Science Last Fortnight

Silica Nanocomposite Adsorbents

A solution to water pollution

Water bodies, the world over, receive tons of untreated toxic wastes every year – effluents from paper, textile, food, cosmetic and other industries. Dyes and metals are the most harmful of these aquatic pollutants.

Last fortnight, scientists from the VIT University, Tamil Nadu and the University of Hyderabad, Andhra Pradesh in collaboration with scientists in Finland and the UK reported a solution for the removal of anionic pollutants from water: silica-based nanocomposite adsorbents.

The scientists used sol-gel and solvo-thermal processes to prepare SiO_2@$CoFe_2O_4$ magnetic nanoparticles on graphene oxide. The team conducted batch mode adsorption studies with these nanocomposites, to understand their adsorption capacity for acid black 1 dye and Cr(VI) ions as a function of contact time, pH, adsorbent dosage and initial adsorbate concentrations. They demonstrated that SiO_2@ $CoFe_2O_4$ nanoparticles on graphene oxide have the potential to remove toxic wastes from aqueous solutions.

Simple design and high adsorption capacity make the technology easy to implement. Because it is stable, reusable and cost effective, the scientists say that the nanocomposite is a commercially feasible solution to water pollution.

Chem. Eng. J., **322**: 472–487

Solar Distillation

Safe water

A World Health Organization 2014 report claims that 748 million across the world lack access to potable water. Urbanization and industrialization are making things worse by discharging waste into water bodies. The recent Make in India initiative has accelerated industrialization which will lead to more wastewater production.

Treating wastewater consumes electricity. The expenses for setting up and running water treatment plants are deterrents to implementing solutions.

To overcome this problem, recently, researchers from the Indian Institute of Technology, Guwahati in collaboration with the Tezpur University, developed a solar distillation unit to purify wastewater. They constructed the unit using naturally available low-cost materials such as a wooden box, charcoal, and jute wicks that are lined on the solar absorber plate for efficient light absorption and distillation of water.

This solar distillation unit can distil nearly 4 litres per square metre of basin. The scientists optimized the shape of the water basin to increase efficiency of distillation. They found that distillation productivity is augmented by increasing water temperature. The solar distillation unit produced the highest yield from 10 am to 4 pm.

In many parts of India, groundwater is contaminated with fluoride, arsenic and heavy metals. Water treatment, especially in remote villages, is impeded by lack of electricity. Now, this cheap and easily produced solar distillation unit brings the dream of pure and potable water closer to reality.

Desalination, **416**: 65–75

Fortifying Zinc in Rice

Effect of cultivars

Zinc deficiency impacts many in poor countries, affecting growth, sexual reproduction and other human functions. Applying zinc fertilizers can fortify zinc in rice, a staple diet in such regions. However, the increase of zinc in grains tends to deplete iron and phytic acid content due to antagonistic effect. Moreover, as zinc is concentrated in the bran and aleurone, most of it is lost during processing. Cooking depletes zinc further. Absorption after eating also impacts the bioavailability of zinc.

Recently, a team from the Bidhan Chandra Krishi Viswavidyalaya, West Bengal and the Bihar Agricultural University collaborated with scientists in Israel and Australia to come up with a solution. They selected six rice cultivars: Gobindobhog, GB 1, MTU 7029, KRH 2, Satabdi and Lalat – all similar in zinc density. They used a rank sum scoring technique to evaluate the effectiveness of zinc application protocols on these cultivars.

The team applied zinc on the soil and leaves at the tillering and flowering stages. And found that zinc application is more effective at the flowering than at the tillering stage. Applying zinc at the flowering stage transports larger amounts of the micronutrient to the developing grains. They also discovered that the loss of iron in rice was lower when zinc is applied at the flowering stage.

The scientists observed that the best results are produced in cultivar GB 1 by applying zinc to the soil and leaves during the tillering and flowering stage. In spite of losses due to processing, the bioavailability of zinc increased by about 50%.

The team claims that optimizing the cultivar and zinc application protocol increases zinc and grain yield. This also reduces zinc–iron antagonism in the grains and enhances zinc bioavailability in cooked products. Farmers would do well to adopt these practices to improve the availability of the micronutrient in food grains.

Field Crops Res., **210**: 52–60

Checking Honey Quality

Simple and precise method

Pure honey contains valuable dietary and therapeutic ingredients. However, the bitter truth is that honey is often adulterated. Common adulterants include sucrose, maltose, fructose, jaggery and beet sugar – fundamental constituents of honey. Hence, detection is not easy. Existing techniques, using Fourier Transform Infrared Spectroscopy, fail to detect minor fractions of adulterants.

Last fortnight, a team of researchers from the University of Calcutta combined Electrical Impedance Spectroscopy

with Fourier Transform Mid Infrared Spectroscopy to detect adulterants in honey.

