

Science Last Fortnight

Rice Straw Revolution

Bio-nano-silica for CO₂ separation

Each kilogram of milled rice produces a corresponding kilogram of straw. Rice straw, considered waste, is either dumped into rivers or burned. This results in greenhouse gas emissions, contamination and pollution. But the same straw can be used to separate carbon dioxide from atmospheric gases, say scientists from the NIT Durgapur.

The conventional process for CO₂ separation involves reversible absorption. This consumes high amounts of energy and is costly. The need for a more efficient and eco-friendly CO₂ separation process led scientists to membrane technology which offers greater energy efficiency, processability and lower maintenance costs.

The scientists from the NIT Durgapur synthesised a nano-composite polymeric membrane comprising a polyether-polyamide block copolymer and nanosilica from rice straw for CO₂ separation.

The researchers used a gravimetric method to isolate bio-nano-silica from rice straw. They analysed the morphological features of the bio-nano-silica using scanning electron microscopy, transmission electron microscopy and dynamic light scattering. The nano-silica had an average diameter of about 15 nm, a surface area of more than 400 square metres per gram and more than two-and-half times the porosity of commercial silica – almost half a cubic metre per gram!

Using field emission scanning electron microscopy, the team found that silica particles from rice straw tend to agglomerate and form clusters. They say that this may be due to the high specific surface area to volume ratio.

The amorphous silica particles reduced the composite membrane's crystallinity. When hydrated, the nano-silica formed a gel-like structure, which helps increase contact with the solvent. And the strong

hydrogen bonds enhanced the stability of the silica in the matrix.

The scientists conducted gas permeation experiments under a steady-state condition at different pressures, temperatures and nano-silica particle concentrations. The blended membranes selectively separated CO₂ gas. Under all parametric conditions, the permeability of CO₂ was more than that of air.

As no chemicals or energy are needed for the separation of CO₂, the scientists hope that this will become a candidate for carbon sequestration technology for climate mitigation.

J. Cleaner Prod., **186**: 241–252

Carcinogens in the Ganga

Unholy cocktail

The Ganga is holy to many Indians. Yet polycyclic aromatic hydrocarbons have been detected in the air, water, and bulk depositions along the river. This is a serious environmental concern as polycyclic aromatic hydrocarbons are carcinogenic, mutagenic, and teratogenic.

Recently, Girija Bharat from TERI, along with collaborators from the Czech Republic and Norway, measured the concentrations and distributions of polycyclic aromatic hydrocarbons in air, atmospheric depositions and surface waters at various locations along the Himalayan, middle and lower reaches of the river. This is the first basin-scale report of the occurrence of polycyclic aromatic hydrocarbons in the region.

The scientists used air samplers and deposimeters to collect air samples and a high volume flow sampler to collect water samples. They recorded the results during two seasons: pre-monsoon and monsoon. And analysed the chemistry of the samples using chromatographic techniques.

In the Himalayan reaches, the effects of forest fires or biomass combustion were evident during the dry pre-monsoon season. The researchers surmised that the seasonality of

the concentrations of these pollutants was also influenced by glacier melting.

The team did not find seasonal effects in the middle and lower reaches of the river. They attributed the presence of atmospheric poly-aromatic hydrocarbons in the middle and lower reaches of the river to fossil fuel combustion.

'Polycyclic aromatic hydrocarbon concentrations in air are strongly correlated with population density', says Brij Mohan Sharma from the Masaryk University, Czech Republic.

'We found that ambient air concentrations correlate with cancer risk. As expected, the risk was higher in the middle and lower reaches than in the Himalayan reach', adds Girija Bharat, TERI.

Policy makers should leverage on such reports to tackle the issue in the clean Ganga programme.

Sci. Total Environ., **627**: 1495–1504

Particulate Matter Pollution

Source profiles

Raipur-Bhilai, in Central India, has a number of industries. These industries release particulate matter making the air polluted. So do burning of domestic and agricultural wastes. Particles with aerodynamic diameter smaller than 10 or 2.5 microns have distinct properties meteorologically, and on the health of the population. PM10 and PM2.5 thus serve as indicators of air quality. While PM10 can be deposited in the lungs, fine particles of PM2.5 can penetrate the alveoli of lungs and affect the cardiovascular system and other major organs. The problem in Raipur-Bhilai was to identify the exact sources and nature of these particles.

