# Science Last Fortnight

### Acid Test for Treatment

*Emperor of Maladies*

Cancer is one among the top ten causes of morbidity and mortality in the world. Conventional chemotherapy for cancer has adverse side effects. Scientists have been evaluating natural compounds for drugs which effectively control cancer without any side effects. One such compound is boswellic acid, obtained from the Indian olibanum tree, *Boswellia serrata*.

Boswellia has been used in traditional medicine for various ailments. The gum resin of this plant (Shallaki) contains boswellic acid. Boswellic acid is known for its anti-inflammatory action and has been used in arthritis.

Nand Kishore Roy and his research team from the IIT Guwahati, in collaboration with the Cancer Research Institute of Singapore, did clinical trials on boswellic acid to screen for its effect on symptoms developed due to cancer therapy. They administered boswellic acid to young people diagnosed with intracranial tumour. There was no side effect during the 9 month period of treatment. Five children showed improvement in their general health status. They found that the treatment is useful in reducing the oedema associated with brain tumours.

They report that a cream containing boswellic acid is useful to reduce the radiation induced adverse effect on skin in breast cancer patients. Boswellic acid application significantly reduced the oedema in the skin caused by radiation.

The main constraint in using boswellic acid for treatment is its poor bioavailability: it gets degraded very quickly. They suggest two alternative approaches to solve the problem: (1) delivering the drug through nanoparticles, adjuvants or liposomes and (2) developing structural analogues of boswellic acid to enhance bioavailability.

*Cancer Letters*, **377**(1), 74–86

### Abrus – A Hope for Breast Cancer

With changing lifestyles, women are becoming increasingly vulnerable to breast cancer. It is the most diagnosed malignancy in India. It is also the cause of the largest estimated cancer deaths worldwide. Scientists are now investigating biological molecules to change the cell processes that cause malignancy.

Now, a team of scientists from NIT, Rourkela and IIT, Kharagpur, India, in collaboration with the Virginia Commonwealth University, have demonstrated that agglutinins – proteins that bind to carbohydrates – from the seeds of *rati*, *Abrus precatorius*, a medicinal plant, is efficient against breast cancer.

The scientists found that it inhibits cancer cell multiplication by generating cell death proteins. It simultaneously triggers the generation of reactive oxygen species. The protein, thus, destroys the cancer cells through a two-pronged approach.

The lectin also inhibits the formation of blood capillaries. This stops the cancer cells from proliferating into tumorous growth. This, in turn, further inhibits the ability of the cells to generate new capillary blood vessels.

Scientists say that abrus agglutinins can selectively target human breast cancer cells. These results would enable scientists to adopt a multidimensional approach for battling breast cancer.

*Int. J. Cancer*, **139**(2), 457–466

### Dengue Virus microRNAs

*New therapeutic arsenal*

The dengue virus causes widespread haemorrhagic fever, morbidity and mortality globally. As many as 400 million people are infected yearly. But there is no specific treatment for dengue. The virus has a compact genome and this poses a challenge to the scientific community in trying to find ways to control the disease.

Kakumani and his team from New Delhi and Faridabad started exploring the role of host miRNAs in dengue replication and pathogenesis. The researchers succeeded in identifying a factor, Glucose Regulated Protein, which is involved in the processing of the small RNAs. Silencing of this protein in human cell lines results in accumulation of dengue viral RNA. Thus the protein restricts dengue replication in human cell lines. The results also reveal that there is a small RNA, called Hsa-mir-126-5p, which directs dengue replication in human cell lines. This discovery suggests that microRNAs might be a potential target against dengue viruses.

This research is evidence enough to support the idea that the RNA interference machinery of the host acts as an antiviral defence mechanism in human cell lines. Since host-derived miRNAs have antiviral activity against many viral infections, miRNA-based therapies may soon be a part of the treatment for a variety of diseases.

*Gene*, **586**(1), 7–11

### Dermal Drug Delivery

*Deep rooted solution*

Popping pills is a common way to consume medicines. The ingested drug is absorbed into the bloodstream which transports it to the site of infection. But this strategy is ineffective for deep rooted skin infections. Due to low penetrability, it is extremely difficult to deliver drugs to a site within the skin. Scientists are now trying to solve this problem using nanoparticles that can seep into the skin. In the last fortnight, Prasad, from the University of Delhi, in collaboration with researchers in the University of Berlin, reported creation of one such drug delivery model.

Prasad and his team made use of amphiphilic branched shells: spherical nanoparticle shells having both hydrophobic and hydrophilic chains. Such shells have been coupled with a branched polyglycerol core in the past to solubilize water insoluble drugs. Branching serves to trap greater amount of drug.

The researchers synthesized two extensively branched polymer cores by linking polyglycerol with different organic acids. They created three such drug delivery systems which were tested for drug entrapment, skin penetration and toxicity.

The core multi-shell systems are 11 times more efficient in penetrating skin compared to a base cream formulation and exhibit negligible toxicity at a low concentration. Scientists are confident

that efficient drug entrapment and minimal toxicity will make their model commercially viable.

doi: 10.1016/j.polymer.2016.04.074

### Ion Passage Restricted

*pH gating of toxic pores*

Bacteria have an assortment of tricks for attacking the human body. One particularly interesting strategy is the release of toxins that self-assemble to form pores. These integrate with the plasma membrane of the target cell and disturb the osmotic balance leading to cell death. A group of scientists from the Indian Institute of Science, Bengaluru, headed by Maiti, has devised a strategy to block these pores by introducing protonated gates.

Maiti's team tested dendrimers a class of hyperbranched polymers, as pore blockers. They used molecular dynamic simulations to study the efficiency of polyamido-amine dendrimers as pore blockers for Cytolysin A – a toxin released by *E. coli*.

Scientists observe that protonation could cause extensive branching between the dendrimer and the negatively charged pore walls which retard its approach into the pore lumen. The positively charged protonated dendrimers also disturb the potassium ion gradient. While both non-protonated and protonated dendrimers can block the passage of water to a similar extent, protonated dendrimers are 3 times more effective than non-protonated dendrimers in blocking ion transport and can inhibit more than 90% of ions from being transported through the pore. This strategy can be used to devise new therapeutics for bacterial infections.

*Nanoscale*, **8**, 13045–13058

### Shrimp Skeleton to Treat Wounds!

Most wound dressings are designed to hasten the process of healing. But cosmetic requirements demand scar-free healing. Thus, an ideal wound dressing should be antibacterial, skin friendly, capable of absorbing moisture and exudates. And it should be easily removable without reopening the wound.

Bhuvanesh Gupta and his team, from IIT Delhi and Jamia Hamdard, have synthesized a 'wound dresser', a combination of chitosan, polyethylene glycol and polyvinyl pyrrolidone gel, smeared on cotton fabric. There is enough evidence in the literature about the use of chitosan in treating inflammation and obesity. Polyethylene glycol, a water soluble polymer, has good absorption properties and polyvinyl pyrrolidone is a major component of butadiene. The composite has a porous structure enabling easy air passage and could absorb water.

The 'wound dresser' was tested for drug release potential. The drug, tetracycline, was released within 48 hours and maintained an antibacterial action over an extended period. It was effective against *Staphylococcus aureus*, an infectious bacteria. Wound healing properties were effective for 21 days with minimal scarring. Thus, the discovery may enable effective scar free wound healing and aid cosmetic surgeries.

*Int. J. Pharmaceutics*, **508**(1–2), 92–101

### Waste Cooking Oil as Biodiesel!

Scientists from the Indian Institute of Technology, Kanpur and the Korea Advanced Institute of Science and Technology, are now suggesting use of waste cooking oil as a fuel. They conducted experiments for a comprehensive investigation of the spray and combustion characteristics of waste oil.

Technically, waste oil exhibits a larger injection delay and higher injection rate peak than diesel, possibly because of its higher fuel viscosity and density. A decrease in flame intensity and visible flame was observed.

Reduction in harmful exhaust emission is evident for waste oil. Carbon monoxide, hydrocarbon and smoke emissions declined. However, nitrous oxide emission was higher, compared to diesel. So, perhaps in the near future, we may start using leftover of kitchen oil for driving our car.

*Fuel*, **176**, 20–31

### Pollution-free Leather Industries

*Next generation greener dyes*

Leather industries discharge effluents containing large amounts of synthetic dyes. In recent years, 30% of the leather industries were closed due to charges of environmental pollution.

To become more sustainable, textile industries started using plant and microbial based eco-friendly dyes to reduce pollution. Microbial based dyes are easy to handle, more easily biodegradable. They are also more efficient and inexpensive. Moreover, large-scale production of these dyes is not difficult.

In the last fortnight, Priya and her team from the Central Leather Research Institute, Chennai, reported developing an eco-friendly protein dye using recombinant technology. The team cloned the genes responsible for the green fluorescent protein from a jellyfish.

The protein-based fluorescent pigment of the jellyfish has biochemical characters similar to microbial dye. Three adjacent amino acids are responsible for the green fluorescent colour. It is also possible to alter the colour by mutation. The fluorescent protein is very stable to heat, extreme pH and chemical denaturants.

Two variants of the green fluorescent protein obtained from the recombinant technology showed more than 85% dyeing efficiency. Optimum level of dyeing is observed in 4 hours with 5 μM protein concentration. The intensity of dyeing, colour difference values and characteristics of leather coated with the fluorescent proteins show that they can be used as an environment-friendly dye.

Green fluorescent proteins will go a long way in making future leather industries cleaner and greener!

*J. Cleaner Production*, **126**, 698–706

### Corrigendum

In the last issue, we had reported in this column, about the possibility that PPRV, a virus that infects small ruminants may be extending its host range to dogs. A regrettable error was made in calling the disease rinderpest. Rinderpest, a disease that infected cattle has been eliminated from the world. PPRV is a distant relative, but they are not the same.

