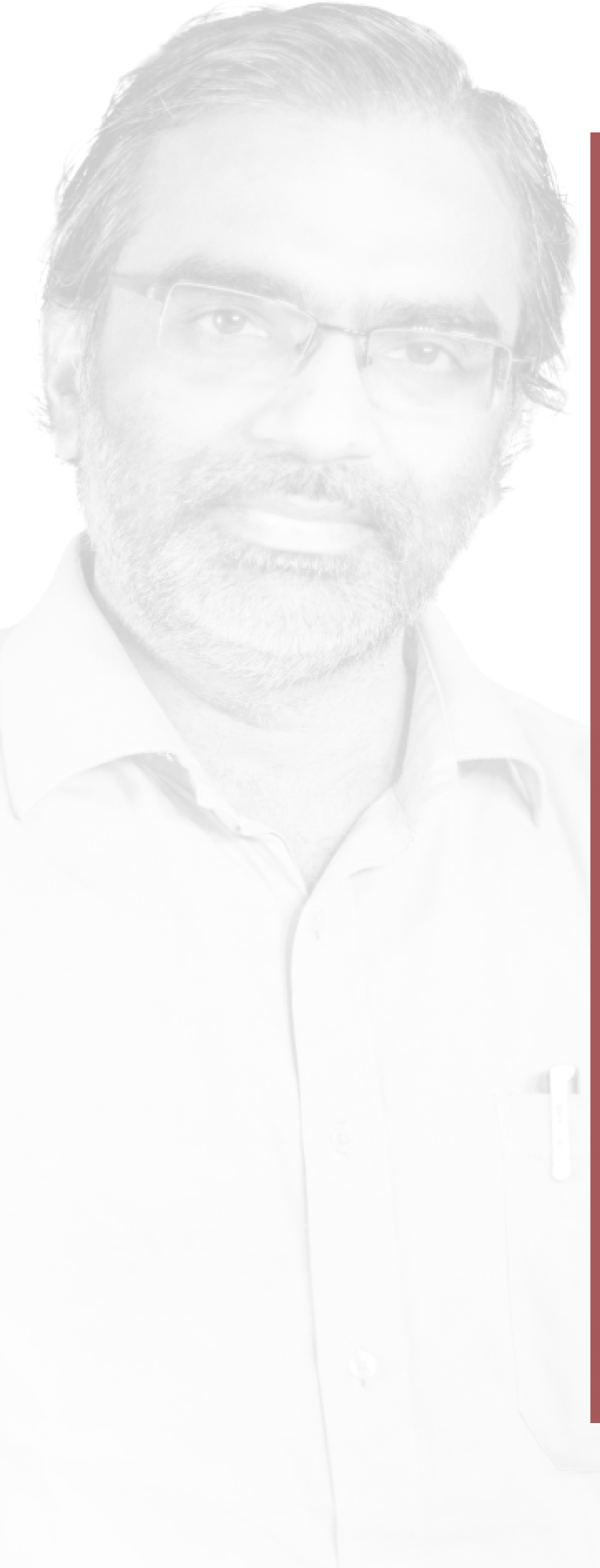

Chief Guest, Convocation Ceremony, Sankara Nethralaya,
November 25, 2016


With Prof. B. V. R. Chowdari,
Nanyang Technological University, Singapore, June 16, 2016


With Anil K. Gupta,
Indian Institute of Management Ahmedabad, August 25, 2016


ISCAN 2016, IISER Thiruvananthapuram

TALKS AND LECTURES



- Inter-cluster reactions between $Au_{25}(SR)_{18}$ and $Ag_{44}(SR)_{30}$, Nano-Scaled Systems for Energy Harvesting, VIT University. February 1, 2016.
- Affordable point-of-use water purification using nanomaterials, PSG Institute of Advanced Studies. February 11, 2016.
- Nanomaterials to clean water: Lab to industry, Institute lecture at IISER Thiruvananthapuram. February 12, 2016.
- Affordable point-of-use water purification using nanomaterials, Sixth International Conference on Metals in Genetics, Chemical Biology and Theraputics (ICMG-2016). February 12, 2016.
- Nanomaterials to clean water: Lab to industry, National Science Day Lecture at IIT Madras. February 28, 2016.
- Inter-cluster reactions between $Au_{25}(SR)_{18}$ and $Ag_{44}(SR)_{30}$, ICONSAT 2016, IISER Pune. March 1, 2016.
- Clean water using nanomaterials, Bangalore Nano. March 3, 2016.
- Inter-cluster reactions between $Au_{25}(SR)_{18}$ and $Ag_{44}(SR)_{30}$, Plenary talk at ISCAN 2016, IISER Thiruvananthapuram. March 9, 2016.
- Affordable clean water using advanced materials, Frontier Lecture Series, University of Calicut. March 22, 2016.
- Affordable clean water using advanced materials, Inaugural lecture at the international symposium, VIT University, Vellore. May 2, 2016.
- Innovations to address groundwater contamination, South Asia Groundwater Forum, Jaipur. June 1-3, 2016.
- Atomically precise clusters of noble metals: From basic science to applications, School of Materials Science and Engineering, Nanyang Technological University. June 17, 2016.
- Nanotechnology: Prospects for tomorrow, Hindu Senior Secondary School, Triplicane, Chennai. July 5, 2016.
- Inter-cluster reactions between atomically precise noble metal clusters, ISCAN 2016, IIST Thiruvananthapuram. July 14, 2016.
- Affordable point-of-use water purification using nanomaterials, Indo-UK Workshop on Clean Water through Advanced and Affordable Materials, Chennai. August 8-10, 2016.
- Clean water using advanced materials: Science, incubation and industry, Ahmedabad University. August 24, 2016.
- Clean water using advanced materials: Science, incubation and industry Journey, from foundational research in nanotechnology to innovation led entrepreneurship, NANOBIOTECK - 2016, All India Institute of Medical Science. November 24-26, 2016.
- Affordable Clean water using advanced materials: Science, incubation and industry, Pan Africa Chemistry Network, Nairobi. November 30 - December 2, 2016.
- Intercluster reactions between atomically precise noble metal clusters, Asian Academic Seminar 2016, The University of Tokyo. December 14-20, 2016.

