

## Science Last Fortnight

### Capturing Cobalt Ions

#### *New cellulose-based adsorbent*

Though cobalt is a necessary element in nutrition, it is needed in miniscule quantities. Larger amounts are toxic. So water contamination by cobalt is a public health concern. However, effectively removing cobalt ions is still a major technological challenge.

Last fortnight, T. S. Anirudhan and team from the University of Kerala, Thiruvananthapuram developed a cellulose-based low-cost biodegradable adsorbent. Cellulose is a low-cost abundantly available natural adsorbent. They encapsulated a magnetic nanomaterial in nanocellulose to increase the surface area and to thus increase adsorption. This also improved the stability of cellulose.

Cellulose tends to adsorb other light metals. This property is attributed to the carboxyl and hydroxyl groups of cellulose. To make cellulose specific to cobalt, the scientists functionalised cellulose with sulphhydryl and carboxyl groups. Adding sulphur and nitrogen to the groups reduced the binding of unwanted light metal ions.

The team examined the adsorbent's physical, morphological and chemical characteristics. It was fluffy, porous, partially crystalline and super paramagnetic.

They investigated parameters which affect adsorbency: pH, contact time, temperature, agitation speed, adsorbent dose and other common ions in water. They then tested the adsorbent on a cobalt ion solution. The team found that the material can adsorb about 350 milligrams per gram – much more than can be achieved with other known adsorbents.

They also discovered that cobalt ions were more efficiently and effectively recovered in each adsorption-desorption cycle. The adsorbent can be easily regenerated and reused, says T. S. Anirudhan, University of Kerala.

After six cycles, adsorption decreased from 97.5 to 84.7 per cent and cobalt ion recovery from 93.2 to 79.3 per cent.

The adsorbent will be ideal for removing cobalt ions from aqueous solutions. Effluents from nuclear power plant coolant water and some industries contain a large amount of cobalt. Along with detoxifying the effluents, the nano-adsorbent provides a means for cobalt recovery.

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### Inexpensive Microfiltration

#### *A unique blend of polymers*

As modes of pollution increase, pure water is difficult to come by. Unavailability of inexpensive purifying techniques to effectively counter these pollutants has increased the risk of exposure to deadly diseases like diarrhoea. Pollution of groundwater by industrial waste and heavy metals poses a hazard to public health. And oil spills in surface waters are harming the ecosystem. It is particularly difficult to completely eliminate these pollutants.

Although a number of polymer membranes have been designed to overcome the problem, none of them was cost-effective. Last fortnight, S. Remanan, N. C. Das, M. Bose, and A. K. Das from the IIT, Kharagpur developed an ingenious method using a unique blend to manufacture an inexpensive membrane.

The team blended poly(ethylene-co-methyl acrylate) and poly(vinylidene fluoride) by melting at 190°C. After experimenting with various blend ratios, the team realised that water permeability and membrane filtration were optimum at 80/20.

They then used hydraulic compression to obtain a very thin film of the polymer blend. And the final porous membrane was prepared by partially etching the film using chloroform.

The scientists found that adding poly(vinylidene fluoride) improved the tensile strength while reducing the elasticity of the film. The membrane rejected serum albumin up to 98.39%. Oil rejection was nearly 90% and bacterial rejection 52%. Although the membrane could also remove suspended solid waste from water, it wasn't quite as effective, say the scientists.

Given this capacity and the low cost of production, the membrane could perhaps be used as first line treatment for purifying drinking water.

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### Superior Pomegranate

#### *Traits from the wild*

Pomegranate, *Punica granatum* L, is a popular, tasty fruit with many health benefits. In India, it grows wild in the Western Himalayan region. The wild pomegranate that grows in such hilly marginal tracts shares morphological characters with the cultivated fruit. It is hard to distinguish between pomegranate cultivars. However, distinguishing phenotypic variations could help select genotypes with superior fruit quality, and create much-needed resistance to fruit borers.



Image: Pavithra Nayak

Last fortnight, scientists from the Dr Yashwant Singh Parmar University of Horticulture and Forestry, Solan reported developing precise identification to select phenotypically superior pomegranates.

For sample cultivars, the team selected three locations in the Sirmour district to test best performing individual trees for phenotypic characters. They selected trees from the same and different locations to develop progeny resembling the parent.

They collected mature fruit samples after open and controlled pollination experiments for comparison. They observed bigger sized fruits from open-pollinated trees than from hand-pollinated trees.

The team analysed the physico-chemical parameters of the fruits and found more ascorbic acid in fruits

under open pollination than in those under controlled pollination.