*Reports by* **Sarah Iqbal, Mary Teresa Miranda, Ratna Prabha, Rekha R. Warrier, Manali Datta, Mona Kejariwal, R. Ramasubramanian, P. Thiruchenthil Nathan, Saravanan Parameswaran** and **H. M. Mahadevaswamy**.

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# Science Last Fortnight

## Crops of the Future

Sea rise, one of the consequences of climate change, threatens farmers across the coastal lines. There is an agricultural crisis due to frequent flooding, drought, soils degraded by agrochemical overuse aggravated by the rising sea engulfing coastal farmlands. But there are some plants that can tolerate higher salt concentrations: halophytes.

Aditya Rathore and team from the Central Salt and Marine Chemicals Research Institute, Bhavnagar, Gujarat, have also proposed that halophytes act as an excellent sink of atmospheric carbon dioxide. According to them, abiotic and biotic variables work in combination, interacting in complex ways to modulate this effect. The understanding of the soil nutrient–halophyte relationship and biotic and abiotic stresses can open new avenues in exploiting the carbon fixation potential of halophytes.

Intertidal sea shores have plenty of mud-flats and salt marshes due to tidal oscillations. This supports the growth of *Salicornia brachiata*, a halophyte. Their ion physiological features allow them to cope with the saline substrates. They adapt to different physicochemical environments and show high productivity in the salty ecosystem. They accumulate salt in their succulent structure to adjust the low osmotic water potential of the soil. Thus, it becomes a source of high value vegetable salt.

*Salicornia brachiata* is considered a potential alternative crop of seawater agriculture, due to its economic potential: its seeds yield special quality oil, a highly polyunsaturated compound rich in linoleic acid, similar to safflower oil. It is also a source of high value vegetable salt. Moreover, the *Salicornia* species, which can tolerate nearly twice the salinity of seawater, is seen to have enormous potential as a biofuel crop.

Despite these potential benefits, saltwater agriculture is still not exploited. For farmers, saltwater still spells crop failure. Sea level rise due to climate warming and increased soil salinity due to irrigation, will require new crops to be introduced to farming communities.

*International Journal of Phytoremediation*, 2016, **18**(8), 801–811

**Manish Kumar Tekam**

## Traffic Accidents!

*Pedestrian risk perception*

Pedestrian–vehicle crash is on the rise across the world. National Crime Records Bureau statistics state that India witnessed a death toll of around 1.41 lakhs persons whereas persons who suffered injury in traffic crashes were around 4.77 lakhs in 2014. Pedestrians have a sizable share of 51% among the 58% fatal accident under the non-motorized category. Experts point out that actual figures would be higher, as most cases are not reported.

Shalini Rankavat and Geetam Tiwari, from IIT Delhi, examined the pedestrian perception of risk. Based on data from 2006 to 2009, Delhi, they analysed the degree of fatal crashes, locations and built environment. And they administered a questionnaire to understand the relationship between these factors and the perception of risk.

When they analysed the data on risk perceptions based on age, gender and demographic characteristics, they found higher risk perception in males than in females, indicating that males are more cautious in high risk areas than their counterparts.

The researchers used the logit model of risk perception to highlight road features, traffic characteristics and overall built environment as major factors in pedestrian–vehicle crash. Built environment also modifies pedestrian risk perception. Detailed approaches of this kind would help prioritize pedestrian safety and provide clues for the modification of cities to reduce traffic problems.

*Safety Science*, 2016, **87**, 1–7

**Bobby P. Mathew**

## Salt-Tolerant Peanuts

Peanut is a marginal and low-resource demanding crop. This leguminous species is found to be moderately salt sensitive. Developing salinity tolerant genotypes would help expand the area of cultivation in non-traditional, saline soils also.

Plants are sensitive to salinity. It limits growth and crop productivity. Since plants cannot move to escape stresses, they have evolved strategies to cope. They have acquired several mechanisms to acclimatize to salinity, the most common abiotic stress. Plants first 'sense' environmental cues, before responding. It is now established that different plant species respond differentially by modulating their antioxidative machinery.

Salinity stress generates Reactive Oxygen Species, otherwise called free radicals. These are harmful by-products of cellular metabolism. They are also considered to be signalling molecules regulating stress tolerance.

A team from the Directorate of Groundnut Research, Junagadh, investigated the responses of different genotypes of peanuts to varying salt stresses. There were changes in enzyme activity detected at both the RNA and protein levels, and non-enzymatic antioxidant activity at the protein levels. They confirmed the presence of free radicals using spectrometry and *in situ* histochemical staining methods. Sensitive genotypes of peanut succumbed to salt stress due to a reduction in membrane stability.

Results revealed that the induction of all the antioxidant enzymes does not occur simultaneously. Instead, salt stress induces one or other components selectively. The process of detoxification occurs in phases, with specific enzymes acting in each phase.

The co-ordinated mechanism of detoxification of free radicals in peanuts has been unraveled in this study. The first line of action is superoxide dismutase. The free radicals generated by its activity are broken down by peroxidase, ascorbate peroxidase and catalase. Peroxidase and ascorbate peroxidase are active at low concentrations of free radicals while catalase is more constitutive in nature.

Specific components of the plant defence system thus play crucial roles. This varies from crop to crop. So, it is important to identify crop-specific components underlying salt tolerance. The study of salt tolerance in peanuts may, however, help in creating a general theory of salt tolerance in other crops.

*Environmental and Experimental Botany*, 2016, **128**, 79–90

**Rekha Warrier**

### Transcription Factors in Diseases

*More than DNA binding*

Transcription factors are proteins that regulate gene expression in living cells. By binding to DNA, they initiate the decoding of genes into proteins. Angshuman Bagchi, from the University of Kalyani, looked for the roles of transcription factors from pathogenic organisms in virulence and disease.

Transcription factors are classified into families based on their DNA binding region or domain. Anshuman analysed the variations in the amino acid sequences of domains within each family of transcription factors. He predicted new domains based on the structural differences in transcription factors.

As expected, new domains were found in transcription factors from 13 pathogens. These domains may be involved in several processes ranging from platelet aggregation, assembly of tails and replication of viruses, and prevention of the growth of beneficial bacteria in humans. These domains may also be involved in hampering the immune system and DNA replication in humans.

Finally, Angshuman Bagchi assigned new functions to the transcription factors. Notably, transcription factors from *Mycobacterium leprae* and *M. tuberculosis* have a pollen allergen domain. This domain might help increase the virulence of the pathogen through carbohydrate binding. Similarly, a transcription factor from *Pseudomonas aeruginosa* might play a role in infecting individuals with Werner syndrome.

These findings may help identifying new therapeutic strategies.

*Gene*, **586**(2), 274–280

**Saravanan Parameswaran**

### Black Panacea for Jaundice!

Black seed oil was first found in Tutankhamun's tomb, in an Egyptian pyramid. Prophet Mohammed is reported to have said: 'Black cumin cures every disease but death itself'. *Nigella sativa*, known as 'Kala jeera', is a significant constituent in Ayurveda and Siddha. These seeds contain more than one hundred chemical constituents and vitamins. Now, a study conducted by Younis and her associates from the Aligarh Muslim University and the Qassim University, indicates that the thymoquinone present in the seed may aid in treating jaundice.

Jaundice is manifested by the characteristic buildup of bilirubin, a toxic digested product of hemoglobin. Spectroscopic measurements in the range of 350–550 nm indicate that thymoquinone binds to bilirubin. Bilirubin is optically inactive. However, when bound to thymoquinone it becomes optically active. Fluorescent studies confirm the interaction between these molecules.

Free bilirubin has a tendency to bind red blood cells and thus becomes toxic. Comparative binding studies show that thymoquinone inhibits the binding of bilirubin with RBCs. Thymoquinone stops cell lysis even when the bilirubin concentration is as high as 100 mM.

Scientists also experimented with CYP, a chemical that induces cell lysis. As all other drugs, CYP is also cleared through the liver. It can lead to severe inflammation and hemorrhage. The study indicated thymoquinone treatment reduced the symptoms. A dosage of 10 mg/kg prevented the formation of free radicals in the liver, thus reducing toxicity. A fat based formulation of thymoquinone was more effective because it is fat soluble and this aids absorption.

Thus, the panacea from ancient Egypt was shown to be therapeutic against a dreaded ailment.

*Biochimie*, 2016, **127**, 205–213

**Manali Datta**

### Camphor in Cinnamon Leaves

*Native varieties show promise*

Cinnamon is popular in India – as a condiment and flavouring material. The genus, *Cinnamomum*, has many evergreen aromatic trees and shrubs. The aromatic oils are present in leaves and bark. Some species produce camphor also.

An endemic species, *Cinnamomum agasthyamalayanum*, was recently described from the southern Western Ghats in Kerala. The species has a strong camphor smell in its inner bark and leaves. A team from the SASTRA University, Thanjavur, studied camphor levels in two distinct populations of the species found in the Western Ghats. The essential oils were profiled using chromatography. And they compared camphor levels in the leaves of both populations with camphor levels in cultivated species. Camphor comprised more than 50% of the essential oil composition in the new species. So, the species has potential as a natural source of camphor!

Commercial natural camphor is usually found in the wood and roots. But in this species, the leaves have high camphor levels. This unique trait of the species will help avert the need for destructive harvest for the extraction of camphor and yet provide large enough quantities for market demand. The content can perhaps be improved further through breeding for commercial utilization.

*Industrial Crops and Products*, 2016, **86**, 259–261

**Rekha**

# Science Last Fortnight

### Impact of Aerosols

*It's big and getting bigger*

The climate models of the past disregarded a few important factors in their analysis. As we now know, human emissions of aerosols too, affect the climate on a global scale. The previous models took only greenhouse gases besides natural factors, such as solar activity and volcanic eruptions, into account. To draw a more accurate picture, Tiwari and his team at the Indian Institute of Meteorology, Pune, examined the influence of aerosols over the regional climate of the Brahmaputra Valley.