TUE - INAUGURATION

The Thematic Unit of Excellence (TUE) was inaugurated by Prof. CNR Rao on January 11, 2016, at 11.00 am in the august presence of Prof. Bhaskar Ramamurthi (Director, IITM), Prof. Indrapal Singh Aiden (HOD, Dept. of Chemistry, IITM), Prof. P. T. Manoharan, Prof. Ashok Jhunjhunwala, Mr. Rajeev Kumar, IAS and Prof. T. Pradeep

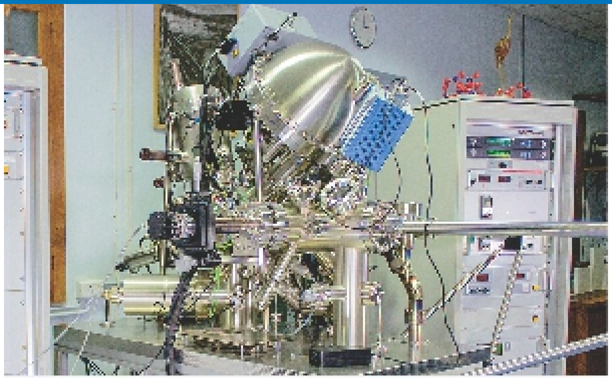
- PerkinElmer Lambda 25 UV-Vis Spectrometer with temperature controller
- PerkinElmer Lambda 25 UV-Vis Spectrometer
- BalzerThermoStar Mass Spectrometer
- PerkinElmer Spectrum One FT-IR Spectrometer and Pelletizer
- Horiba Jobin Yvon Nano Log Spectrofluorometer
- MALDI-TOF MS Model: Voyager-DE PRO Bio-spectrometry with Workstation- Applied Bio-systems

- High Resolution Transmission Electron Microscope (HRTEM) with EDAX (Jeol JEM 3010)
- 3200 Q TRAP LC/MS/MS
- Scanning Electron Microscope (FEI QUANTA 200) with EDAX

  XPS-UPS-TPD (Omicron NanoTechnology)
- Low energy Ion Scattering Spectrometer (EXTREL CMS)
- WITec GmbH Confocal Raman Microscope (CRM-Alpha300 S) with Atomic Force Microscopy (AFM) and Scanning Near-field Optical Microscopy (SNOM) (lasers: 532, 633 nm) and Dark-field condenser attachment
- PerkinElmer Gas Chromatograph Mass Spectrometer (GC-MS) Model: Clarus 600 C
- Thermo Scientific Ion trap LTQ-XL Mass spectrometer with Desorption Electrospray Ionization (DESI) setup
- CytoViva Hyperspectral Imaging System
- Low energy Ion Scattering (Vera Spec) MS-RAIRS (Bruker Optics, VERTEX 70) –TPD with Ion Gun from Kimball Physics (IGPS-1016B)
- Leica Ultramicrotome
- Ball Mill Grinder (Retsch, MM 200)
- Kubota Refrigerated Centrifuge
- Electrochemical Analyzer/Workstation (CHI600E, CH Instruments, Inc.)
- Shimadzu Prominence HPLC system with accessories
- Isothermal Microcalorimeter (MicrocaliTC 200)
- Inductively Coupled Plasma Mass Spectrometry (ICPMS), PerkinElmer, NexION 300X
- Metrohm Ion Chromatograph with Auto Sampler and Accessories (883 Basic IC Plus)
- Eyela Rapid Sythesizer (PPS-2510-CE)
- Rotavapor (BUCHI, R-200)

Molecular materials are generally characterised by optical spectroscopy.