Researchers from Raipur, Jagdarpur, Chhattisgarh, Nagpur and New Delhi, collaborated with scientists in the US and China to understand this problem. With the help of Minivol air samplers, they collected PM10 and PM2.5 on quartz fibre filters from various locations. They used atomic

absorption spectrophotometry, ion chromatography and thermal/optical transmittance to analyse the samples and evaluate similarities and differences between the profiles of 32 chemical species from various sources. The team profiled PM10–2.5 from both domestic and industrial facilities.

In both domestic and industrial locations, there was more PM2.5 than the PM10–2.5 fraction. The researchers observed more carbon in domestic and municipal solid waste burning. There were more toxic elements in industrial emissions. They also noted high amounts of calcium from steel rolling mills and cement industries, and iron from ferromanganese, steel and electric-arc welding industries. There were more emissions from brick kilns, followed by steel rolling mills and nickel steel industries. This, they suggest, may be due to the incomplete combustion of fuels.

This study will help policy makers take steps to reduce pollution from industries and formulate strategies to protect people from toxic emissions.

Sci. Total Environ., **627**: 1137–1145

Nanoparticles for Soil Health Promoting antifungal compounds

Though nanoparticles are good antimicrobial agents, their presence in soil affects beneficial microbes. These microbes produce antimicrobials and protect plants from various fungal diseases. Nanoparticles also reduce the production of secondary metabolites by the microbes and this impacts soil health. However, now, Shams Tabrez Khan from the Aligarh Muslim University, Uttar Pradesh in collaboration with scientists in Saudi Arabia and the Netherlands, suggests nanoparticles to promote soil antimicrobials.

The team synthesised nanoparticles of silver, silicon dioxide, titanium dioxide and zinc oxide and characterised them. They used *Pseudomonas protegens* CHA0 – a beneficial bacterium – which produces *pyrrolnitrin*, an antifungal compound that protects plant roots from fungal pathogens.

The team tested different concentrations of the nanoparticles – 500 micrograms and 500 nanograms – on the growth of *P. protegens* CHA0. Then they assessed the growth of the bacterium and its ability to suppress *Candida albicans*, a fungal pathogen, using a green fluorescent protein as reporter to measure the expression of the fungal genes.

The researchers noted that, while the higher concentration of nanoparticles inhibited the growth of *P. protegens*, the sub-lethal dose stimulated the production of *pyrrolnitrin*. The team found that the sub-lethal dose of nanoparticles induces the expression of *prnA* operon – a functional unit of DNA which accounts for *pyrrolnitrin* production.

The team suggests that nanoparticles, in low doses, can be used to stimulate the activity of beneficial microbes. Agriculture extension agencies and the Krishi Vigyan Kendras can do a pilot study in the field to corroborate the usefulness of the technique for sustainable agriculture.

Sci. Total Environ., **627**: 658–662

Managing Pests in Stored Grains Plant based pesticide

Storage pests ruin grains, postharvest. Managing grain pests with chemicals leads to environmental retention of pesticides in the food chain. The use of plant-based pesticides, however, can circumvent the problem.

Now scientists from the ICAR-National Rice Research Institute, Cuttack report the insecticidal and insect repellent activities of *Cleistanthus collinus* against the rice weevil and the red flour beetle.



By J. M. Garg, Wikimedia Commons

Cleistanthus collinus is toxic and is often used to commit suicide. The researchers prepared a *Cleistanthus collinus* leaf concentrate by solvent extraction followed by rotary evaporation. They reared the storage pests in a closed jar with rice grains and flour.

The team performed toxicity assays, spraying adult rice weevils and red flour beetles with varying concentrations of the extract. The researchers monitored the insects for one, three and seven days. The rice weevil showed more mortality than the red flour beetle. The toxicity of the extract was comparable with that of a common insecticide, deltamethrin.

To test for repellent activity, the researchers exposed the insects, for just 30 minutes, to a filter paper infused with the leaf extract. The extract showed repellent activity against both insect species.

The extract also impacted the reproduction of the insects. Upon evaluating the survival capacity among the insects after exposure, the scientists found a decrease in the population build up for the succeeding two generations.

The team proposes to substitute synthetic pesticides with such eco-friendly botanicals especially in storage warehouses. However, it is essential to customise formulation to avoid toxicity, before extending plant-based insecticides to field trials.

Ecotoxicol. Environ. Saf., **154**: 92–99

Medicinal Properties of Black Clam

Black clams are exclusive to limited geographic regions. They are endemic in the brackish waters of the southwestern coast of India. Coastal populations in Kerala depend on this species for their livelihood. This traditional seafood is extensively harvested from the wild for its commercial and export value.

Studies on the nutritional values and bio-potentials of the black clam – *Villorita cyprinoides* – have been reported. Now, scientists from the Central Marine Fisheries Research Institute, Cochin, report finding anti-inflammatory and antioxidant compounds in bivalve black clams.