Aerosols are fine particles spread in the atmosphere, emitted as dust, soot and ashes. They scatter sunlight; reflect the energy back and thus induce a global cooling effect on the climate. While some may argue that it is a good effect, it turns out they also add up to the warming effect since they indirectly affect the clouds also. They modify the size of the cloud thereby reducing the reflectivity (albedo) which changes the Earth's energy budget.

To understand the impact of aerosols such as black carbon, Tiwari and his team looked at Guwahati. They measured the aerosol concentration and temperature of the city for a span of one year. And they found that there is a significant cooling due to these soot particles. They also point out that the concentration of black carbon and carbon monoxide varies from season to season due to the burning of fuel. Biomass burning increases it and rainfall clears the air.

So much for regional climate. However, more is at stake. The team points out that their study can also be linked with other major global climate drivers. Aerosols perturb the hydrological cycle significantly. Black carbon can potentially alter the Indian summer monsoon. It triggers a chain of responses over the regional climate. The absorption and reflection of solar radiation by the aerosols induce cooling of sea-surface temperatures over the Bay of Bengal, and the Arabian Sea because of the decreased solar radiation at the sea surface.

Aerosols bring changes in varied ways. They heat some places, cool others, altering precipitation patterns in unpredictable and sometimes dangerous ways. Developing nations in the tropics and Asia are the major source regions for black carbon aerosols. The governments are keen to have a check on the situation because they are deeply rooted in our global industrial infrastructure.

*Sci. Total Environ.*, **562**, 504–516

### Urban Pollution

*Threat of polychlorinated biphenyls*

Polychlorinated biphenyls – chlorinated hydrocarbons with two or more phenyl groups – are used in numerous industrial applications. They are quite stable and do not break down easily. Once they are released into the environment, they persist as pollutants in air, water and soil. And they slowly accumulate in the food chain. This has been a matter of environmental and health concern, especially in urban areas. Regions along the coast, particularly, the metropolitan cities, have higher atmospheric levels of these biphenyls.

A team comprising researchers from the SRM University, India, the Chinese Academy of Sciences, the Norwegian Institute for Air Research, the University of Oslo and the Lancaster University, UK, investigated the occurrence of biphenyls in surface soil and the diffusive exchange of these chemicals between air and soil. They quantified about thirty combinations of the biphenyls in surface soil in seven metropolitan cities of India, on a regional as well as local scale.

They find that polychlorinated biphenyls with high molecular weight are abundant in the urban cities. Soil seems to act as a sink for the heavier molecules. However, low molecular weight compounds get volatilized easily and act as a source of air pollution. These atmospheric phenyls eventually make their way into less polluted areas.

The Government of India plans to prohibit these compounds by 2025. However, the present findings call for innovative research on containing the levels of these biphenyls in urban environments on a more urgent basis.

*Sci. Total Environ.*, **562**, 928–934

### Recharging Groundwater

Exploitation of the groundwater resources increased in the late 20th century, bringing the attention of scientists to the need for recharging of groundwater in depleted aquifers. But implementation and the effects of the present mitigation efforts take time.

S. Roy and A. S. Sahu at the University of Kalyani, West Bengal, studied a small watershed, Kunur River Basin, to understand the potential for recharge, using a multi-disciplinary approach: identification and assessment of hydrogeological factors, their influence on controlling groundwater occurrence and movement. Geomorphology, basin morphometry, remote sensing studies along with geological, geophysical and field data were also used to understand the basin hydrogeological framework. Based on these data, they propose a model to derive the groundwater recharge potential index of the basin.

They attempted a sub-basin wise and a grid wise approach to explore the recharge potential of the Kunur River Basin and found that a grid wise approach is more suitable: the results are correlated with the land-use pattern.

This multidisciplinary approach will help demarcate prospective recharge areas in a basin. Similar studies on other watersheds would help to adopt faster recharge methods to replenish groundwater resources in India.

*Frontiers Earth Sci.*, **10**(2), 274–291

### Removing Nitrate

*Organic resin to purify water*

There has been an increase in the use of chemical fertilizers to ensure food

security. But this has led to a problem: nitrate pollution. Most fertilizers contain nitrates which are converted to nitrites within the body. These nitrites can oxidize the ferrous iron in haemoglobin to its ferric form which diminishes its oxygen binding capacity. The health hazards of nitrate consumption are so drastic that nitrate pollution of drinking water has been recognized as a global issue by the World Health Organization.

Prabhakar and his colleagues from the Department of Chemical Engineering, SRM University, Tamil Nadu took inspiration from the commercial polymeric ion exchange resins which contain quaternary ammonium chloride functional groups, to solve the problem. They have synthesized an organic anion exchange resin to remove nitrate ions from brackish water. For the resin, the team selected chitosan – a biodegradable biopolymer bearing a primary amine in its structure. They first cross linked chitosan with glutaraldehyde up to a certain limit and then ethylated all the free amines to produce *N,N,N*-triethyl ammonium functionalized chitosan beads. These were then evaluated for nitrate removal from brackish water.

They tried different concentrations of ethyl bromide for synthesizing quaternized chitosan beads. The use of 5% ethyl bromide yielded the most capable variant. These beads swell up in 90 minutes and could remove about 60% of nitrate in the first 15 minutes. The presence of chloride and sulphate ions reduced nitrate ion removal only marginally. The resin could be regenerated by treatment with dilute HCl without affecting its ion exchange capacity, for up to 10 cycles. Given the promising results and minimum costs involved, the scientists are now optimizing this technique for field applications.

*Carbohydrate Polymers*, **147**, 525–532

### Virus in Drinking Water

*Fluorescent film for testing*

Virus-contaminated drinking water is a major route for the transmission of epidemics. Nearly 25% of world population is exposed to sewage contaminated water and, thus, to water borne infections. Routine filtration and sterilization methods may not remove the viral load completely from water.

Krupadam and his team of researchers from NEERI, Nagpur, have now designed an artificial molecular recognition sensor for the detection of virus. The first of its kind, the viral biosensor is rapid and cost-effective.

The researchers coated a gold electrochemical electrode with polythiophene, a film which, when activated via imprinting, binds the tobacco necrosis virus. The binding of the virus to the film generates signals capable of being detected by a voltameter. They tested the specificity of the sensor using the Tobacco Mosaic Virus and the Tobacco Necrosis Virus. Specific affinity of the sensor for the necrosis virus was confirmed using kinetic studies.

When a virus binds to the film, it gives off a fluorescent emission. The lowest detection limit is about 2 ng $l^{-1}$ and the response time is about 12 seconds. Thus, the sensor has high sensitivity and stability in solutions.

The nanofilm fluorescence virus sensor may serve as an epic step towards translational research aiding in the prevention of epidemics.

*Biosensors Bioelectronic*, **82**, 20–25

### Makings of a Mosquito Model

*Aiding the fight against Aedes*

The *Aedes aegypt*i mosquito is the vector of the virus that causes dengue fever. The dissemination of *A. aegypti* is limited by spatial and climatic constraints. Mosquito survival is dependent on vegetation, human hosts, and breeding sites. These factors that allow for the breeding of *A. aegypti* are found to correlate with the outbreaks in Delhi. Overhead and ground level tanks, evaporation coolers and tires or pots have been reported as key containers harbouring Aedes. This allows for the description of the conducive environment for *A. aegypti*, using geographical information systems and remote sensing.

Somsakun Maneerat, New Delhi and Eric Daude from CNRS, France developed a predictive model for controlling dengue transmission, using GIS. They used this 'Model of Mosquito Aedes' or MOMA, to simulate the mosquito populations in Delhi. In the model, the mosquito 'agent' interacts with artificial environments representing different localities stored in a Geographical Information System. The model was verified by entomologists to check whether activity planning is in line with available knowledge. MOMA simulation shows that Aedes are sedentary. Maximum dispersal observed is 21.35 m in all scenarios studied. The mosquito 'agent' adapts its behaviours to its needs and to the availability of its targets. The mosquito's longevity obtained from the MOMA model provided a daily survival rate very close to the survival rate found in literature.

The geospatial constraints captured in the MOMA model represent the distribution of *A. aegypti* in Delhi. There is a significant correlation between urban topology, human densities, and adult mosquito flight. The model can thus be used as a decision support tool for local health providers in Delhi. The same technique can also be applied to other geographical locations.

*Ecol. Modeling*, **333**, 66–78

### Predicting Poverty

*Overcoming lack of dependable data*

The goal of eliminating poverty cannot be reached without dependable data on poverty. But in many cases – war torn countries, for example – such data is not easily available. So scientists found a way to get around the problem: measure wealth and consumption.

High resolution night time satellite data gives an indication of the use of electric lights. And day time data gives an indication of habitations. So it is not difficult to get an idea about the consumption of power, an indication of wealth. This data in conjunction with machine learning – training a convolutional neural network using the limited data available – can help in getting a fairly accurate measure of the level of poverty in countries where the data on poverty is either missing or unreliable, claim scientists. Based on these parameters, scientists have been able to predict poverty levels in five African countries.

Limited data can be overcome using machine learning techniques in other areas as well, where similar situations exist, say scientists.

*Science*, **353**(6301), 790–794

### Alleviating Alzheimer's

*Rational drug design*

Alzheimer's disease is a multifactorial neurodegenerative disorder, which usually develops in old age. The cause for Alzheimer's disease is still elusive. We know that the accumulation of amyloid plaques and neurofibrillary tangles in the brain leads to the death of neurons. Current therapy involves the inhibition of acetylcholinesterase, the enzyme that breaks down acetylcholine. This slows down the progression of memory loss and enhances cognition.

