

Science Last Fortnight

Sulphur Mustard

Decontaminating with nanoparticles

Sulphur mustard, a deadly World War I chemical warfare agent, now threatens to resurface in the hands of terrorists. Inhalation, ingestion or skin contact results in blisters and burning. Scientists have been seeking to decontaminate it. Last fortnight, Kumar and colleagues, from the DRDO Establishment, Jhansi, devised a solution.

They tested Mg, Ca, Mn, Co, Ni, Cu, Zn and Mn-Zn, Co-Zn mixed metal ferrite nanoparticles on sulphur mustard. The researchers used the co-precipitation method for nanoparticle synthesis. Ni, Zn and Co-Zn ferrite nanoparticles exhibited high decontamination: 99.99% of sulphur mustard within 10 h of treatment.

Gas chromatography coupled with mass spectrometry data indicated that the nanoparticles convert toxic sulphur mustard into non-toxic products. Basic sites and Lewis acid sites were responsible for the decontamination properties of nanoparticles, as confirmed by CO₂ and NH₃ temperature programmed desorption.

Ni, Zn and Co-Zn ferrite nanoparticles show significant reactivity towards sulphur mustard and high adsorption capacity. These findings suggest their application in decontamination kits.

J. Alloys Compounds, **692**, 833–840

Detecting Duplication

Diagnosing leukemia

B-cell acute lymphoblastic leukemia is a blood cancer with poor prognosis. Gene duplication and deletion are frequently noticed in patients.

Last fortnight, Gupta and team from AIIMS, New Delhi, reported the prevalence of copy number alterations and its clinical correlation in B-cell acute lymphoblastic leukemia patients. Analysis of gene copy number alterations is done by the multiplex ligation-dependent probe amplification assay. The scientists tested 162 patients for any copy number alterations of the genes. They observed copy number alterations in 114 cases. Based on copy number alteration profile, patients were classified into high and poor risk categories. Interestingly, at least one

of the tested genes showed copy number alteration.

The copy number alterations were higher in older patients. The researchers found a significantly higher incidence of chemotherapy failure in some patients with the deletion of Retinoblastoma 1 and Ikaros family zinc finger 1 genes.

Thus, detection of copy number alterations of genes related to B-cell lymphoblasts will help diagnose or even predict this disease to some extent. This improves informed treatment decisions and, hence, chances of disease recovery.

Leukemia & Lymphoma, **58**(2), 333–342

Detect Melamine in Milk

Do it in the kitchen

In the 2008 Chinese milk scandal, at least six infants died and thousands were hospitalized. They consumed milk products which were adulterated with melamine. It leads to kidney stones and renal problems in infants and adults. Compounds like melamine and urea bulk up apparent protein content. These adulterants are difficult to detect. So scientists have been looking for rapid and accurate techniques.

Last fortnight, two independent research groups made transformative strides in developing such techniques. Madeswari Ezhilan and associates from the SASTRA University, came up with an enzyme-based biosensor, which detects melamine and urea in millimoles¹.

The biosensor is fabricated with zinc oxide, and modified with platinum electrodes. Acetyl cholinesterase (AChE) was used as the primary target for inhibition. Melamine and urea block the serine hydroxyl group of AChE. The extent of blocking depends on the concentration of the melamine. The metal electrode in the sensor measures this activity.

While Madeswari focused on the aggregation of the nanoparticles, Kiruba Daniels and team from the Indian Institute of Science, Bengaluru, concentrated on the size and shape of the nanoparticles². They used a *Parthenium* extract, a reducing agent, to detect melamine. The extract interferes with synthesis when it forms nanoparticles. This gives a visible colour change when melamine is present.

Both teams have a simple goal in mind: to develop low cost and accurate

techniques. These methods detect the compounds rapidly and can also identify selectively. Biosensors are also used for monitoring glucose and a similar design can work for milk detection too. Interestingly, Daniels and his team have even filed a patent and plan to commercialize the process. Soon, instead of going to labs, we can test milk purity in the kitchen too.

¹*Sensors and Actuators B*, **238**, 1283–1292

²*Sensors and Actuators B*, **238**, 641–650

Surveying Sunflower Productivity

Genetic diversity as solution

Sunflower is an introduced edible oilseed crop, popular with Indian farmers. A major limitation in its cultivation is its susceptibility to diseases. Especially, leaf blight, caused by *Alternariaster helianthi*, a fungal infection that produces spots on the leaves. The result: reduced seed and oil yield. The infection is more common during the rains, and at times occurs in epidemic proportions. This discourages farmers from cultivating the crop.