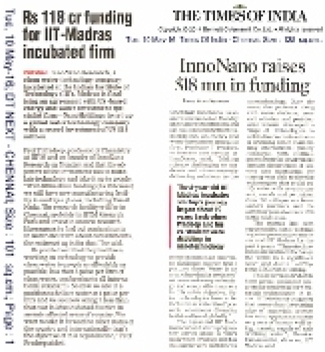
EQUIPMENT AND INFRASTRUCTURE



- Eyela Freeze dryer (FDU-1200)
- Ultrasonic Processor (Sonics Vibra Cell)
- Mayura Gas Chromatography with Autosampler (Auto GC-1100)
- Needle based Electrospinning Machine M No: ESPIN Nano – Physics Instruments Co, Chennai
- Biocare Deep Freezer (-80°C and -20°C)
- Millipore Milli Q Laboratory Grade Water Purification/Deioniser System Model No: Integral 3
- Mettler Toledo Digital Weighing Balance (AB 104- S)
- CAS Digital Weighing Balance
- Cintex Precision Hot Air Oven with digital display
- REMI Laboratory Centrifuge (R-8 C)
- Eyela Rotary Evaporator (N-1200 BV-W)
- Eyela Freeze Dryer (FDU – 1200)
- Eyela Personal Organic Synthesizer with Accessories (PPS-2511)
- Leica Fluorescence Microscope with High resolution Digital Camera (DMI 3000 B)
- Leica Inverted Phase Contrast LED Microscope (DMIL LED)
- Anton Paar Microwave Sample Digestor (Microwave 3000)
- Elmarco Nanospider Needleless Electrospinning Machine (NS Lab-200).
- Eutech Mutiparameter Monitor for pH/conductivity/dissolved oxygen/ ORP (Cyberscan PCD-650)
- Medimeas Semi-Automatic Rotary Microtome (MRM-ST)
- Medimeas Full Automatic Cryocut Microtome (MCM- AT)
- Remi Centrifuge (CM-12 Plus)
- Sigma Hot Air Oven
- Shimadzu Digital Weighing Balance Model No: AY-220
- Elico TDS Analyzer(CM-183 EC)
- Sigma Scientific Rotary Shaker
- Scigenics Biotech Orbital Shaker (Orbitek)
- Cryoscientific 4°C Laboratory Refrigerator
- Shimadzu Nexera Advanced UHPLC system with Softa300S ELSD, Fluoresence and PDA Detector.
- Shimadzu Prominence Preparative-cum-analytical HPLC system with UV-Vis Detector.
- Programmable Spin Coating system Model: Spin NGX - Apex Instruments
- Plimmer Alpha Capacitive Deionization (CDI) Water purification unit
- Pfeiffer Vacuum HiCube 80 Eco Turbo molecular dual vacuum pump
- ESCO Biological Safety cabinet
- Nabertherm 1500°C Tube furnace
- Kiethley 2611B Source/Measure meter
- SYNAPT Ion Mobility Mass Spectrometer - Waters
- Metal evaporator (additional attachment for metal evaporation to the low energy ion scattering mass spectrometer)
- Laboratory Refrigerators Cryo Scientific - 4 Nos
- - 80°C Deep Freezer - Biocare
- Airstream Biological Safety Cabinet - ESCO
- Laboratory Fume hoods Godrej Interio - 3 Nos

EQUIPMENT ADDED IN 2016

- Polarizing Microscope - Leica DM750P
- PerkinElmer Lambda 365 UV-Vis Spectrometer
- 3D Printer - Flashforge DreamerDual Extruder - Think3D
- Plasma Chamber - Harrick Plasma



THE TIMES OF INDIA

Tue, 10 May-16; OT NEXT - CHENNAI; Size : 101 sq.cm.; Page : 1

Rs 118 cr funding for IIT-Madras incubated firm

InnoNano raises $18 mn in funding

DECCAN Chronicle

Tue, 10 May-16; Deccan Chronicle - Chennai; Size : 87 sq.cm.; Page : 2

IIT-M INCUBATION CO WINS $18 MN U.S. INVESTMENT

THE HINDU

Tue, 10 May-16, Hindu - Chennai; Size : 125 sq.cm.; Page : 5

IIT-M incubated firm gets $18 million funding

The clean water tech firm plans labs and offices in North America, Asia and Africa

Indian Express

Tue, 10 May-16; New Indian Express - Chennai; Size : 289 sq.cm.; Page : 6

Water tech incubated at IIT draws $18 mn investment from US firm

mint

Tue, 10 May-16; Mint - Delhi; Size : 191 sq.cm.; Page : 11

WATER TECHNOLOGY

InnoNano Research in $18 million deal with NanoHoldings

Firm plans to set up manufacturing facility, research lab, technology delivery offices across North America, Asia and Africa

Tue, 10 May-16; Dinamani - Chennai; Size : 73 sq.cm.; Page : 4

சென்னை ஐஐடி-யில் ரூ.100 கோடியில் தண்ணீர் தொழில்நுட்ப நிறுவனம்

THE FINANCIAL EXPRESS

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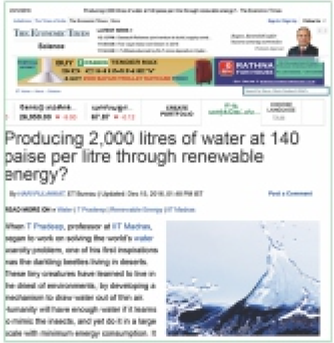
Tue, 10 May-16; Financial Express - Delhi; Size : 187 sq.cm.; Page : 5

IIT Madras-incubated water tech firm raises $18 million

WORK IN NEWS


THE HINDU

Photo: Special arrangement


The Economic Times

Science

Producing 2,000 litres of water at 140 paise per litre through renewable energy?

When T Pradeep, professor at IIT Madras, egan to work on solving the world's water carcity problem, one of his first inspirations as the darkling beetles living in deserts. hese tiny creatures have learned to live in he driest of environments, by developing a mechanism to draw water out of thin air. umanity will have enough water if it learns o mimic the insects, and yet do it in a large cale with minimum energy consumption. It


Tiny particles with mega impacts

In India, a research scientist and his team are manipulating invisible
in ways that could quietly disrupt the global water purification industr


Tiny particles with mega impacts

In India, a research scientist and his team are manipulating invisible matter in ways that could quietly disrupt the global water purification industry


CIRRUS

THE TIMES OF INDIA

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Tue, 10 May-16; Times Of India - Chennai; Size : 135 sq.cm.; Page : 16

InnoNano raises $18 mn in funding

TIMES NEWS NETWORK

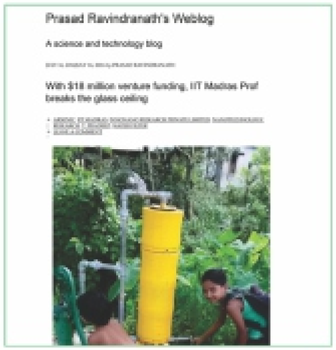
Chennai: InnoNano Research (InnoNano) on Monday announced that it has raised $18 million funding from NanoHoldings, an energy and water investment specialist firm. Professor T Pradeep, co-founder and advisor of InnoNano, said, "Making science challenging to academia and simultaneously

nanotechnology. Over the years, the professor along with some students, research scholars and post-doctoral fellows developed a range of technologies to tackle diverse contaminants in drinking water, maintaining international quality standards. With multiple grants from the government through department of science and technology, the