A team of researchers from three universities in Delhi have now synthesized new molecules to inhibit acetylcholinesterase, based on rational drug design approach. It is known that triazolopyrimidine interacts with the peripheral anionic site while quinoline interacts with the catalytic site of acetylcholinesterase. They connected triazolopyrimidine and quinoline with piperazine. Computational studies reveal that these molecules interact with acetylcholinesterase and have drug-like properties. The molecules selectively inhibit acetylcholinesterase over another similar enzyme, butyrylcholinesterase. Moreover, the molecule inhibits self-induced and acetylcholinesterase-induced amyloid aggregation. It provides a neuroprotective effect, relieves oxidative stress and disintegrates amyloid plaques. Thus, the molecule shows promise as a multi-functional acetylcholinesterase inhibitor for the treatment of Alzheimer's disease. Further testing and trials are, of course, needed before using the molecules in clinical practice.

*Eur. J. Med. Chem.*, **119**, 260–277

### Morphing Morphine Activity

*Discovery by docking studies*

Morphine, derived from opium has been used for pain relief for many decades now. But it has a severe limitation: it suppresses respiration and can even cause death in some cases. Aashish Manglik and others have come up with candidate molecules for effective analgesia without the concomitant side effects.

Scientists used computational docking studies to home in on the candidate molecules. The $\mu$-opioid receptor G-protein signalling is responsible for the analgesia caused by morphine whereas the $\beta$-arrestin pathway is possibly responsible for the fatal respiratory arrest. Scientists tried out about three million molecules to find molecules that can selectively cause only analgesia – a feat that would have been impossible if not for computational studies. The study has been published in last week's *Nature*.

DOI: 10.1038/nature19112

### Aging, Mutations and Cancer

*Correlations become stronger*

As we age, somatic mutations continue to accumulate. There is enough evidence now that shows that these mutations – especially in the mitochondria – and aging are correlated. The mutation load tends to double every 8 years or so.

The accumulation of mutations increases with the cell proliferation rates of tissues. Cells of some tissues are more prone to mutations than others. Thus, for example, the reproductive system tends to have more mutations.

Scientists examined the mutation accumulation in cancer and find that, though the age related increase in mutations leads to the development of cancer by about a decade, which implies that the precancerous stage may perhaps be detected earlier than previously thought.

Interestingly there is a close parallel between the development of cancer and aging. Males tend to accumulate mutations earlier than females. This is reflected in cancer development. Moreover, in both sexes, the mutations tend to taper off at late life, which again, is seen to be the case with cancer.

*Nature Commun.*, **7**, 12157

### Baby, It's Hot Outside

*Songbirds tell their eggs*

Just before going out into the cold outside, we may ask our children to put on a jacket. But that would be too much to ask of songbirds. But they too are concerned about the young ones. Happily, there are some developmental modifications that help the new hatchlings withstand the weather outside. And it appears that the Zebra finches acoustically signal high ambient temperature before the eggs hatch.

In a recent report in *Science*, scientists provide evidence to show that these cues alone can change the way the nestlings beg for food and thus impact their growth pattern.

*Science*, **353**(63010), 812–814

### New Source of Chitosan

*Muga silkworms are cost effective*

Muga silk is famous being a stain resistant and fast-coloured fabric. The silkmoth, *Antheraea assamensis*, is commonly found in Assam, India. In the process of sericulture, the cocoons are reeled off for silk thread and the dead pupae inside are treated as waste. A. K. Pal and his team from IIT, Guwahati, now suggest that dead Muga silkworms are a new source of raw material for the synthesis of chitosan. Chitosan is formed by direct deacetylation reaction in chitin, the exoskeleton of the pupae.

The scientists used various methods to calculate the degree of deacetylation for the formation of chitosan. They recommend proton nuclear magnetic resonance as the most reliable method while potentiometric titration is the easiest and most cost effective technique.

The chitosan, obtained through these methods, had high crystallinity index. Since chitosan has higher thermal stability, scientists prepared poly lactic acid-chitosan biocomposite films. This revealed that the composite has higher thermal stability.

The scientists could obtain about seven per cent chitosan from silkworms on dry weight basis. Thus, this waste material can be used for the extraction

of chitosan which has diverse applications in the field of pharmaceuticals, cosmetics and food. An important value addition to the silk industry in Assam.

*J. Appl. Polym. Sci*., **133**(31), 9–14

### Meat Meets Ultrasound

*Sound ways for juicier food*

Ultrasound treatment can change the colour, texture and even the gelation properties of chicken meat. Thus it has emerged as a novel approach to alter the biophysical properties of meat, which can find use in the food industry. Even though the macroscopic effects of low frequency ultrasonication have been explored on chicken meat, there seems to be a lacuna in our understanding of how ultrasonication affects the major myofibrillar proteins: actin and myosin.

Ahmad and his student from the Department of Zoology, Aligarh Muslim University, isolated and purified the actomyosin complex for chicken breasts and sonicated it at 20 kHz. When treated for 5 minutes, no discernible changes were detected in the protein structure. However, upon increasing the duration of treatment there was significant loss in the UV absorption spectra and alpha helical content of the protein.

Parallel changes were also expressed in the enzyme activity and chemical nature of the protein. ATPase activities that correspond to structural integrity were reduced and there was a concomitant increase in the amount of reactive sulfhydryls. When the scientists looked at actomyosin gels under an electron microscope, they found that the ultrasound treatment before gelation can improve the 3-dimensional network of these gels. This increases its water holding capacity.

The scientists are of the opinion that treatment may expose charged residues to the surface which, along with increased availability of sulfhydryl groups, may contribute to a more ordered arrangement. The scientists are confident that the insights gained from this study can be utilized for modifying the properties of muscle protein to improve the attributes of food products.

*Food Chem.*, **205**, 43–51

### Imaging Fluorescent Zinc

*Sensors for zinc detection*

Zinc is one of the most abundant micronutrients and is intricately involved in cellular functions. Therefore, it requires regular monitoring. However, zinc is spectroscopically silent. This has prompted several scientists to construct selective zinc sensors. Recently, Roy and his research team from the Jadavpur University, collaborated with researchers in Italy to develop one such turn on fluorescence sensor.

The scientists synthesized a small Schiff base molecule, through a condensation reaction between 4-(2-aminoethyl) morpholine and vanillin in methanol. They found that there is considerable difference in both the UV absorption spectra and fluorescence emission spectra of the Schiff base in the presence and absence of zinc.

The scientists tested the zinc selectivity of the compound in the presence of about 15 other commonly found metals like sodium, potassium, magnesium, copper, cadmium and nickel. They found that, although a few metals can quench the fluorescence emission intensity, zinc and cadmium give a characteristic green fluorescent colour when irradiated with UV light. This can be used as a distinguishing feature for zinc detection using the test Schiff base molecule.

Given its non-toxic nature and excellent results at physiological pH, the compound can be used for bio-imaging. Currently, scientists are further studying the molecule to understand how various functional groups can affect its spectral properties. It can then be employed for routine biological imaging.

*J. Mol. Struct.*, **1118**, 325–334

*Reports by* **Manish Kumar Tekam, Rekha Warrier, Bobby P. Mathew, P. Saravanan, Manali Datta, P. K. Udham, H. M. Mahadevaswamy, Mona Kejariwal** and **Sarah Iqbal**

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# Science Last Fortnight

### Surprise Blooms in the Southern Ocean

In the Indian Ocean sector of the Southern Ocean, there is an extensive submarine topographic high: the Kerguelen Plateau. It stands against a major ocean current, the Antarctic Circumpolar Current, which flows clockwise from west to east around Antarctica. The mightiest ocean current on Earth!

The presence of the plateau allows a mixing process developed through turbulence and eddies which can bring up iron-rich water from shallow Plateau to the sea surface, fertilizing the mixed layer. Once the mixed layer on the Plateau is fertilized, the waters flow eastward along with the Antarctic Circumpolar Current.

These physical processes create a zone of upwelling nutrients in the waters around the Kerguelen Plateau and its downstream sections. This leads to growth of phytoplanktons – microscopic plants in the ocean. These tiny plants which feed on organic micronutrients are at the base of a huge food chain in the oceanic ecosystem. The surge in phytoplankton population results in an abundance of oceanic food chains including fish, whales, seals, penguins, albatrosses and a wealth of other species of economic and ecological importance.

Observation of biophysical parameters by ocean cruises over vast areas of the southern ocean does not supply sufficient data to analyse this phenomenon adequately. However, the data from satellite remote sensing datasets are well suited to observe and quantify the seasonal areal extent of phytoplankton blooms in the Kerguelen Plateau ecosystem. Jena B from the National Centre for Antarctic and Ocean Research, Goa, therefore used the satellite datasets to analyse the phytoplankton blooms. Analysis of monthly oceanographic satellite data revealed that the Kerguelen Plateau blooms are pronounced only during the austral spring-summer period in a year: November to February.

Besides the economic and ecological aspects, phytoplanktons have global impact on climate. They absorb the $CO_2$ from the ocean surface and transmit it into the ocean ecosystem. The associated food chain may transport the $CO_2$ deeper into the ocean and directly affect the biogeochemical cycle of the region.

We now have the capability to look at the southern ocean, sitting far away in Goa. With the launching of more dedicated satellites to map ocean wealth, we hope to unravel more oceanic mysteries in the times to come.

*Frontiers of Ear. Sci.*, **10**(3), 479–486
*Geophys. Res. Lett.*, **29**(23), 49.1–49

### Drought can't stop us

*Nitrogen fixing species for drylands*

Drought affects plant growth and productivity. The critical stages affected are seed germination and seedling establishment. Inadequate soil moisture results in irregular seed germination. This leads to asynchrony in seedling emergence, resulting in poor yield. The effect is more pronounced in degraded lands. To restore vegetation, we need to know which species can tolerate harsh conditions.