Santha Lakshmi Prasad and team, from the ICAR-Indian Institute of Oilseeds Research, Hyderabad, hypothesized that low genetic diversity was the prime reason for susceptibility to such infections. The team undertook a five-year study to identify new and diverse sources of *Helianthus*, resistant to blight. The sources included wild *Helianthus* species, interspecific derivatives, superior lines and exotic germplasm. They employed two different assay methods, a detached leaf technique and the whole plant assay method to screen the plants. The plants were tested under glass house conditions against three strains of *A. helianthi*.

Under lab conditions, wild *Helianthus* species showed resistance to leaf blight. Crosses of cultivated sunflower with the wild ones showed better resistance to the disease. Field studies revealed varying expressions of resistance under different environmental conditions. Six accessions showed low leaf blight severity across locations. These lines can help develop sunflower hybrids with inbuilt resistance to leaf blight.



This intensive study can serve as a baseline for sunflower breeders in developing new cultivars. It emphasizes the need to exercise caution while introducing new species and stresses the importance of a broad genetic base for crop improvement.

Crop Protection, **92**, 70–78

Bacteria to Boost Agriculture

An unexplored reservoir

The Himalayan region has many well-known biodiversity hotspots. Though rich in ecological diversity, it suffers low agricultural productivity due to difficulties in cultivating on small landholdings at high altitudes where water runoff is fast.

Ragi, *Eleusine coracana* L., is one of the main food grain crops cultivated here. This particular crop is known for its ability to withstand water stress.

A team of scientists led by Dheeman from the Gurukul Kangri University, Haridwar, in collaboration with scientists from the Republic of Korea, explored the ecological diversity of bacilli growing in difficult environments for improving agricultural production in the Himalayan tract.

The researchers studied the diversity of the *Bacillus* population associated with ragi. They analysed the functional ecology in relation to plant growth promoting attributes. The team used two universal primers derived from the highly conserved region of 16S rRNA gene *fD1* and *rD1* for species identification. They studied the site-specific diversity of the bacterial strains using the Simpson and Shannon–Wiener index.

The team confirmed the suitability of 48 isolates of aerobic endospore forming *Bacillus* spp. from the rhizosphere of ragi. The functional traits of the *Bacillus* species exhibited direct or indirect

impact on plant growth. The isolates showed metabolic diversity in the use of various carbon and nitrogen sources. Phylogenetic analysis of the isolates revealed three species in the *Bacillus* genera and two in *Paenibacillus* genera.

Among the strains, more than 90% of bacilli were phosphate solubilizers, more than 70% auxin producers, 70% biocontrol agents and about 50% isolates produced hydrocyanic acid. The site-specific diversity and density of culturable bacteria showed positive correlation with the altitude gradient.

The rich reservoir of *Bacillus* spp. provides an opportunity for the development of bioformulations to improve agricultural production in other similar problematic sites.

Applied Soil Ecology, **110**, 127–136

Humic Acid in Vermicompost

Vermicompost has gained popularity as an alternative to chemical fertilizers which have proved harmful. It serves as a source of nutrients for microorganisms that promote indigenous microbial communities, increasing overall microbial growth. However, organic manures can be further enriched and improved to boost agricultural productivity.

It is well known that microbial activity can improve organic manure. Maji and team, at the CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow, examined microbial diversity in soils subjected to different fertilizers with and without humic acid, a compound that supports plant growth and tolerance to stress.

The researchers inoculated vermicompost, made from rice straw wastes and cow dung, with *Trichoderma atroviride* RVF3, a fungal strain. And they assessed the growth and yield of *Pisum sativum* plants along with microbial population dynamics.

Plants treated with humic acid-rich vermicompost show maximum shoot length, root weight, height, higher nodulation, more colonies of cultivable microorganisms and the highest microbial diversity. And soil treated with humic acid-rich vermicompost shows the highest microbial biomass carbon and nitrogen as well as enzyme activity.

They conducted a second set of experiments using inoculums of *Rhizobium leguminosarum* and arbuscular mycorrhizal fungi, applied alone or in combina-

tion with one of the fertilizers: chemical fertilizer, normal vermicompost and humic acid-rich vermicompost.

Plants treated with both rhizobia and arbuscular mycorrhizal fungi along with humic acid-rich vermicompost show maximum shoot and root length, fresh weight as well as improved root nodulation and AMF colonization.