Next, they tested the fruits for fruit borer infestation. They found that the incidence of fruit borer was more in fruit from hand-pollination than where there was open-pollination.

The team then tested the hybrids using twenty-one molecular markers. They found that seven out of fifteen hybrids were similar to the parents.

The team also discovered that half sibs, from Narag and Daron, with ovate-shaped fruits, performed best for seedling height and had low fruit borer incidence.

Considering the economic importance of pomegranates, it makes sense to enhance fruit quality through selective breeding. Indeed, quality improvement to develop hybrids marks the future of field crops. Going back to wild pomegranates to genetically improve cultivated varieties may yield results in the future.

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### Tomato, Potato or Eggplant?

#### *Tuta absoluta's* choice

*Tuta absoluta* is an absolute pest! The pest attacks solanaceous plants such as the tomato, the potato, the brinjal, the capsicum and even tobacco. It has no preference for time of year, making life hard for farmers. Having travelled around the world from South America, it now threatens the already burdened Indian farmer. How do we contain this invasion?

Knowing how it grows, survives, reproduces and dies is the first step to develop strategies for control. However, so far, such studies have focused on females at different ages. But this approach does not tell us the whole story. So, Nitin Kanle and Akshay Kumar Chakravarthy from the ICAR-Indian Institute of Horticultural Research, Bengaluru teamed up with researchers from the Van Yuzuncu Yil University, Turkey to create age-stage, life tables incorporating both sexes to understand how *Tuta* population grows. The answer could help us strike at the root of the problem.

Using *T. absoluta* eggs and larvae from infected host plants, the team reared the pest on tomato, potato and

eggplant hosts separately. To understand the effects of the hosts, they raised seven generations on their respective host plants. Adult pests were also fed a ten per cent honey solution.

To get eggs of uniform age, the team led 25 two-day old *T. absoluta* males and females into a nuptial chamber to mate for 24 hours. This rearing box, covered with nylon net, housed pots with host plants.

Every day, the researchers collected twenty to hundred eggs from each host plant. One egg on each respective host plant leaf was placed on a petri dish and appropriate humidity was maintained. The team checked the petri-dish eggs daily and fed the larvae the respective host leaves from the experimental unit until pupation. And they recorded the developmental duration and survival rate on different host leaves.



Image: Nitin Kanle

Two days after moths emerged, they were segregated into male and female based on abdomen size. Then, the team put one pair each into containers with the host plant for egg laying. The moths continued to be fed the same honey supplement.

The scientists recorded survival and fecundity daily until all the moths died. Every day, they also noted the number of eggs laid on the host plant leaves. And they recorded adult pre-oviposition period, total pre-oviposition period, number of eggs laid per female, adult longevity and total lifespan of *T. absoluta* on different host plants.

'We used oviposition days. They reflect the actual number of days an insect produces eggs. This will help understand the damage-causing potential of the pest', says Nitin Kanle.

Then the researchers analysed the life history data of *T. absoluta*. They estimated age-stage survival rate, age-

specific survival rate, and age-specific fecundity as well as population parameters using data from tomato, potato, and eggplant.

'On tomato, *T. absoluta* foraged more intensively and completed the larval stages within a shorter period compared to potato and eggplant', says Akshay Kumar. The pupal stage was significantly shorter. So was the survival rate of larvae. 'Ninety per cent of the larvae survived on tomato leaves. But, on brinjal leaves, only about 65% survived', says Nitin.



Image: Nitin Kanle

The rapid population growth of the pest on tomato warns tomato farmers to take immediate action if *T. absoluta* is detected in their fields. Farmers growing solanaceous crops like tomato, potato or brinjal need to be on the lookout for white patches on leaves, small greenish larvae that crawl inside the leaves creating galleries, or hundreds of small yellow, oval eggs under the leaves. To manage and contain the pest, the scientists recommend a multi-pronged integrated strategy.

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### Fortified Snack

#### *Wheat with tomato and saffron*

As India has become self-reliant in food, more and more processed foods are packaged and lie in shops, waiting to be picked up by consumers. From the process of extrusion to baking, packaging, transportation, and storing, the nutritional quality of cookies degrades. Are there ways to reduce or prevent this?

Naseer Ahmad Bhat and team from the University of Kashmir thought of saffron. Saffron has antioxidant properties and many other health benefits. They also thought of tomato powder, a

waste product of processing tomato puree. The powder has lycopene, which is also an antioxidant. So the team developed a ready-to-eat snack, with whole wheat flour and these components.