Kiran Bargali and S. S. Bargali from Kumaun University, Nainital, looked into the drought-withstanding ability of fifteen leguminous species. They tested the germination capacity of the seeds in response to water deficit: up to moisture levels as low as –20 bars. Seed germination reduced with increasing water deficit. Some species were specific in moisture requirements, while a few others retained their germination capacity at higher gradients.

Moisture is a key factor controlling germination in field conditions. It is the initiator of germination. Seeds of leguminous plants have seed coats with low permeability to water. During favourable conditions, the seeds imbibe moisture and germinate.

These species are easier to establish in the field as they can tolerate prolonged dry spells in the field. They can be directly seeded on degraded sites with low moisture content. Their nitrogen-fixing ability would further hasten the recovery of degraded lands.

*Tropical Ecology*, **57**(3), 445–453

### Stomach and liver infections

*Helicobacter identification*

*Helicobacter* is causal agent in many human diseases. But it is quite difficult to identify different species of this genus using conventional approaches. Among this genus, *Helicobacter pylori* is the most common, responsible for about 50% of the infections by *Helicobacter*.

There are various approaches available for the initial diagnosis of *H. pylori* infection. Urease testing is most rapid and cost-effective. However, it has limitations. The same is true for other tests, misleading the detection of this pathogen.

A team of researchers from Delhi University analysed genes from 45 species of this genus. Their goal was to develop a systematic method for strain characterization with efficient accuracy. So they used different approaches, by using the internal features of 16S rRNA genes, phylogenetic tree construction, *in silico* restriction enzyme study, species-specific conserved motifs and assessment of genetic variability. They also employed another housekeeping gene hsp60 for result validation.

Phylogenetic analysis emerged as a strong tool for assessing the classification of *Helicobacter* despite a few limitations. Analysis showed significant heterogeneity among the species. 624 restriction enzymes were taken for *in silico* restriction enzyme study. 72 of these are specific to seven species. Later, they identified unique motifs for 6 clinically significant species. Thus they were able to characterize different species of *Helicobacter*, including *H. pylori.* The group also identified Hsp60 as an authenticate marker, a result corroborated by the analysis of 16S rRNA results.

This systematic approach can help us identify prevalent *Helicobacter* pathogens quickly. Translational research is needed to make this method clinically available.

*Indian J. Microbiol.*, **56**(3), 277–286

### *Escherichia coli* in milk

*LEDs throw light on decontamination*

Milk is a nutritious food for human beings, but it also serves as a good medium for the growth of microorganisms. The chance for contamination of milk is more during milking, handling and selling and leads to the spoilage of the product. Providing safe milk and milk products to quality conscious consumers is, therefore, a challenge for the dairy industry.

Thermal pasteurization has an adverse effect on taste, smell, etc. as well as on the nutritional value of milk. Repeated boiling leads to energy consumption. But avoiding it results in unsafe milk for consumers...

Among micro-organisms, *Escherichia coli* is found to be the most frequent in contaminated milk. This species is an indicator of fecal pollution due to insanitary conditions. It can cause several health problems such as bloody diarrhea, abdominal pain and fever. A. Srimagal, from NIT, Odisha, T. Ramesh from the School of Food and Agriculture, University of Maine, USA and J. K. Sahu from the Center for Rural Development and Technology, New Delhi, studied the effect of LEDs for inactivating *E. coli* in milk.

The scientists assessed the effect of blue LED light of 405 to 460 nm on the inactivation of *E. coli* ATCC25922 in a food matrix like milk. They found significant differences between the microbial inactivation at different wavelengths and temperatures. The best results are at 406 nm at 13.8°C for 38 min. Milk treated this way shows maximum degradation of microbes and doubled shelf life under refrigerated storage without affecting the innate qualities of milk.

As LEDs consume less energy and are highly durable, the LED treatments may be a better opportunity for the dairy industry to produce hygienic products without losing benefits within a minimum treatment time and expense. Perhaps one day such milk decontaminators may even be a common kitchen gadget.

*LWT-Food Sci. Technol.*, **71**, 378–385

### Herbicides in a fungal world

*Penoxsulam degrading fungi*

In addition to fertilizers and pesticides, agricultural practices heavily rely on the use of herbicides. Of late, it has been realised that certain herbicides can persist in soil for longer durations which can affect the growth of other plants and microbes. One such herbicide – Penoxsulam – has recently caught the attention of scientists. Penoxsulam is a post emergence sulphonamide registered for weed control in India. There is evidence that it is beginning to accumulate in the soil. To promote its biodegradation, Shondia from the Department of Chemistry, Directorate of Weed research, Jabalpur, decided to isolate fungi capable of degrading Penoxsulam.

To isolate Penoxsulam degrading fungi, Sondhia and her team collected soil from farmlands where Penoxsulam was in routine use. The isolated fungi were characterized on the basis of colony morphology and partial gene sequencing. two isolates *Aspergillus niger* and *Aspergillus flavus* were then probed further to understand the mechanism employed for Penoxsulam degradation. Soil samples incubated with Penoxsulam and fungi were withdrawn periodically and analysed through mass spectrometry to identify the herbicide degradation products. The study revealed that even though both the species employ a similar method for cleavage of the Sulfonamide bridge for herbicide degradation, *A. flavus* is more efficient compared to *A. niger*.

The insights from this study suggest that either *A. flavus* and *A. niger* or enriched mixed fungal consortium could be used to promote Penoxsulam degradation in soil. Since fungi accounts for 75% of microbial biomass, researchers are confident that this would be a new low cost method to control herbicide contamination and soil detoxification.

*Applied Soil Ecology*, **105**, 196–206

### Shape Matters

*Structure–function of BPA analogues*

Bisphenol A (BPA) is the first chemically synthesized variant of estrogen lacking a classical steroid nucleus. Due to availability of more potent variants of the hormone, BPA, instead of being commercialized as a hormone, was channeled into the making of plastics.

This resulted in a massive exposure of humans to BPA which led to its accumulation in the body. Due to its structural similarity to estrogen, BPA acts as an endocrine disruptor. Its trademark benzene rings and hydroxyl group backbone can sit well within the pocket of certain membrane and nuclear receptors thereby affecting metabolism and hormone function. Studies show that exposure to even minute quantities of BPA has adverse affects on human health because it mimics the function of the hormone which is required only in nano quantities.

Following multiple studies that outline the hazardous effects of BPA accumulation on human health, the chemical has been replaced by its structural analogues. Masood Ahmad from the Aligarh Muslim University, and his student recently reviewed available literature on BPA and its analogues to assess the cost–benefit ratio.

All the BPA analogues also contain the same benzene-hydroxyl backbone and are found to possess endocrine disrupting potential. Some of them can stay in the body for longer durations and can also act as carcinogen.

BPA analogues find use as epoxy resins that line most food cans and are also a component of plastics used to make baby bottles which is a cause for concern. The authors thus conclude that the use of BPA analogues needs to be put under scientific scrutiny. 'Instead of introducing new endocrine disruptors into the environment we need to find safer alternatives' says the lead author of the paper.

*Chemosphere*, **158**, 131–142

Reports by **G. Manoj Praveen, Ratna Prabha, Rekha R. Warrier, P. Vijisha** and **Sarah Iqbal**

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# Science Last Fortnight

### Viral Outbreak

*Haematopoietic necrosis in goldfish*

The introduction of alien fishes into local aquatic systems as part of aquaculture trade and ornamental fish culture has often alarmed scientists, indicating the threat posed by exotic species to native fishes. Many scientific studies have been done on the impact of exotic ornamental species on native aqua diversity. Along with the domination of exotic species in local water bodies, experts are also concerned over the possibility of parasites and pathogens getting introduced into the native environment. But, no studies have reported any parasitic outbreak or the presence of any pathogens in Indian water bodies.

For the first time, in India, P. K. Sahoo and a group of experts, report on a recent viral disease outbreak in freshwater aquaculture, in Serampore, West Bengal. The virus, called goldfish haematopoietic necrosis herpes virus (cyprinid herpes virus-2), was detected in association with multidrug resistant *Aeromonas hydrophila* infection in goldfish, *Carassius auratus*.

The virus causes destruction of cells of blood forming organs (haematopoietic necrosis) in goldfish and it is diagnosed by large scale haemorrhages on the body, fins and gills, lepidorthosis, necrosed gills, protruded anus and shrunken eyes. White nodular necrotic foci in spleen and kidneys were also noticed along with necrosis and fusion of gill lamellae.

Transmission electron microscopy revealed the presence of mature virus particles. And it was confirmed using polymerase chain reaction.

Scientists isolated a bacterium from the internal organs of the affected fish which they found to be *Aeromonas hydrophila*. According to the scientists, this could be a secondary infection. The primary etiological agent responsible for this outbreak is cyprinid herpes virus-2 itself.

Experimental infection trials failed to reproduce the disease in co-cultured rohu and koi carp. Since it is the first virus outbreak report in Indian waters, the study bears further investigation, they added. It is better to take precautions rather than be sorry later.

*Acta Tropica*, **161**, 8–17

### Methane from Landfills

*Tapping trash*

India's cities are rapidly growing in population. Per capita income is increasing, as is per capita consumption of resources, which in turn, leads to generation of waste. We are often greeted by the sight of scattered open dumps in cities. Most municipalities take these to landfills, the dump yards for solid waste. In the landfill, organic waste is anaerobically decomposed. The microbes consume the organic matter and produce methane, a gas that has significant global warming impact, second only to carbon dioxide.

Last fortnight, a team of researchers, headed by Sunil Kumar, from the National Environmental Engineering Research Institute, Nagpur developed a model framework to measure methane emissions. The team monitored emissions at Shillong, Kolkata and Jaipur. They utilized LandGEM, a commonly used model for projecting methane emission. They modified the model for Indian climatic conditions and formulated correction factors. They report that the methane concentration shows a correlation with the temperature fluctuations.