The adulterants in honey are non-conducting. Hence, adding adulterants to honey affects electrical parameters linearly with adulterant content. Electrical impedance is directly proportional to the adulterant. So the scientists prepared seven adulterated honey samples and measured impedance, capacitance and conductance to evaluate adulterant content in honey.

The researchers say this simple, rapid, point-of-care test can be extended to detect and quantify adulterants in other food products. The Food Safety and Standards Authority of India can use such techniques to monitor adulterants.

Talanta, **171**: 327–334

Citrus to Deal with Diabetes

Alternative drug and delivery

India has some 50 million type-2 diabetes patients. Though there are treatments to control the problem, prolonged use of oral antidiabetics adversely impacts health.

Recent research has shown that naringenin, an antioxidant flavonoid in citrus fruits, prevents the kidneys from re-absorbing glucose. And, hence, it can be used as an anti-diabetic. Unfortunately, when ingested, only 15% naringenin is absorbed. So, its efficiency becomes limited at the site of action.

A team of scientists from the University College of Science, Kolkata and IIT Roorkee now report a new biocompatible, biodegradable vehicle for site-specific delivery of naringenin. They embedded naringenin in a nanovehicle made of chitosan coated with alginate. The team performed a spectroscopic study to quantify the amount of naringenin encapsulated by this core-shell composite. The encapsulation efficiency was more than 50% and, under certain conditions, went up to nearly 100%.

The size of the nanovehicles influences drug delivery. So the team used a light scattering experiment and found the size to range from 150 to 300 nm.

The spherical nanocomposites had a surface charge ranging from –26 to –38 mV. The higher negative surface charge prevents the aggregation of the nanocomposites, thus increasing their bioavailability.

The team evaluated nano-vehicles with optimum particle size and charge, and more than 90% encapsulated naringenin. *Ex vivo* mucoadhesion test indicated attachment of the nanoparticles to rat intestinal lumen. *In vivo* studies confirmed strong interactive binding of these nanoparticles to the rat's small intestine.

The researchers fed diabetic rats naringenin nanoparticles and observed that blood glucose normalized after 27 days and was maintained thereafter. In contrast, free naringenin, when fed to rats, could not show consistent decrease of blood glucose.

The team attributes the efficiency of this treatment to slow, sustained release and enhanced permeability of naringenin. With extended clinical trials, this non-toxic and biodegradable vehicle for site-specific drug delivery may soon be a boon to the type 2 diabetes patient.

Carbohydrate Polym., **170**: 124–132

New Drug for Alzheimer's

Alzheimer's, a neurodegenerative disorder characterized by memory loss, might be due to the breakdown of acetylcholine in brain cells and the consequent build-up of amyloid-β plaques. Current medication such as donepezil, rivastigmine, galantamine, and tacrine are directed against acetylcholinesterase, the enzyme that breaks down acetylcholine. However, they have many side-effects such as diarrhoea, liver toxicity, headaches and sleep disturbances.

Last fortnight, a team of scientists from the Jamia Milia Islamia, Delhi, University of Delhi, the B. R. Ambedkar Bihar University and the Indian Institute of Technology, Delhi reported a new breakthrough in Alzheimer's treatment: triazine-triazolopyrimidine hybrids.

Earlier, triazine compounds have been used in the formulation of antibacterial, anti-viral and anti-cancer drugs. In the current study, the scientist showed the efficacy of a triazine-triazolopyrimidine for treating Alzheimer's.

The scientists synthesized seventeen triazine-triazolopyrimidine hybrids using chemical processes. Among them, two triazine-triazolopyrimidine hybrids were found to be most effective against Alzheimer's – as per their inhibitory activity towards acetylcholinesterases and amyloid-β disaggregating ability.

Computational studies showed that these compounds have lesser toxicity than the present drugs. The researchers, therefore, believe that they have potential candidates for Alzheimer's treatment. Pharmaceutical companies may now initiate steps to validate the efficacy of these drugs using clinical trials.

Eur. J. Med. Chem., **18**(136): 36–51

Cardamom for Healthy Heart

In recent times, economic prosperity and the consequent sedentary lifestyles have negatively impacted human health, increasing obesity, hypertension, and heart disease. A natural food constituent that is useful to prevent chronic heart diseases is increasingly being explored.

Cardamom, *Elettaria cardamomum,* is a spice grown abundantly in India. In the Ayurveda and Siddha systems of medicine, cardamom is a component in balms, ointments and therapeutic oils used for cramps, rheumatic pain, inflammations, etc. Some studies have also suggested that cardamom may reduce cholesterol levels.