They prepared the snack using extrusion technology, where saffron powder, crude lycopene and tomato powder were added to a constant quantity of whole wheat flour. The team found that the fortified snack had better nutritional properties than snacks with only whole wheat flour.

The snack has enhanced crude carotenoid content and antioxidant activity. Crude fat, total dietary fibre and phenolic content were also higher in the whole wheat flour snack after the addition of the plant extracts. However, the extruded snacks lost some nutritional properties under high temperature but improved in flavonoids afterwards.

What is more, the snack has good sensory properties and retains taste and nutritional value for up to six months. Tasty news for the food industry!

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### MSG in Food

#### *Immuno-electrochemical detector*

Monosodium glutamate, better known by its brand name Ajinomoto, is used as flavour enhancer. It is a sodium salt of glutamic acid, considered safe by the US FDA. From 0.2% to 0.8% is acceptable in foods. Though studies say that normal concentrations in foods are not toxic, there are reports of people developing uneasiness and nausea. However, quantifying concentration in foods with accuracy is difficult.

Recently, scientists from the CSIR-North East Institute of Science & Technology, Jorhat and the CSIR-Advanced Materials and Processes Research Institute, Bhopal invented an electrochemical method to detect monosodium glutamate in foodstuffs.

The scientists used a combination of the principle of immune reactivity and electrochemical detection to ensure high selectivity and specificity. They harvested an anti-glutamate antibody from rabbits and attached the antibodies to gold-molybdenum disulphide

nanoparticles so that the immune reaction is translated into an electrical signal. And the gold/molybdenum nanoparticles were attached to a glassy carbon electrode to carry the signal.

The sensor showed high sensitivity towards monosodium glutamate. The scientists tested the sensor and they found it highly conductive and sensitive. After statistically analysing the results, they claim that the electrochemical sensor has good selectivity and stability.

The detector is easy to synthesise. Electrochemical sensors, in general, are reliable, affordable and easy to handle. So the technology could be used to test if the level of MSG in foods is as per safety regulations.

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### Banking on Human Milk

#### *Investing in infants*

Breast milk is ideal for babies. The WHO recommends exclusively breastfeeding neonates for the first six months. However, sometimes, mothers' milk is unavailable. In such situations, the WHO recommends pasteurized donor human milk. Human milk banks systematically collect, pasteurize, properly store, and distribute donated breast milk. However, literature on the impact of the human milk bank on neonatal health remains sparse, especially in the Indian context.

So B. Adhisivam and team from the Jawaharlal Institute of Postgraduate Medical Education and Research, Puducherry conducted a pre- and post-intervention study in their tertiary care teaching institute. They investigated the impact of the human milk bank on neonatal mortality, the incidence of necrotizing enterocolitis and the rate of exclusive breastfeeding.

They collected data for a period of 6 months before and after establishing a modern human milk bank. 'A third of new born children is preterm or has low birth weight. We hope to improve their survival using the human milk bank', says Adhisivam, JIPMER.

Healthy lactating mothers, with written consent, donated milk under sterile

conditions using breast milk pumps. After pooling the milk and pasteurizing it, the team microbiologically screened it.

They then prescribed the milk to pre-term, sick and abandoned babies, as well as to those whose mothers died after delivery or those with postpartum illnesses, or lactation failure.

Data related to the pre- and post-intervention period, from the new born intensive care unit database, showed a decreasing trend in neonatal mortality rate, from 11.32 to 10.77 per 1000 live births. They say the decrease may be due to the nutritional and immunological benefits of human milk. They did not observe any significant improvement in necrotizing enterocolitis in the infants.

Another parameter they checked was exclusive breastfeeding rates. For this, they collected data for 6 months with a follow-up every 45 days from mothers who delivered babies at JIPMER. Of the 22% of women that received antenatal counselling on exclusive breastfeeding, 15% donated breast milk and 8% of their babies received pasteurized human donor milk.

Adhisivam says: 'The human milk bank increased breastfeeding in the hospital. The rate went from thirty-four to seventy-four per cent'. The researchers say that human milk banking boosts breastfeeding rather than competing with it.

This drastic jump in exclusive breastfeeding of neonates is reason enough to set up human milk banks at least in teaching and tertiary care hospitals.

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### Onion Peel Powder

#### *Raw material for nutraceuticals?*

India produces about 21 million tons of onions per year. An estimated 500 kilograms of onion peels are thrown away every day. Onion processing industries find it difficult to deal with the waste that is generated: it stinks.