When methane emissions rise, the concentration of the pollutant ozone, in the troposphere, also rises. It is well known that methane does not yield its secrets easily. Its residence time in the atmosphere is short. Thus, a reduction of methane will be an effective solution in reducing its impact. Waste minimization and recycling are the way to go.

Waste management must translate into resource management. Trapping the methane from landfills for energy needs is the next step. We need to develop robust systems to do this. With these new insights, we can explore alternative approaches to dealing with waste.

*Bioresource Technology*, **216**, 981–987

### One Good Fuel Supports Another

*Pongamia and Calophyllum biodiesel*

Alternative sources of fuel have always attracted researchers. Biodiesel, one such alternative, has caught the eye of many. This has the potential to replace fossil fuels. But high viscosity and density impedes its use as sole fuel. However, in combination with fossil fuels, its efficiency improves.

Combustion, gaseous emissions and oxidation stability are important factors contributing to the efficiency of biodiesel. These depend on the properties of the fuel and, subsequently, engine performance.

Ramalingam and team from Tamil Nadu tested the efficiency of calophyllum biodiesel using plant extracts as additive and emission suppressants. They tested a 20% blend of calophyllum biodiesel on a Kirloskar SV1 four-stroke engine. Varying concentrations of ethanol extracts of pongamia were used as fuel additive. Addition of leaf extract increased the oxidation stability of the biodiesel.

The scientists assessed the performance, combustion and emission characteristics of the blends. CO and hydrocarbon emission of the blends was lower than that of pure diesel. Smoke emission reduced with increase in additive in the fuel.

Smoke emission increases with increase in load on the engine. The highest reduction in smoke was at 80% load. The presence of 15% leaf extract additive reduced the $NO_x$ emission by about 20%.

Currently, synthetic fuel is added to blend biodiesel for use in diesel engines. The team's efforts to explore the possibility of using plant-based antioxidants are a welcome move, as these increase the stability of biodiesel and reduce $NO_x$ emissions. One more step towards an eco-friendly future...

*Fuel*, **180**, 263–269

### Eco-friendly Concrete

*Using waste ferrochrome ash*

Demand for concrete is increasing in India. Concrete is a composite material

composed of coarse to fine aggregates joined together by a cementing material. Lime powder was used as a cementing material in many historical monuments. Now-a-days, ordinary portland cement is widely used in general concrete construction. Limestone and clay are the major raw materials in producing portland cement.

In the recent years, industrial wastes and by-products such as fly ash and ground granulated slag are used as a supplementary cementitious material in making concrete. This reduces the use of portland cement and is also an effective way to make use of the industrial waste.

Researchers from the KIIT and the VSS University of Technology in Odisha are now suggesting the use of ferrochrome ash as a supplementary cementitious material for concrete. Ferrochrome ash is a dust generated as a waste material from the gas cleaning plant of ferro alloy industries. The researchers experimented with a nominal mix proportion of 1 part portland cement, 2 parts of fine aggregates and 4 parts of coarse aggregates, with a water to cementitious materials ratio of 0.45. Cement part was substituted with ferrochrome ash ranging from 0% to 40% and 7% lime, partially replacing the portland cement up to 47%. They also checked the mechanical properties and durability of cement mixtures with varying proportion of ferrochrome ash for periods ranging from one month to three months.

The mechanical properties and durability of the samples improved with increasing ferrochrome ash compared to control concrete sample. Microscopic examination of concrete samples further substantiated these findings.

The researchers also tested the effect of possible groundwater pollution on these mixtures since the ash materials were likely to contain large quantities of chromium and other toxic materials. Results show the contaminant levels are much lower than prescribed limit and will have no adverse impact on environment.

Thus concrete made with this mixture and lime can be a good alternative to reduce the dependence on portland cement while using up industrial waste.

*J. Cleaner Production V*, **131**, 237–246

## Going Zero Waste

*Recycling Sunflower By-products*

Sunflower is one of the most cultivated crops around the world. While sunflower seeds represent the fourth major source of vegetable oil in the world, the heads, stalks, and leaves remain unused. After harvesting the seeds, they are burnt, usually, under not well-controlled conditions. This produces atmospheric pollution. About 5 tonnes of dry matter waste residue is produced from every hectare of sunflower fields. Thus, the attention of the scientific community is now oriented to the revalorization of wastes after sunflower harvesting. A research team from the Mahatma Gandhi University, Kerala joined hands with scientists in Italy and Spain to propose that sunflower stalks could be an economical source for cellulosic materials.

Cellulose nanofibrils are extracted from sunflower waste by steam explosion. And cellulose nanocrystals are extracted by hydrolysis. The nanocrystals, 150–200 nm in length and 10 nm in diameter, could be extracted with a high yield of 21%. Chemical characterization revealed that cellulose nanocrystals had a cellulose II structure and nanofibrils were cellulose I.

Scientists made gluten nanocomposite films with the nanofibrils and crystals by solvent casting. Investigations highlighted that gluten based bionanocomposites showed a homogenous morphology. The different morphology and consequent dispersion of the cellulosic materials into the gluten matrix also affected the barrier properties of the composite.

The presence of carbon nanocrystals was more efficient in reducing the permeability to gases, due to their ability to increase the path of gas molecules. But the presence of some nanofibril agglomerates, as shown by optical microscopic images of Gluten-CNF based systems, negatively affected the barrier properties of these formulations, especially with oxygen.

The study proposes recycling sunflower waste since sunflower stalks exhibit encouraging potential as nanofillers for polymer matrices.

*Carbohydrate Polymers*, **149**, 357–368

## Ashes and Plastic

*New recipe for shaping plastics*

Plastics can be molded into any shape upon heating. To improve the efficiency of this process, fillers are frequently added to molten plastic which help shaping it. Scientists are now studying different additives for their shape changing ability. Among the available fillers, fly ash is an attractive option since it is inexpensive and readily available. But it requires surface treatment before incorporating in polypropylene. Besides, not much is known about polypropylene–fly ash composites.

Last fortnight, Mahanwar from the Institute of Chemical Technology, Mumbai, reported success in improving the properties of plastic using coconut treated fly ash.

Coconut water has been used to generate nanoparticles in the past. In their study scientists used it to reduce the size of the filler. Fly ash was soaked in coconut water for 24 hours before it was compounded with different quantities of polypropylene at high temperature. Both treated and untreated fly ash was used to form pellets which were characterized by spectrometry and X-ray diffraction to examine any structural changes.

The scientists then studied the melt properties of the pellets – the viscosity of samples was determined over a wide range of shear rates and angular frequencies. These were compared with polypropylene composites containing titanium nanoparticles.

Results reveal that coconut water treatment is able to generate fly ash particles of the order of 2 μM that could be easily dispensed in the polymer matrix. The coconut water treated variant demonstrated abrupt change in complex viscosities even as the untreated fly ash composite displayed gradual rise in viscosity.

The study suggests that surface treatment of fly ash promotes better coupling between the filler and the polymer which can effectively reduce the melt temperature. This would reduce costs involved in molding plastics and also make the process more efficient.

*J. Applied Polymer Sci.*, **133**(36), 43900

### In Search of Cysteine

Thiols are sulfhydryl-containing molecules which participate in several environmental and biological processes. Selective detection of thiols is vital in basic research and diagnosis of diseases. Cysteine, for example, is a thiol-containing amino acid. It takes part in essential metabolic pathways in biological systems and serves as a precursor for many biological molecules. Most importantly, it plays a special role in maintaining the structure and function of proteins. It is no wonder then that cysteine is associated with several cardiovascular diseases, neurological disorders and so on.

Abraham John along with Kirthika Rani from Gandhigram Rural Institute, Tamil Nadu synthesized a fluorescent probe for the selective and sensitive detection of cysteine over other biothiols. The probe is based on a pyrene molecule containing $\alpha,\beta$-unsaturated carbonyl moiety. The fluorescent probe exhibited optimal absorption at 374 nm and emission at 467 nm. Adding 2.5 nM of cysteine enhanced the emission intensity.

The fluorescent probe was able to detect cysteine in the presence of a 250,000-fold higher concentration of other common interferents. The minimal cysteine required for detection is 10 pM/L ($S/N = 3$) with response time less than 1 minute.

The study is carried out under physiological conditions for diagnostic applications. The probe detected cysteine in blood serum samples. Cell permeability and selectivity of the probe are confirmed in HeLa cells.

*Biosensors and Bioelectronics*, **83**, 237–242

### Designs for Phenolics Extraction

*Extraction of secondary metabolites*

Extraction, quantification and isolation of compounds of interest are major processes in pharmaceutical industries. Inefficient extractions lead to large quantities of waste. This issue demands attention in today's context, where raw material availability is often a limiting factor. Smarter resource management would enable efficient use of the available stock.

There are various factors that influence the extraction processes. The procedure of addressing one factor at a time, is time consuming. The interactions between the factors often go unnoticed.

Tarun Belwal and colleagues from G.B. Pant Institute of Himalayan Environment and Development tested designs to optimize the extraction of phenolics of *Berberis asiatica* fruits.

They adopted a design termed Response Surface Methodology to achieve optimization. This method uses different experimental parameters to maximize responses. It defines effects of independent variables, and also the interaction effects.

They selected varying temperature, time, solvent ratio, pH and solvent dilution as variables and analysed the concentrations of compounds under different conditions. The scientists then fitted the results into linear, quadratic and interaction models.

They find that the quadratic model fitted well for all the responses. Temperature, solvent ratio and solvent dilution affect the responses. The optimal conditions for obtaining high yield of phenolics are a solvent ratio of 1 : 50; pH 3.0; 80% methanol heated at 80°C for 30 minutes. The predicted values matched the experimental results!