To identify the bioactive compounds, they used nuclear magnetic resonance spectroscopy, nuclear Overhauser effect spectroscopy, ultraviolet spectrophotometry, gas-chromatography mass-spectroscopy and high-pressure liquid chromatography. The scientists thus discovered furano-meroterpenoid analogues in the black clam.

Furano-meroterpenoids are antioxidants and have anti-lipoxygenase activity. This signifies the utility as functional food ingredient, says Minju Joy. The greater antioxidative and anti-inflammatory properties of the furano-meroterpenoid in the black clam may be because of the optimum hydrophobic-hydrophilic balance along with lesser steric bulk in the compound, proposes Kajal Chakraborty.



Image: indiabiobiodiversity.org

The scientists also discovered specialised naturally occurring chromenyl or pyranoid metabolites in the black clam. These could be used as potent anti-inflammatory and antioxidant agents in functional food preparations and nutraceutical formulations, say the scientists.

Food Chem., **251**: 125–134

Targeting Colon Disorders

Drugs in nano-micelles

Many diseases, including colon disorders, cannot be cured by oral drugs due to the acidic environment of the stomach. Even if the drug crosses the acidic region it may get absorbed in the small intestine. This leads to the colon not receiving the therapeutic dosage. Hence, such diseases require special treatment.

Recently, researchers from the CSIR-IGIB, Delhi developed a new targeted drug delivery system for colon disorders using nano-carriers.

They selected polyethylene glycol as nano-carrier for sulfasalazine and ornidazole. Sulfasalazine is prescribed for colon diseases such as Crohn's disease and ornidazole for amoebiasis.

The carriers self-assemble as micelles in a dimethylformamide solution. Dicyclohexylcarbodiimide forms reversible chemical bonds with both drug and carrier. Thus, the drugs are encapsulated in the nano-micelles.

These nano-carriers release the drug based on the pH of the surroundings. The drug is not released in the acidic pH of the stomach. The nanocarrier releases the drugs only near neutral pH, similar to that of the colon.

Both drugs have an azo moiety in their structure. This bond is easily broken down by the azoreductase enzyme secreted by the colon's microflora. This was demonstrated by the scientists using a mimic of the enzyme. Based on these studies, they say that the activity of the drug ceases within five hours for sulfasalazine. And around three hours for ornidazole.

Colon related diseases are distressing and hard to tackle. Also, bacteria are getting resistant to most antibiotics. Sulfasalazine is usually prescribed only when no other drug works and, hence, this report is significant for pharmaceutical companies and the health care sector. It has the potential to improve targeted delivery of drugs for diseases of the colon.

Colloids Surf. A, **547**: 157–167

Lab-on-body: Wearable Sensors

Flexible electronics step forward

In the past two decades, the electronics industry has witnessed some paradigm shifts – device miniaturisation, organic base materials and flexible components. Thanks to these advancements, we now have wearable health monitors, human-robot interfaces, and soft-actuators. But there remains an underlying challenge: developing components that are pliable and which adapt to human skin.

Though there exist magneto-electric systems based on ultra-thin glass,

metal foil and polymer substrates, these fall short of expectations due to their fragility, opacity and thermal instability. Last fortnight, scientists from the Indian Institute of Science, Bengaluru and the National Chiao University, Taiwan presented an approach to overcome these limitations. They developed a pliable magneto-electric nano-composite that responds to changes in the magnetic field by changing its electrical properties.

To build the nano-composite, the researchers used muscovite, a transparent, poly-silicate mineral containing potassium and aluminium, as substrate. Muscovite is elastic and has high thermal stability, properties that make it a good choice as substrate. Moreover, the two-dimensional nature of muscovite facilitates van der Waals epitaxy, alleviating stringent lattice matching conditions. The result is a sensing structure with almost free-standing layers, an essential property of pliable devices.

The researchers fabricated a heterostructure comprising bismuth ferrite rods embedded in a cobalt ferrite matrix. Cobalt ferrite has large magnetostriction and bismuth ferrite has ferroelectric properties. Together, they offer high magneto-electric coupling. This, in turn, influences the sensitivity of the device.

Thus, with a sound combination of materials and fabrication techniques, the researchers created the largest lab-on-body to perform non-invasive sensing. They are sure that this would accelerate progress in the area of flexible electronics. For capitalists aiming to find a niche, here is something to invest in.