THE TIMES OF INDIA

'Use nanotechnology to help people'


THE HINDU


Prasad Ravindranath's Weblog

A science and technology blog

With $18 million venture funding, IIT Madras Prof breaks the glass ceiling


വെള്ളം ശുദ്ധീകരിക്കാന്‍ 5 പൈസ: പദ്ധതിയുമായി മലയാളി പ്രൊഫസര്‍

January 1, 2016, 10:48 AM IST


Rs 118 crore funding for IIT-Madras incubated firm

InnoNano Research, a clean water technology company incubated at the Indian Institute of Technology (IIT), Madras is finalising an agreement with US -based energy and water investment specialist firm — NanoHoldings to set up a global water technology company with a second investment of US $18 million.

IIT Madras

Prof. Sarit Kumar Das

Dept. of Mechanical Engg.

Nanofluid assisted solar desalination

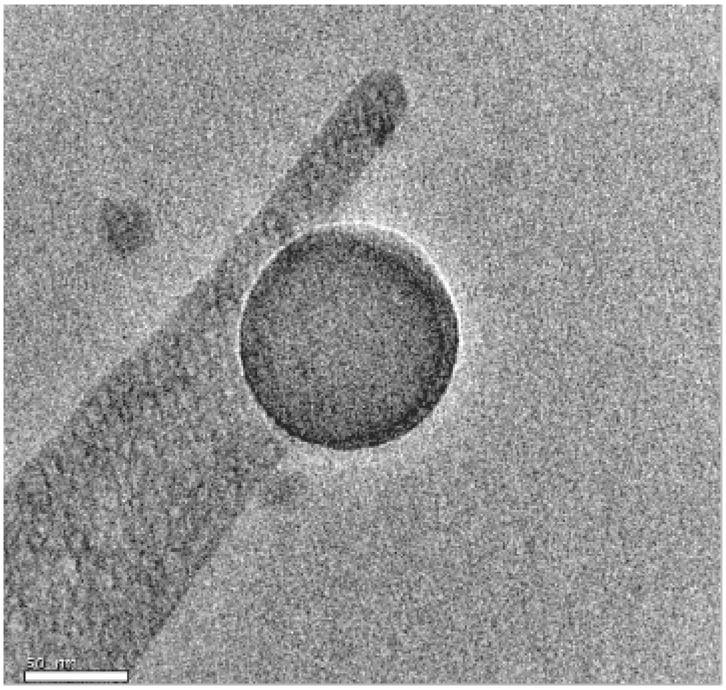
Nanofluid assisted solar desalination project is a novel and useful technology for medium level water purification in coastal rural areas.

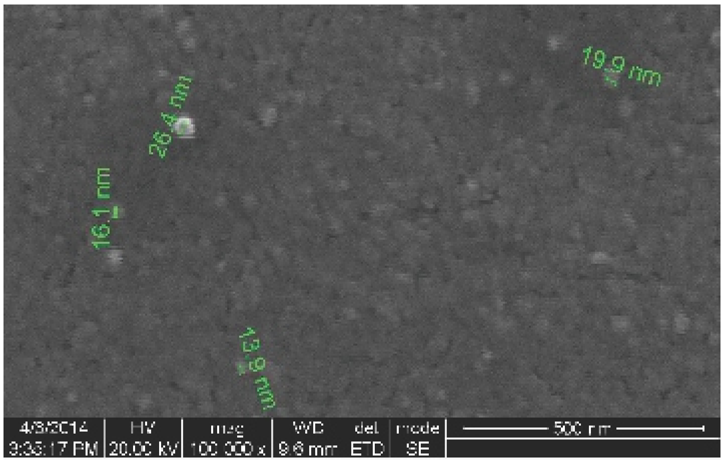
The technology works on the humidification-dehumidification (HDH) cycle in which saline water is evaporated in unsaturated air using sprays. The saturated air is then dehumidified in a heat exchanger using the incoming saline water to make it more energy efficient. In the intermediate stage, the saline water is heated by solar radiation. To avoid scaling of the solar collector at high temperature, an intermediate nanofluid (nano particle suspension) is used to keep the saline water away from the solar collector.

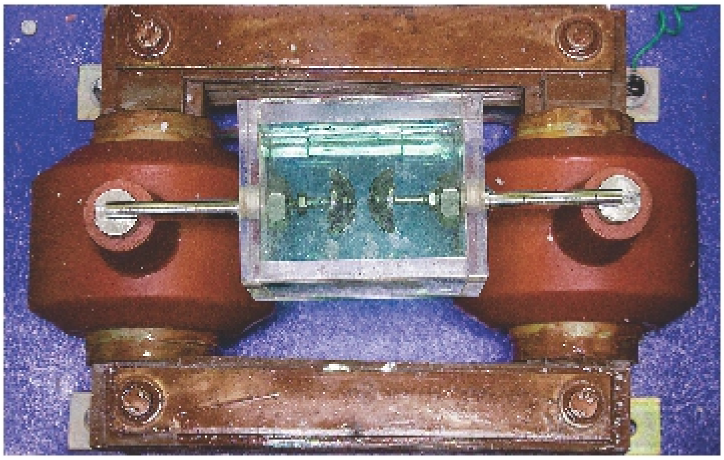
The technology has got scarce maintenance and low energy inputs to make it appropriate for village level desalination units in coastal areas.