This methodology thus has improved accuracy in predicting models and optimizing extraction conditions for phenolics. It adopts a strategy of simultaneous maximization of many parameters to minimize loss of material. An increase in yield during extraction is the goal for large-scale industrial applications. This could find use especially in Traditional Systems of Medicine which heavily rely on extraction of compounds from medicinal plants.

*J. Food Chem.*, **207**, 115–124

### Sensor for Pesticide Detection

*Antibodies for parathion*

Parathion – a commonly used insecticide – is toxic to humans. At high concentrations, it can meddle with the nervous system and cause headaches, nausea, muscle twitching and shortness of breath. Such instances are becoming more common due to its unregulated use and its tendency to persist in the environment. Most methods used for its detection are cumbersome and not suitable for field applications. Deep from Central Scientific Instruments Organisation, India partnered with the Hanyang University, Korea, to develop a cost efficient method for on-site detection of this insecticide.

Deep and his team made use of screen printed electrodes as starting material for their sensor. They coated the electrode with graphene sheets which were later functionalized with 2-amino benzyl amine to introduce free amine groups. These free amine chains were used to link the insecticide specific antibody to the sensor. The design is such that the fixed component of antibody is used for linking while the variable portion is free to interact with the insecticide.

After the electrode was thus modified, it was used to detect parathion in test samples over a wide concentration range. To check for interference from other biomolecules, the scientists spiked fruits and vegetables with parathion and used the sensor to detect its presence in their blended supernatants. All results were validated through gas chromatography to check the quantification efficiency.

The study shows that the sensor can detect extremely small quantities of parathion. It can also maintain specificity for the target even in the presence of other common insecticides. Since the sensor is cheap and easy to use it can serve as a vital tool for regulating the use of parathion in agriculture. Scientists are confident that a similar strategy could also be extended for the detection of other toxicants for field applications.

*Biosensors and Bioelectronics*, **83**, 339–346

### Recovering Gold from Electronics

Gold is an inert metal with high electrical conductivity which makes it an important component of electronic circuits. The large build-up of electronic wastes can, therefore, serve as a secondary source for this precious metal. However, methods for gold extraction are non-selective and can cause leaching of other metals. Even partial

separation of gold from the leachate requires cost intensive techniques. Recently Chhavi Aggarwal, a researcher from the Bhabha Atomic Research Centre, has devised a way to separate gold from this mixture by using ion exchange membranes.

The scientists used a method called Donan exchange which involves the use of salt for ionic separation. But instead of using commercially available ion exchange membranes, the researchers constructed pore-filled membranes to promote the transfer of target ions. For this, the researchers grafted monomers onto a micro-porous host membrane which was tested for selective transport of gold ions between two compartments – one housing ionic gold solution and the other containing sodium chloride. Once the experiment was set up, the scientists drew liquid from each compartment at regular intervals to quantify the amount of gold present in each chamber. The ion transport was studied both as a function of time and concentration across the membrane. To assess the efficiency of this method the researchers examined ion transport in the presence of copper and also by using actual metal solutions of electronic boards.

As much as 96% of the total gold ions present in the feed could be recovered through this method. Even though the initial concentration of gold does not influence the ion exchange, the process could be made more efficient by increasing the salt concentration up to 0.5 M.

The process was unhindered even in the presence of 500 fold copper, suggesting that the method is highly selective. This method can serve as a low cost technique for the recovery of gold from electronic wastes.

*J. Membrane Sci.*, **514**, 210–216

### Digital Technology

*Environmentally sustainable practices*

Environmental sustainability of industries has been in the limelight for sometime now. In the past few years, developments in the ICT sector have harmful effects on the environment. ICT industries are involved in environmental problems like natural resource depletion, greenhouse gas emissions and global warming. But are the people working in this sector aware of the issues?

A team of researchers led by Chugh from Central Queensland University, Australia studied the awareness level among Indian Information and Communication Technology professionals about environmentally sustainable practices and measures employed by their organizations. They administered a web-based questionnaire to elicit data on demographic information, environmental sustainability awareness, environmentally sustainable practices and any interruptions in sustainable ICT practices.

They find that respondents aged 35 or more are conscious about renewable energy and had a greater understanding about e-waste. They are more concerned about their liability towards environmental issues. Organizations with more than 1000 employees are more aware and acquainted with environmental sustainability practices rather than smaller ones. Female professionals possess more knowledge on issues like greenhouse gas emissions, renewable energy and e-waste.

Improving awareness about sustainable information and communication technology practices can assist organizations implement different policies. This will lead to an increase in efficient environmentally sustainable work environments.

*J. Cleaner Production*, **131**, 435–446

*Reports by:* **Rekha R. Warrier, Ratna Prabha, P. Saravanan, K. T. Mufeeda, Bobby P. Mathew, H. M. Mahadevaswamy, Manish Kumar Tekam** and **Sarah Iqbal**.

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# Science Last Fortnight

### Exploring Gold

*Prospecting using modelling*

The African continent is known for its mineral resources which constitute around 30% of the Earth's remaining mineral resources. The 21st century witnessed large scale exploration for these resources in this region. Some of the world's largest gold deposits are localized around the Birimian Supergroup of West Africa. However, exploration activities around the Kumsai Basin are limited: Lack of geological understanding of the area and late discovery of these deposits in the 1990s had deterred detailed exploration for gold in this area.

Recent exploration activities in this area have provided geological understanding and identification of prospective areas. And what is even more important, it has provided insights about the factors controlling gold mineralization. This, in turn, has helped develop a conceptual model for determining the prospectivity of gold resources.

A team led by researchers from IIT Bombay, in collaboration with an Australian research group, carried out a detailed study on the prospectivity of orogenic gold mineral systems in the Kumsai Basin. They developed a knowledge-driven model based on a Fuzzy Inference System to identify the process of mineralization. Fuzzy Inference System based models were generated by identifying the key components of the mineral systems and integrating these individual outputs to generate a continuous scale prospective map. This map reclassified high, moderate and low prospectivity areas.

The model was tested on known and unknown gold prospective areas to evaluate the capture efficiency of the model. The high and moderate prospectivity areas show strong spatial correlation with elongated features indicating a strong structural control on gold mineralization in the study area.

This knowledge-driven model reflects the main mineralized trend effectively. This demonstrates that reliable input data on processes and components leading to the mineral deposits can be used to predict the prospectivity of known deposits without considering the spatial distribution of known gold deposits.

*Ore Geology Reviews*, **78**, 692–711

### Plutonium Trapped

*Using the vetiver plant*

Radioactive isotopes vary in their half-lives. Some survive for mere seconds, while some others have half lives of hundreds or millions of years. Plutonium-239 is one such isotope having a half life of 24,100 years. It is a hazardous radionuclide having carcinogenic and toxic properties. It poses a serious environmental challenge and threat to biological systems.

Besides naturally occurring radioactive isotopes in the soil, air and water, nuclear weapon testing, discharge from nuclear installations, occasional nuclear accidents like Chernobyl and Fukushima, also add to the woes. Disposal of nuclear waste is a challenge even with given technologies.

Last fortnight, Shraddha Singh and others from the Bhabha Atomic Research Centre, Mumbai, reported a phytoremediation method for Pu-239 radionuclide using *Vetiveria zizanoides*, commonly known as the vetiver plant or *khus khus*. Vetiver is a subtropical grass having large biomass and a dense root system which makes it favourable for phytoremediation. According to them, this is the first demonstration of the uptake potential of vetiver plants for the remediation of Pu-239 in hydroponic and in various soil conditions.

In 2000, a group of American scientists demonstrated the ability of Indian mustard (*Brassica juncea*) and the sunflower plant (*Helianthus annuus*) to remove Pu-239 from hydroponic conditions. Another study in 2014 by Sunita Sharma and team recorded the remediation capacity of vetiver plants in radionuclides like Cs-137 and Sr-90 and heavy metals namely As, Cd, Cr, Cu, Hg, Ni, Pb, Se and Zn. But plutonium uptake by vetiver has not been recorded earlier.

Now Shraddha and team report that the uptake potential of the plant is higher in hydroponics (66.2% in 30 days), but limited in soil. Addition of chelating agents like citric acid and diethylene triamine pentaacetic Acid (DTPA) into the growing medium increases the uptake in soil too.

As a chelating agent, DTPA was found more effective than citric acid. The Pu-239 – chelating agent complex raised the translocation index by 8 times and 6 times in water and soil respectively.

The findings provide a remedial mechanism for a highly toxic contaminant found in our surroundings, with little cost, and high efficiency. Plants possess a natural ability to eliminate, detoxify or immobilize environmental contaminants by means of various biological processes. In addition, plants help improve soil quality and soil carbon sequestration. For cleaning a large stretch of contaminated area, it is a suitable method.

*Ecotoxicol. Environ. Safety*, **132**, 140–144

### Bowled by Nano-Gold

*Endotoxin detection*

Consumption of food contaminated with bacteria often leads to food poisoning. This is due to the presence of an endotoxin released by bacterial cells. A heightened reaction to endotoxins can lead to life threatening systemic septic shock in some cases.

There are, of course, methods for regular monitoring of food samples. However, most methods used for endotoxin detection are either expensive or lack precision. In the last fortnight, Mukherjee and his team from the Vellore Institute of Technology, Vellore, collaborated with the Indian Institute of Science, Bengaluru, to improvize an endotoxin detection method using gold nanoparticles.

Previously, antibodies and aptamers have been coupled with gold nanoparticles for the colorimetric detection of endotoxin. In this study, the scientists attached different sizes of gold nanoparticles with cetyltrimethylammonium

bromide (CTAB). The premise is simple: endotoxin contains a negatively charged region that will interact with positive charge supplied, in this case, by CTAB. Interaction between the moieties would increase the size of the nanoparticle sphere, often causing aggregation, leading to changes in its photometric properties.