Last fortnight, researchers from the Department of Spice & Flavour Science in collaboration with the CSIR-Central Food Technological Research Institute, Mysore, conducted an animal study to authenticate the ability of cardamom to reduce the lipid levels in rats. By feeding the rats cardamom oil, they found a reduction in the cholesterol level and restoration of lipid balance. The cholesterol level in serum went down by about 30% and in the cardiac muscle it decreased by more than 40%. The serum triglycerides too

reduced by 40%. Moreover, there was enhanced antioxidant activity.

Thus, the use of cardamom may help reduce the risk of cardiovascular diseases, say the scientists.

J. Sci. Food Agric., **97**(10): 3204–3210

Chronic Pulmonary Obstruction

Point-of-care monitoring

Despite recent advances in medical technology, monitoring of chronic obstructive pulmonary diseases has not changed significantly. Chronic obstructive pulmonary diseases such as asthma, are not curable and are a growing challenge to the healthcare industry. Precise early diagnosis, along with on-going monitoring, will help take steps to control the pulmonary obstruction caused by diseases such as bronchitis, or pneumonia.

Diagnosis of pulmonary obstruction is done using tests in a lung function lab. This testing often comes too late when significant irreversible lung damage has already occurred. A research team from IIT Guwahati developed an economic and user-friendly lung function monitoring point-of-care-testing device. It helps detect chronic obstructive pulmonary diseases.

The device has four components: a mouthpiece to focus exhaled air on the sensor, a resistive paper-sensor integrated to the mouthpiece for moisture detection, a micro-heater integrated with the sensor to maintain an optimal temperature, and a real-time monitoring unit to display lung condition.

The team used the principle that the exhaled air from human breath contains ~90–100% humidity. They deposited gold nanoparticles and cadmium sulphide nanoparticles on a paper-surface. Gold nanoparticles help enhance electrical and thermal conductivities while cadmium sulphide nanoparticles help in high precision humidity sensing.

When the humidity sensor is exposed to human exhalation, water molecules progressively adsorb on the cadmium sulphide nanoparticles. This helps reduce electrical resistance. The variation in the flow rate of the exhaled air could be correlated with the variation in the electrical resistance across the sensor.

The micro-heater integrated with the sensor helps in maintaining an optimal temperature and facilitates rapid desorption and evaporation of the molecules once the exhalation is complete.

Two types of real-time monitoring units are integrated with the device. A LED based unit displays the diseased, critical, and fit conditions of the lungs by blinking in specific colours. A mobile-based monitoring unit developed using an open source software, helps operate the device on a smartphone interface.

This lung function monitoring device is capable of measuring the frequency of breathing and peak flow rate of human exhalation. It provides clinical information faster than could be delivered by a conventional laboratory tests.

The WHO forecasts that chronic obstructive pulmonary diseases will become the third-leading cause of death by 2030. So it is critical that the healthcare industry focus on early diagnosis at the point-of-care. However, entrepreneurs need to take up further development to bring out the device as a commercial product.

Biosens. Bioelectron., **94**: 544–551

Diagnosing Purine Metabolism

Sensors from nanodots

Purines are important components in all life forms. Besides being constituents of DNA and RNA, they play other major roles: as ATP, the energy currency of the cell and as GTP which has a major role in transduction of signals across membranes, as cyclic AMP a major intra-cellular signal, etc. Metabolic disorders of purines, therefore, have wide implications on the human body. One of the signs of the metabolic disorder is increase in uric acid in urine.

Existing methods of estimating uric acid rely on the use electronic sensors that are tedious, costly and lack sensitivity. Now scientists from The Gandhigram Rural Institute have leveraged the properties of carbon nanodots to make superior electronic sensors for monitoring purine metabolic disorders.

The researchers constructed carbon nanodots from asparagine by heating it at 100 degrees until it liquefied and turned brown. Next, they combined the nanodots with a glassy carbon electrode by immersing the electrode in the nanodot mixture for eight hours. They examined the structural changes associated with carbon dots after modification, using electron microscopy and X-ray diffraction.

After running tests, the scientists found that conjugation with nanodots makes electrode performance superior in terms of current flow, detection, and stability. The electrode was extremely selective and could identify trace amounts of uric acid even in the presence of common interferents such as glucose and dopamine. It could also simultaneously detect the presence of tyrosine and allopurinol and could be used for checking for disorders of purine metabolism.

The scientists found that the electrode could be used reversibly for up to 20 times without any loss in function even in body fluids like blood, serum, and urine.

These enhanced properties are attributed to ease of current flow facilitated by the carbon dots. The scientists are confident that such simple, cost effective approaches could be used for producing sensors for routine use in healthcare. We can thus take steps to reduce such painful conditions as gout and many other symptomless conditions that often go unrecognized.