Purbarun Dhar, Ajay Katiyar, Arvind Pattamatta, and Sarit Kumar Das; Large electrorheological phenomena in graphene nano-gels; *Nanotechnology 28 (2017) 035702.*

Nithya Murugesan, Tapobrata Panda, and Sarit Kumar Das; Effect of gold nanoparticles on thermal gradient generation and thermotaxis of *E.coli* cells in microfluidic device; *Biomedical microdevices 18 (2016) 1-10 [DOI:10.1007/s 10544-016-0077-8].*







Top:
CuO TEM

Middle:
Fe_2O_3 SEM

Bottom:
Electrical Breakdown Voltage setup

CO-INVESTIGATOR

Prof. Ligy Philip

Dept. of Civil Engg.

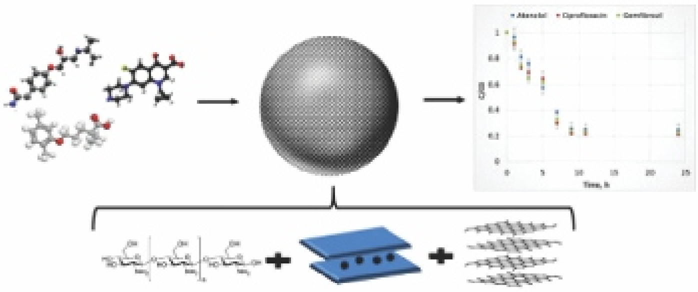
Modified TiO_2 based photocatalytic systems for water treatment

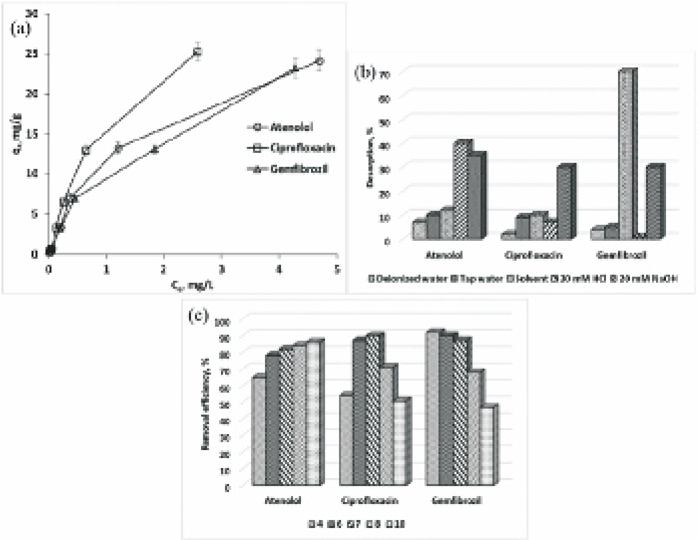
Adsorption of three pharmaceuticals, namely, atenolol, ciprofloxacin and gemfibrozil using synthesized magnetic polymer clay composite was investigated in detail by conducting batch kinetic, equilibrium and desorption experiments. Optimum ratio of composite adsorbent was found to be clay: chitosan: powdered activated carbon (PAC): magnetic nano particles (MNP) as 1:0.5:0.3:0.3. Characterization studies showed the incorporation of modifiers into the clay structure. Surface area of the synthesized pellets was 94.81 m^2/g with mesoporous surface. Freundlich model was able to predict the adsorption equilibrium data. Maximum adsorption capacities were estimated to be 15.6, 39.1 and 24.8 mg/g for atenolol, ciprofloxacin and gemfibrozil, respectively. The main driving force of adsorption was electrostatic interaction. The adsorbent performance was affected at lower and higher pH and by the presence of humic acid. Desorption of atenolol and ciprofloxacin were significantly higher in acid and alkaline solution whereas gemfibrozil was desorbed upto 70% in methanol. Magnetically separable clay composite was found to be a suitable adsorbent for removing pharmaceuticals from water.

Anupama Surenjan, Balaji Sambandam, Thalappil Pradeep and Ligy Philip; Synthesis, characterization and performance of visible light active C-TiO_2 for pharmaceutical photodegradation; *J. Environ. Chem. Eng. 5 (2017) 757-767 [DOI: 10.1016/j.jece.2016.12.044]*

Top:

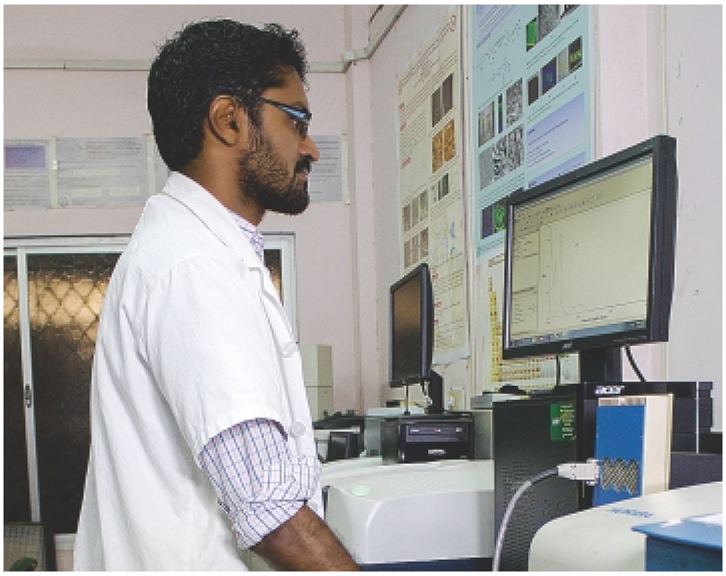
Batch photocatalytic reactor employing N-doped TiO_2 working under visible light