Chandra Bhushan Pal and Girirajsinh C. Jadeja from the Sardar Vallabhbhai National Institute of Technology, Surat examined the issue. Onion peels contain flavonoids and

phenolics – pharmacologically important compounds. But extracting them by traditional methods will lead to other environmental problems.

So they chose to use a eutectic solvent – a mixture with much lower melting points than the components. They experimented with using choline chloride mixed with three different hydrogen bond donors like urea, sucrose and sorbitol in different molar ratios. They also tried heating-stirring, the Soxhlet method and microwave to assist the extraction process.

Choline chloride with urea and water at a ratio of 1 : 2 : 4 gave the best results. The ratio of liquid to onion peel power, 50 : 1, at 60 degrees centigrade for two hours yielded most of the total polyphenols – more than 200 milligrams of gallic acid equivalent per gram dry weight of onion peel powder.

Microwave assisted extraction is better than using the Soxhlet method or heating-stirring, they found.

The analysis revealed the presence of 15 main polyphenols in the extract. Quercetin, kaempferol and myricetin were the major constituents.

The nutraceutical industries now have good raw material – the waste from onion markets and onion processing industries.

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### Degrading Diclofenac

#### *Photocatalysis by mixed oxides*

Diclofenac, a widely used drug, is found in surface water and groundwater. Ingesting high levels of diclofenac could cause stroke, or damage the liver and kidney. Diclofenac tends to accumulate as it goes up the food chain. Large scale reduction in vulture populations has been attributed to diclofenac. So scientists have been trying to devise methods to remove diclofenac from drinking water.

Titanium oxide or titania can be used as catalyst to degrade diclofenac in the presence of sunlight. But the efficiency is low. Recently, P. E. Jagadeeshbabu and team from the National Institute of Technology Karnataka, Mangalore came up with a low-

cost solution to improve the photocatalytic degradation of diclofenac. They doped titanium dioxide with stannic oxide at different molar ratios. Stannic oxide is a wide-band-gap semiconductor. Coupling a wide-band-gap semiconductor with another wide-band-gap semiconductor helps reduce the recombination rate of photo-generated charges and improves photocatalytic activity.

Using the low-cost hydrothermal method that quickly forms nanoparticles with titanium dioxide and stannic oxide at 1 : 1, 5 : 1, 10 : 1, 20 : 1 and 30 : 1 molar ratios. They used a similar method to make pure titanium dioxide without adding a stannic oxide precursor solution, as control.

Photocatalytic activity is usually correlated with the active surface area available for adsorbing and desorbing organic pollutants. Using X-ray diffraction spectroscopy and transmission electron microscopy, the team examined the particle size and surface area of the nanoparticles and noted that the mixed oxide catalyst had larger surface area.

They used dynamic light scattering to analyse the particle-size distribution of the titanium dioxide-stannic oxide catalysts prepared at different molar ratios. The scientists found that particle size increased with stannic oxide concentration.

The team conducted experiments at various initial pH values ranging from 3 to 9, with a diclofenac concentration of 20 milligrams per litre and catalyst loading of 0.8 gram per litre. They found that the titanium dioxide-stannic oxide mixed oxide catalyst showed higher degradation efficiency than did pure titanium dioxide.

The researchers found that the photocatalytic degradation of diclofenac was 90% effective when titanium dioxide and stannic oxide were in the ratio 20 : 1 at pH 5.

Scientists recommend these nanoparticles to purify aquatic environments without using electrical or chemical inputs.

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### Sustainable Development *Higher education institutions*

In the international arena, the notion of sustainable development has gone through an evolution over decades. But in the popular mind, it is only an extension of environmental awareness. In the last decade, realising that education is a necessary component in realising the objective of sustainable development, UNESCO spearheaded Education for Sustainable Development. But how do higher education institutions in India fare?

Avlokita Agrawal at IIT Roorkee and her PhD scholar Nikhat Parvez set out to find out. They considered nine higher education institutions in north India. And applied two rating systems: the UI GreenMetric WUR that has a comprehensive list of indicators and the Sustainability Tracking, Assessment and Rating System or STARS.

The researchers found that even premier higher education institutions in India have a narrow vision of the notion of sustainable development, focus primarily on environmental issues and do not consider the economic and social dimensions of sustainable development. Thus, only fifty percent of the parameters are taken into account for implementing sustainability in campuses.

Higher education institutions need to align their policies and strategies to meet the standards set by the Sustainable Development Goals. UI GreenMetric WUR is developed in Asia and is most suited for countries like India, say the researchers.

A common sustainable development framework for campuses today will lead to a citizenry that helps India meet the Sustainable Development Goals tomorrow.

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