Humic acid thus improves vermicompost by enhancing the performance of diverse beneficial microbial populations. Scientists are now planning to carry out next generation sequencing to estimate true microbial diversity and the role of microorganisms in shaping the structure of the community in the soil.

Applied Soil Ecology, **110**, 97–108

Extracting Oleoresins from Ginger

Ultrasound and enzyme pretreatment

Ginger is a popular spice with many health benefits. These pharmacological effects are due to the gingerols and shogaols of its oleoresin. Conventionally, they are extracted using Soxhlet and cold percolation. However, these methods require longer extraction time, more organic solvents and also expose the extract to degradation or modification. Hence, alternative methods were developed. But these come with high investment and maintenance costs.

To overcome this, three phase partitioning was developed. When cell homogenates are mixed with *t*-butanol and aqueous ammonium sulphate, they form three layers, separating polar constituents, proteins and hydrophobic constituents. The oleoresins are separated at the interphase of the organic and aqueous layer.

Last fortnight, Varakumar, Umesh and Singhal from the Institute of Chemical Technology, Mumbai, explored the effect of enzyme and ultrasound pretreatments on this separation technique.

The scientists prepared rhizome powder and optimized the conditions for maximum extraction of oleoresin by three phase partitioning. Though this yielded more gingerols, 6-shogaol yield



decreased. Ultrasound pretreatment increases oleoresin yield. But it imposes constraints in scale-up.

More oleoresins can be extracted using amylase and cellulase treatments before three phase partitioning. The process takes less than 4 h, unlike conventional methods that require more than 12 h. Therefore, scientists claim that the enzyme-assisted three phase partitioning can be a promising approach for ginger oleoresin extraction. Such scaling-up can be commercially viable.

Food Chemistry, **216**, 27–36

Smartphones Detect Salinity

Salinity is an important parameter for monitoring marine environments. Marine species adapt to certain salinity levels. Changes in salinity affect marine populations and ecology. So measurement of salinity is relevant for fishermen and scientists alike.

Scientists at the Tezpur University have now developed two smartphone-based systems to estimate the salinity level of sea water. The first technique is based on the Beer-Lambert principle: the intensity of the transmitted light depends on the concentration of the medium. The second is based on evanescent field absorption from a U-shaped fiber optic sensor.

The scientists prepared solutions of different concentrations of artificial sea salt, containing all the minerals found in a real oceanic environment. They used two freely available android applications, 'light meter' and 'stanXY', for data acquisition and analysis to standardize the measurements. Now, using a simple optical set-up and these two free applications, the salinity of any unknown sample can easily be estimated.

The performance of both the techniques was compared in terms of sensitivity, reproducibility and dynamic range. Among the two schemes, the linearity in sensor response for U-shaped fibre probe is found to be better than the first scheme in the salinity range 0–1 ppt. Unclad U-shaped fibre probes offer higher sensitivity than that provided by absorption sensors.

These smartphone-based measurements of salinity are useful as field data from remote locations can be easily transmitted to a central laboratory through existing mobile networks for continuous monitoring.

Sensors and Actuators B. Chemical, **239**, 1042–1050

Renewable Energy

A business for farmers?

India has the ambitious target of achieving a 175 GW capacity of non-fossil fuel-based energy by 2022. Any strategy to access private farm lands would be of great advantage for this target. Land, though, is a major bottleneck for setting up renewable energy projects.

In recent years, community energy models have achieved great success in countries such as Germany, Denmark, Austria, Scotland and the US. But, for India, the demographic and socio-economic profile is significantly different. The challenge, therefore, is to build a business model that works for Indian conditions.

Last fortnight, a team of researchers from the Indian Institute of Technology, New Delhi, addressed the issue. They derived a business model where farmers can become co-owners by offering their land for energy production. The reward? A constant source of income estimated at about Rs 270,000 per hectare per annum.

In the proposed model, farmers can participate in renewable energy production under a joint venture company and earn by providing labour for upkeep. The usual cost incurred in procuring land and its development for a renewable energy project is estimated to be up to 10% of the total project cost. This cost will be reduced up to 6% when farmers share their land.

The ownership of the farmers would be limited to land and development costs. The remaining shareholding will lie with the project proponent. The proponent–farmer joint company can sell power to a nearby grid.

Already, India has many success stories of community participation in the dairy and sugar sectors. This new model will enable policy makers to enhance India's energy security. For farmers, this spells better access to energy and an additional source of income.