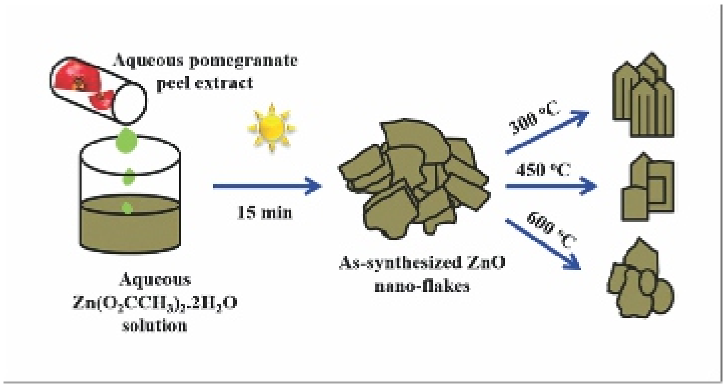


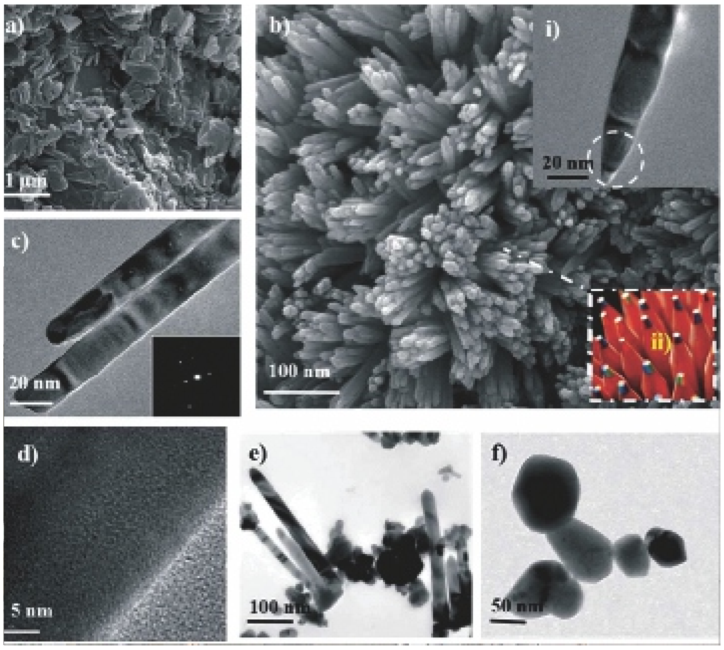


Bottom:

(a) Sorption of pharmaceuticals at different initial pharmaceutical concentrations, (b) Desorption of pharmaceuticals in different solutions, and (c) Effect of pH on adsorption of pharmaceuticals.







Prof. Edamana Prasad

Dept. of Chemistry

Eco-friendly synthesis of ZnO nanopencils in aqueous medium

Synthesis of monodispersed nanostructures would be attractive if the synthesis is simple, one step and cost effective. In this work, an eco-friendly approach for the synthesis of ZnO nanostructures using the aqueous extract of pomegranate peel has been described. ZnO nanoflakes were formed initially upon 15 min sunlight irradiation of an aqueous solution of Zn acetate in the presence of pomegranate peel extract. We observed that the nanoflakes formed are converted to ZnO nanopencils upon mild heating. The nanopencils have been characterized by diffused reflectance spectroscopy, X-ray diffraction analysis, photo-luminescence spectroscopy, FT-Raman spectroscopy, X-ray photoelectron spectroscopy, scanning electron microscopy, and transmission electron microscopy. Furthermore, we examined the photocatalytic activity of the ZnO nanopencils and compared the performance with commercial ZnO and TiO_2 (P25) nanoparticles towards the photocatalytic degradation of methylene blue under direct sunlight irradiation. The total carbon removal efficiency of the ZnO nanopencils for methylene blue is 95% which was achieved by 4.5 h.

Top:
Fluorimeter

Middle:
Synthesis of ZnO nano structures using aqueous pomegranate peel extract

Bottom:
(a) SEM image of as-synthesized ZnO nano flakes, (b) ZnO nanopencils calcined at 300 °C {(inset i) TEM image of the tip of the ZnO nano pencil, (inset ii) photographic image of pencils}, (c) TEM images of ZnO nanopencils (inset is the corresponding SAED pattern), (d) HR-TEM image of ZnO nano pencil, (e and f) TEM images of ZnO nano structures calcined at 450°C and 600°C.