Biosens. Bioelectron., **94**: 30–38

Plastic Waste Management

PET primed for recycle and reuse

Poly(ethylene terephthalate), or PET, is a common material for plastic containers, especially for carbonated drinks. Though strong, transparent, versatile and recyclable, its indiscriminate use in packaging generates solid waste – a threat to the environment. PET can be depolymerized, recycled and reused to make automobile bumpers and door panels. Existing methods to depolymerize PET – hydrolysis, alcoholysis, glycolysis, ammonolysis and aminolysis – either need high temperature and pressure or specific chemicals or conditions. So they are either not economic, environment friendly or energy efficient.

Meenu Teotia and colleagues from the Chaudhary Charan Singh University, Meerut now report developing an efficient, economic, environment

friendly, method to depolymerize PET as a means to manage the waste PET.

The team depolymerized the PET into four useful aromatic amides using aminolysis at ambient temperature and pressure, without any catalyst. All the four resultant products were confirmed to be true-to-type by various analytical methods. The aromatic amides so derived can find use in photocuring, pharmaceutical coating and many other such applications.

The process need to be optimized for making it industrially viable. However, this is a potential route for making useful goods and for managing PET waste.

J. Appl. Polym. Sci., **134**(31): 45153

Flexible and Disposable Batteries

Eyeliner-coated paper electrodes

Imagine: you can generate power with paper and eyeliner! The complicated electrode fabrication process is now history.

Last week, Debabrata Das and team from the IIT, Kharagpur designed an environment friendly Whatman filter paper-based electrode for microbial fuel cells.

Paper has cellulosic fibres and is non-conductive. The researchers made the paper conductive by directly applying commercially available eyeliner without binder. The eyeliner contains carbon nanoparticles and Fe_3O_4. The Whatman filter paper acted as a support for electrode fabrication and as a separator. The unit used the bacterial strain, *Shewanella putrefaciens,* at the anode. Thus, in effect, the device became a microbial fuel cell that exploits the bacterial metabolism to produce bioelectricity. Current is produced by chemical oxidation of organic matter in waste water. The system yielded more than 12 W of power per cubic metre.

This is perhaps the simplest way to fabricate low cost electrodes for a microbial fuel cell. Unlike traditional batteries, these can be safely discarded. And the day is not far when we would have digital devices that can be folded since they run on flexible batteries.

Biosens. Bioelectron., **94**: 464–470

The Great Barrier Leaf

Treating mild steel corrosion

Mild steel installations require a coat of anti-corrosive substances to protect them from acids. However, most anti-corrosive substances are expensive and detrimental to the environment. Now, a team of scientists from the PSGR Krishnamal College for Women, Coimbatore, collaborated with researchers in South Korea to look for an eco-friendly alternative.

Corrosion inhibitors form a layer that is impervious to acids. Many naturally occurring compounds in plants also display these properties. To extract such compounds, the scientists used the leaves of a South Korean plant – Korean starwort – which is rich in polyphenols. The scientists washed the leaves of starwort, dried and crushed them to a fine powder. They dissolved this in methanol and used the extract for coating metal rods. They then conducted a series of anti-corrosive tests where metal rods were dipped in sulphuric acid. As control, they used uncoated metal rods.

The scientists found that up to 90% of the corrosion could be prevented by a concentration of 2 parts in 1000 of the extract. The scientists are confident that such alternative approaches will reduce the use of synthetic corrosion inhibitors in the industry. In the midst of rising demands for corrosion inhibitors and increasing restrictions on the use of toxic products, such eco-friendly approaches will lead the way to corrosion-free metal surfaces.

J. Ind. Eng. Chem,, **52**: 235–242

Underwater Sensor Networks

Efficient power management

Wireless sensor networks are widely used for oceanographic data collection, offshore exploration, pollution monitoring and disaster prevention. These networks use sound signals for transmitting information because sound travels well in water. Such sensors are deployed, as three-dimensional networks underwater, for long durations. However, often, the sensors become useless because of poor battery management.

To reduce the need for power, Sarang Dhongdi and team from BITS Pilani, Goa recently reported developing an energy efficient cross-layer protocol approach for three-dimensional acoustic sensor networks. They arranged the network architecture in the form of clusters of sensor nodes.

The base station node, deployed at sea-surface, receives and transmits information to the surface station from the cluster head nodes. The cluster head, in turn, receives and transmits information from both geographically upper and lower cluster head nodes and from cluster member nodes. And the cluster member nodes receive control information from the cluster head node and transmit data to the cluster head at regular intervals.

In the cross layer approach, various layers such as physical, data link, and network layers as well as management planes, such as mobility and task management, are tightly coupled with power control. This increases the interaction among the various layers which, in turn, help manage power resources efficiently.

The team used UnetSim, an open source simulator, to test the efficiency of the cross-layer protocol. The simulation results show that the cross-layer protocol stack approach yields better energy efficiency. The team is confident that setting application-specific parameters in the protocol will improve network performance further.

JNCA, **92**: 3–19

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