J. Phys. D: Appl. Phys., **51**(23): 234006

High Energy Bio-Oil

From agri-plastic waste

Renewable liquid biofuel is a hot topic for research, as an alternative for fossil fuels. Last fortnight, a team of scientists led by R. Vinu, IIT Madras, reported a technique for producing high quality, high energy bio-oil via microwave-assisted co-pyrolysis of waste biomasses and plastics.

The researchers collected five different types of lignocellulosic

biomasses: groundnut shell, bagasse, rice husk, *Prosopis juliflora*, and sawdust. The plastics for the study – polypropylene beads and polystyrene pellets – were procured from local markets.

The team pyrolysed the mixtures of the biomasses and the polymers in batch mode, in a microwave oven. To increase the heating rate and reduce the processing time of the feedstock, they used industrial grade graphite powder, as susceptor to convert electromagnetic energy into heat.

First, the susceptor and the feedstock were mixed in 1 : 5 ratios. Then, the team co-pyrolysed each biomass and polymer in 1 : 1 mass ratios.

They found that when the biomasses are mixed with polymers, the heating value of the mixture is more than that of the biomass alone. The pyrolysis temperature of 600°C is reached in about 10 minutes in all the combinations at a moderate 450 W microwave power.

The scientists also report that the energy yields of the bio-oils from the co-pyrolysis of all five polystyrene-biomass mixtures were consistently higher than yields of bio-oils from individual biomass pyrolysis. They found that polystyrene mixed with sawdust gave maximum bio-oil yield. Rice husk–polystyrene and rice husk–polypropylene mixtures were better biomass–plastic combinations than others for recovering high quality, high energy density bio-oil.

Moisture content and total acidity counts of these co-pyrolysis bio-oils were lower than those from individual biomass pyrolysis. Generally, bio-oil obtained from biomass pyrolysis is acidic, contains high moisture and oxygen, and has low calorific value. Co-pyrolysis of different combinations can overcome these limitations, say the scientists.

‘Microwave-assisted heating is a promising technique for pyrolysing different biomasses and common plastics in combination’, says R. Vinu, IIT Madras. These findings can be useful for solid waste management and for producing much needed high-energy bio-oils.

Fuel Processing Tech., 175: 64–75

Signature Based Authentication 3D Convex Hull Approach

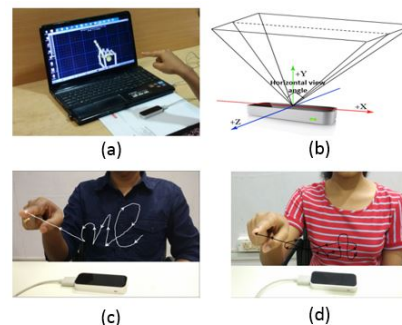
Signature-based authentication is considered reliable in biometric systems. Signatures are collected either online or offline. Online, signatures are collected with pen-sensitive devices and a pointer or finger. While online verification is carried out with the help of writer dependent features like velocity and pressure, offline verification is carried out by validating only the writing pressure, extracted from the handwritten stroke. Hence, the online mode is more secure than the offline mode.

Earlier research suggests that storing signatures in 3D format will increase the robustness of the biometric systems. But comparison and verification take a lot of processing time, if the user database is large. Scientists from the IIT Bhubaneswar proposed a new method, recently, to reduce processing time without compromising accuracy.

The team used a leap motion sensor to capture the signatures and stored them in 3D format. Then they extracted features or attributes from that data and represented them in the form of a convex hull structure.

To establish the authenticity of the signature, the team first classified the signatures with the help of classifiers such as the k -nearest neighbours algorithm and the hidden Markov model. The first looks at the patterns of relationships in the strokes of the signature while the other looks for

patterns hidden in the process of signing. Both algorithms find use in learning machines. To compare features against values stored in the database, the team used different classifiers.



To test the effectiveness of this method, they recorded the signatures of eighty volunteers using a leap motion sensor. Then they used another set of volunteers to forge the signatures. They found that their algorithm accurately and rapidly predicted forgery.

They found the hidden Markov model classifier computationally more efficient than the k -nearest neighbour algorithm. The team says that the method significantly reduces average time for signature recognition and verification.

The team proposes that this method can be used to develop robust biometric techniques and for designing computer interface systems.

Expert Syst. Appl., 100: 106–119

Reports by: **Sileesh Mullasserri, R. Srinivasan, K. Siranjothi, R. Baskar, K. V. Srividhya, Sushmitha Baskar, Mahadeva Swamy, S. Aishwarya, A. Siva Shakthi and Sanghamitra Deobhanj**

ACKNOWLEDGEMENT: IISER Pune, for access to scientific databases.

scienceandmediaworkshops@gmail.com