Renewable Energy, **101**, 873–885

Better Biodiesel

A nano-cleansing solution

Biodiesel is a sulphur-free renewable fuel with a fuel value comparable to petroleum derivatives. However, producing biodiesel that adheres to international standards has proved difficult using current technology. The presence of impuri-

ties like soap, residual catalyst, free fatty acids and metal ions are detrimental to the efficient operation of diesel engines.

Last fortnight, researchers, from the Central University of Gujarat, reported a novel solution for the problem. They designed polyurethane-functionalized starch nanoparticles. These nanoparticles have large surface area, surface volume and porosity at the nano-level, making them ideal adsorbents. Moreover, they are biodegradable.

Dhananjay Mondal and team synthesized fresh biodiesel from Karanja (*Pongamia pinnata*) oil, using acid catalysed transesterification. They designed two classes of polyurethanes – nano-polyurethanes and bulk-polyurethanes – and challenged them with partially purified biodiesel. The adsorbents were graded on their ability to reduce the levels of free fatty acids, a major contaminant in the partially purified fuel mix. The team showed that nano-polyurethanes were much more efficient than bulk polyurethanes.

The use of adsorbents in the purification of biodiesel can help reduce the use of solvents currently deployed in the wet washing process, an inefficient and wasteful technique. The adoption of the new technique by industry could lead to a substantial reduction in water consumption.

J. Appl. Polym. Sci., **134**, 44463

Swamp Dwellers to Sugar-makers

Streptomyces olivaceus

Technologies to replace fossil fuels with renewable biofuels such as ethanol have been gaining momentum. Unfortunately, modern methods of ethanol production use high quality crops such as corn, leading to increased price and causing food shortage while consuming valuable farm and forest land¹. This can be avoided if ethanol can be produced from organic wastes.

Next to cellulose, hemicellulose is the most abundant renewable biomass. It mainly contains xylan, a sugar which can also be used for bioethanol production. Bacteria and fungi, particularly actinomycetes like *Streptomyces*, are natural producers of xylanase, an enzyme that can convert xylan to alcohol.

Actinomycetes are usually collected from soil and in the water and floor of streams and lakes. Last fortnight, Muthusamy Sanjivkumar and coworkers,

from the MS University and the Periyar University, reported a new source of xylanase². They isolated several *Streptomyces* species from the sediments of mangrove forests in the Manakudy estuary of southern Tamil Nadu. Of these, *S. olivaceus* was found to give the highest xylanase yield. The highest xylanase yield was reported at pH 7 and 40°C, using sucrose as carbon source and yeast extract as nitrogen source.

The xylanase gene of *S. olivaceus* was similar to those from other related species. The researchers isolated and purified the enzyme protein and its properties and activity were studied. It was found to give good yields for sugarcane juice, sugarcane bagasse (2.47 g/l at 72 h), vegetable waste, mango peels and banana waste.

If bioethanol can be economically produced from waste materials such as bagasse, it can replace fossil fuels such as petrol and environmentally and socially harmful alternatives such as corn-based ethanol.

¹*Environ. Health Perspectives*, **116**(6), A254–A257

²*Protein Expression and Purification*, **130**, 1–12

Nullifying Noise

Unwanted noise sometimes mars our enjoyment of radio or TV. Receivers use a noise control mechanism to nullify primary noise, but secondary noise, a non-Gaussian distribution, remains.

Scientists, from IIT Gandhinagar, have devised an efficient nonlinear Active Noise Control scheme using an information theory approach.

Active noise control is based on destructive superposition and is achieved using a microphone, loudspeaker and adaptive controller. A smaller distribution of signals results in highly impulsive noise signals.

The team used an adaptive FIR filter which minimized costs. For dealing with nonlinearity in noise, a nonlinear functional artificial network filter is used as controller. The change in the parameters of the ‘filtered mean square algorithm’ is directly proportional to the magnitude of error signal.

To tackle this, the researchers came up with the notion of ‘correntropy’, the correlation between two variables in a small neighbourhood. They used adaptive filters which minimize the mean square error and maximize the correntropy. The

robustness of the algorithm lies in the fact that the parameters become constant – derivative becomes zero – for a high magnitude of error. This has been found to work even for non-Gaussian noise, giving faster convergence.

The validity of these noise reduction techniques was tested using MATLAB simulations.

These techniques can lead to a more sensitive controller output transmitter and help customers get the desired signal with robust noise cancellation ability.

Applied Acoustics, **117**, 180–184

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