Prof. C. Vijayan
Dept. of Physics

Electrospun nanofibers

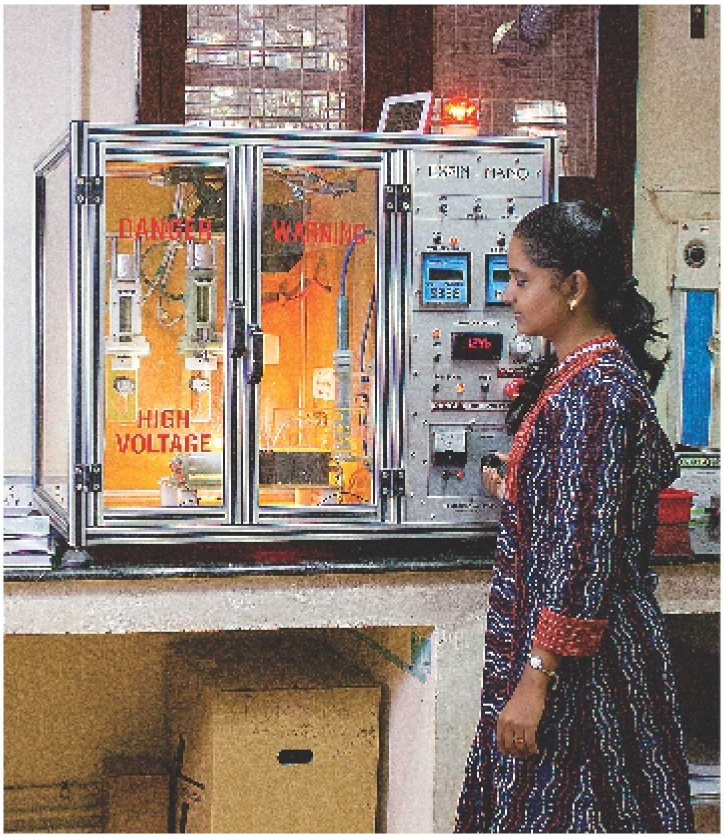
Electrospun fibers show very high surface area-to-volume ratio, making them suitable for applications such as filters, sensors and adsorbing media.

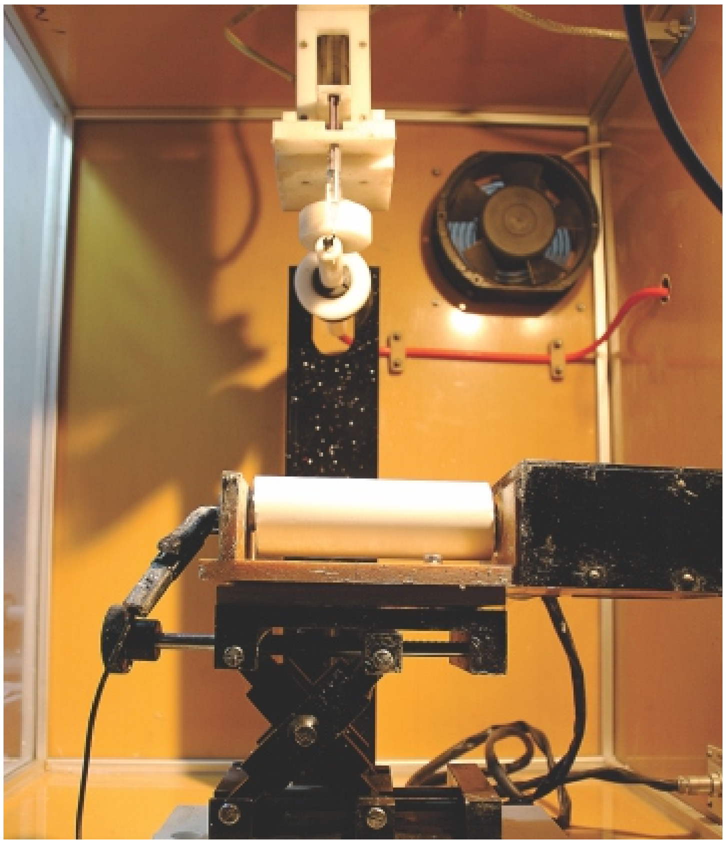
Nanoclay and new forms of luminescent nanoclusters have been successfully incorporated into a variety of flexible fibers such as those of PVA, PHB, Nylon and PMMA in our laboratory using a simple and low cost electrospinning method. Appropriate biochemical materials are being incorporated into the nanofiber-based membrane so as to enhance its efficiency as filters for different contaminants of water.

Our work focuses on understanding the Physics and Chemistry of these novel nanocomposite materials and utilizing them in applications such as detection of microorganisms in drinking water and purification by filtering.

Anita R. Warrier, Chithra Parameswaran, Jayachandra Bingi, and C. Vijayan; FRET controlled photoluminescence in-In2S3 microflower-Au nanoparticle ensemble; *Material. Res. Exp. 3 (2016) 065016.*

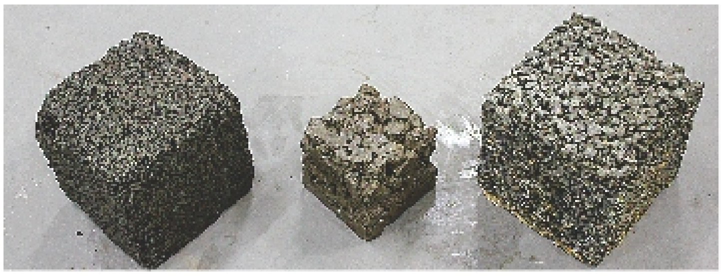
Radhika V. Nair, M. Jijith, Venkata Siva Gummaluri, and C. Vijayan; A novel and efficient surfactant-free synthesis of Rutile TiO2 microflowers with enhanced photocatalytic activity; *Optical Mater. 55 (2016) 38-43 [DOI: 10.1016/j.optmat.2016.03.015].*

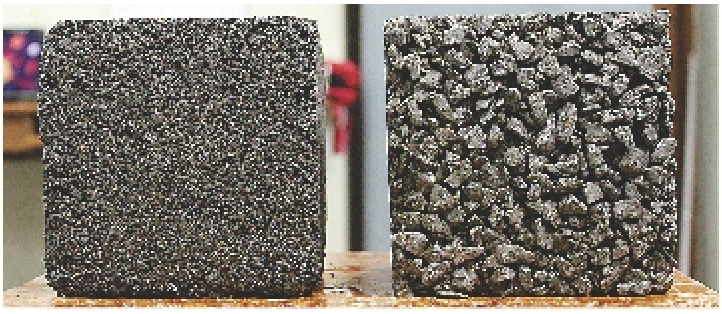


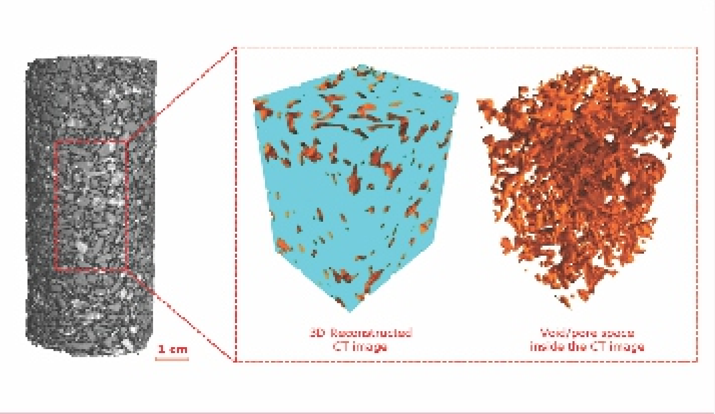


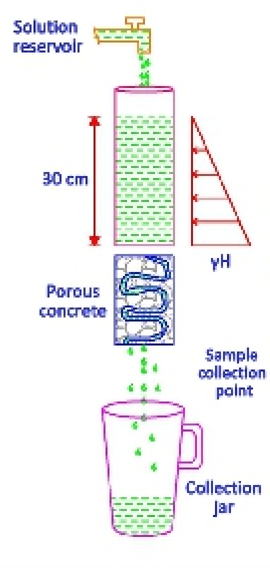
Top:
Jessy is making electrospun mats for sensors

Bottom:
A closer view of the process of electrospinning









Prof. Manu Santhanam

Dept. of Civil Engg.

Application of porous cement concrete for heavy metals removal

Due to rapid industrialization, heavy metals contamination is a growing problem worldwide. Toxic heavy metals that are of particular concern in treatment of industrial wastewaters include arsenic, cadmium, lead, chromium, manganese, mercury, zinc and copper. Porous concrete, which is made of cement, gap-graded coarse aggregate and water, can present a way forward for slow filtration, as it allows the water to percolate through its interconnected pores. In this study, aqueous solutions containing lead, zinc, cadmium and copper at concentrations of around 10 mg/L were passed through porous concrete with controlled hydraulic conductivity under continuous flow for a period of eight hours. By surface complexation mechanism, significant amounts of those metal pollutants were removed with the porous concrete.

M. Murugan, Manu Santhanam, Soujit Sen Gupta, T. Pradeep, and Surendra P. Shah; Influence of 2D rGO nanosheets on the properties of OPC paste; *Cement and Concrete Composites, 70 (2016) 48-59 [DOI: 10.1016 /j.cemconcomp.2016.03.005].*

N. Shajil, S. M. Srinivasan, and M. Santhanam; An experimental study on self-centering and ductility of pseudo-elastic shape memory alloy (PESMA) fiber reinforced beam and beam-column joint specimens; *Mater. Structur., 49 (2016) 783-793 [DOI: 10.1617 /s11527-015-0538-1].*

Top:
Enhanced porosity concrete (EPC)

Middle:
Porous cement concrete specimens of size 10 × 15 cm
(ø × H) are mounted on the permeability set up

Bottom:
Tomography image of the cylindrical shaped porous cement concrete based water filter and its section illustrating the porous matrix inside the material

CO-INVESTIGATOR

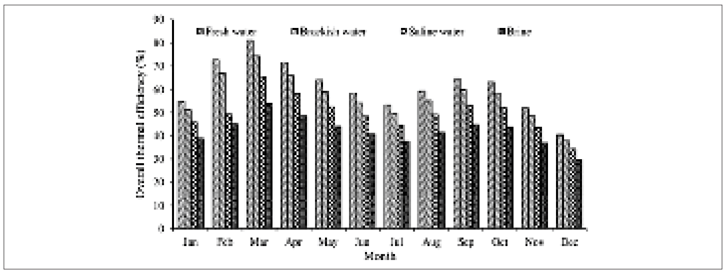
Prof. K. S. Reddy

Dept. of Mechnical Engg.

Solar thermal desalination

Solar thermal desalination is an effective way to meet fresh water requirements of remote and rural communities. The distillate produced from solar thermal based desalination units are of high quality. Moreover, the technology is eco-friendly and can reduce green house gas emissions from conventional fossil fuel based desalination plants.

A novel multi-stage desalination system has been developed to cater the potable water demands of small communities in rural and remote areas. The desalination system works on evaporative cooling and the unit consists of multi-stage metal trays used for both evaporation and condensation. The heated feed water from solar collector is allowed to flow as a thin film over the trays such that due partial pressure difference mass transfer occurs from the evaporating to the condensing surface there by releasing latent heat to the next tray favoring enhanced evaporation in successive trays. The distillate yield from the unit is nearly four to five times higher than the conventional solar still. The unit can also be operated at low feed water temperature by evacuating the unit, thereby the area occupied by the solar collector required is minimized and hence favoring the unit to be more suitable even for urban applications. The desalination system can also be operated in tri-generation mode for effective utilization of solar energy in cascaded approach.



Top:
Multi stage evacuated solar desalination system

Middle:
Year round performance of solar desalination Unit

Bottom:
Concentrating solar collector for desalination

Pradeep Research Group - Summer Students 2016.


Pradeep Research Group - Ph.D. Students 2016.

Pradeep Research Group 2016.

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