To refine this approach, the researchers synthesized CTAB coupled gold nanoparticles of three different sizes: 15, 30 and 40 nm and tested them for endotoxin detection. The size of functionalized gold nanospheres increased, by almost 6 fold, in the presence of endotoxin. This altered the intrinsic fluorescence of the nanoparticles which could then be detected through fluorometry. Sensitivity of the detection was highest for nanoparticles of the order of 15 nm with lower limit of detection around 0.5 nM.

Fats and proteins interfere with the detection. The CTAB capped gold nanoparticles could assess the presence of endotoxin with great precision once these were removed. Researchers believe that given the ease of detection, CTAB capped gold nanoparticles can be employed for routine monitoring of endotoxin in the food industry.

*J. Luminescence*, **178**, 106–114

### Are these Grapes Safe?

*The picture tells it all...*

Grapes have been in existence for thousands of years. Referred to as the Fruit of the Gods, they are popular and cultivated both for the fruit and for making wine. The crop is highly susceptible to fungal attacks. Uncontrolled application of fungicides has resulted in the presence of pesticide residues. When grapes are consumed without pre-treatments, they become the fruits of the gods of death and disease.

Malay Kishore Dutta and team, distributed in institutions in the National Capital Region and Maharashtra, developed a simple method to identify pesticide contamination at field level. Imaging methods using different wavelet domains distinguish the treated and untreated lots. Images of the pesticide treated and untreated samples are converted to gray scale images. The region of interest is marked and differences in wavelet domains identified. The discriminatory wavelets identified are subjected to statistical features.

The Support Vector Machine classifier tool, distinguished untreated grapes and pesticide-treated grapes. The tool revealed that diagonal coefficients discriminated between samples. A lab analysis of the pesticide residues in the selected samples confirmed the results.

Image processing as a non-destructive analytical tool can go a long way in assessing food quality. It finds application in the food industry, especially perishable commodities, where regular checks are mandatory. The process is cost effective and efficient and can develop as a real time application.

*LWT-Food Science and Technology*, **72**, 368–376

### Holy Cow Provides Elixir

*Milk as chemotherapeutic!*

The goodness of milk has been elaborated in Indian scriptures, as a 'youth elixir'. Now, researchers have discovered a method of using cow milk along with a herbal drug which is capable of curing and curbing cancer.

A group of scientists from the D. Y. Patil University, N. S. N. Research Centre, and Walchand College of Arts and Science, Maharashtra, synthesized a therapeutic graphene quantum dot (GQD) using milk. A quantum dot is a tiny 2–4 nm sized semiconducting particle which is capable of emitting light.

The researchers pasteurized milk by heating it in a microwave oven and processed it for 5 hours to generate GQDs. Formation of GQDs was monitored by a fluorescent emission at 375 nm. GQDs were then loaded with berberine, an anticancer drug. To observe the size, shape and loading of the drug on GQDs various spectroscopic techniques were used.

Cancerous cells create an acidic environment due to a faster metabolic rate. The berberine-GQD complex releases the drug only in the vicinity of acidic cancerous cells. An acidic pH of 5.8 ensured the drug was released over a period of 72 hours. The scientists could monitor the localization of the drug in cells using fluorescence microscopy, highlighting the property of QD complex as 'nanoprobes'. High concentrations of nanoprobes were found to be biocompatible, compared to other currently available bioimaging molecules.

Ease of synthesis and the promising results given by GQDs generated from milk make it an attractive alternative as opposed to the toxic therapies currently available. Additionally, such an amalgamated approach as chemotherapeutic and bioimager opens up a new avenue for a chemistry based synthesis of cancer therapeutics.

*Material Science & Engineering C*, **16**(67), 467–477

### Eggshell Membrane Magic

*The benefits of eggshell membranes*

Eggs are a powerhouse of nutrients such as proteins, vitamins and minerals. On an average, a person consumes 150–200 eggs annually. That's over a trillion eggs worldwide! And the shells are usually thrown away.

Eggshell is an inexpensive, natural source of calcium. And the membrane attached to the shell is rich in fibrous proteins. Many of its components are known to offer benefits.

The membrane is used as a natural source of collagen, glucosamine, chondroitin and hyaluronic acid, a potential biomaterial for tissue engineering applications, particularly for connective tissue repair.

In the last fortnight, Mahesh Kumar Sah and Subha Narayan Rath, from IIT Hyderabad reviewed the role of eggshell membranes in tissue engineering and regenerative medicine. They spell out a wide variety of uses of the membrane.

The semi-permeable behaviour of membrane could be used for developing dialysis and filtration units. Soluble eggshell membrane protein can be cross-linked with another collagen to form new and improved fibres with higher stability and antibacterial properties. The approach could be utilized to fabricate novel biocompatible fibres that support osteo-regeneration, i.e. remodelling membrane after processing through soluble eggshell protein membrane. The affinity and utility of

membrane for Cu and Mg metal ions play a vital role in bone tissue engineering application and cancer therapy.

The processing of membrane/soluble eggshell protein into hydrogels/organogels and composites will make it useful in various tissue engineering and biomaterial applications. The hydro/organogel forms appear promising enough to open up the development of effective drug delivery for targeted therapy. The soluble eggshell protein, with further modification, could be utilized as bio-ink with promising regenerative impact.

Eggshell membrane is an easily available, biocompatible, contaminant free, eco-friendly material that can be used as such or after modification. Based on the composition, the soluble eggshell membrane, with ease of processing, may have a great potential in clinical practice. The problem that remains to be conquered, for industrial scale utilization of this massive and valuable resource, is collection of the shells that are thrown away.

*Material Science & Engineering C*, **67**, 807–821

### Temperature Matters

*Cryo-grinding of black pepper*

Black pepper, the king of spices, is indigenous to India, and, more specifically, to the Western Ghats. Aroma, pungency and colour make it a favourite at dining tables. Apart from flavouring and preserving food materials, black pepper is used in pharmaceuticals, insecticides and in cosmetics.

Like many other spices, pepper is available in powdered form in the market. Grinding makes it easy to transport, store and to mix with other ingredients; the increased surface area improves the availability of flavouring components and nutrients. But if grinding is not done with care, the powder loses its characteristic qualities.

Many studies have effectively demonstrated how cryogenic grinding – grinding at low temperature with the aid of liquid nitrogen or liquid carbon dioxide – improves retention of volatile oil content, an important active flavouring component, colour, particle size, and total surface area and that the energy costs are worth incurring. But these studies focused mainly on particle size and the sensory attributes of the black pepper powder; they paid little attention to other powder characteristics required for particle engineering.

Now, in the last fortnight, Bhupendra M. Ghodki and T. K. Goswami from IIT Kharagpur have reported a design of a cryo-grinding technology to obtain high quality pepper powder. They considered numerous other variables that influence powder characteristics: intrinsic variables like moisture content, shape and size and extrinsic variables like rotor speed and speed rate. They also addressed environmental variables such as relative humidity, and temperature of surrounding atmosphere which influence intrinsic variables.

As the grinding temperatures increased from –120 to –80, –40, 0 and 40 degrees on the Celsius scale, flowability, crucial to prevent problems like agglomeration and sticking, also increased. The remaining variables were negatively correlated. Availability of mineral composition of the powder also significantly increased with the reduction in the grinding temperature.

This quantitative investigation and comprehensive theoretical understanding of the powder properties of black pepper in terms of flowability, particle size, morphology, moisture, water activity, etc. will aid in cost reduction, capacity and process optimization of transportation, storage and grinding operations. Moreover, the findings can be immensely useful for the design of equipment for feeding, conveying, processing, handling, mixing, packaging, storing and transporting, say the scientists.

*Powder Technology*, **299**, 168–177

### Coffee to Pass Infrared Test

*Inline monitoring of roasting*

Coffee comes in a variety of colours and blends. Each region boasts of its unique taste which is largely determined by the sugar content and the process of roasting. Even though coffee roasting is carefully controlled and sugar content is dedicatedly determined in each batch, there is a lack of a method for continuous monitoring to determine end points of roasting, for quality control purposes. A research team, led by Ricardo N. M. J. Páscoa from Portugal, has now come up with a one step method to determine sugar content and roast colour in coffee blends.

The scientists made use of near infrared scanning method for determining two parameters that can greatly influence coffee flavour among different batches: the sugar content and the colour of the roast. The researchers placed a simple infrared probe outside a coffee roaster that allows direct visualization of the roasting drum through a glass window. They roasted coffee beans from Brazil, Uganda and India in separate batches at different speeds and scanned the contents with near infrared after short intervals throughout the process. And they compared the scan results with established industry parameters for colour and sugar content.

The sugar content decreases rapidly in fast roasts. Scientists found that the changes in spectra are consistent with this. The researchers noticed that the industrially defined parameter for colour change – luminosity – was greatly affected by the roasting temperature. For the same value of luminosity, the sugar content of the different roasts could be partially controlled by tweaking the roast process, especially for light roasts, thus producing sucrose-enhanced natural coffee.

The near infrared scanning technique and multivariate methods used are quite rugged and these can be easily employed for continuous monitoring of coffee roasting in industrial facilities for quality control.

*Food Chemistry*, **208**, 103–110

### From Forest Waste to Biofuel

*Babool seeds to produce oil*

Agricultural biomass contains compounds that directly serve as fuel and yield energy when burnt. But extracting fuel in the form of oil or gas from biomass is cost intensive. Different crops give different yields of oil. Selectively growing plants for biofuel production can encroach upon agricultural lands. This raises several issues with respect to deforestation and the sustainability of the process.

Scientists have now come up with a solution to the problem. In the last fortnight, Neeru Anand and her colleagues from the Guru Gobind Singh Indraprastha University, Delhi, reported a new source – Babool seeds – for large scale cost efficient production of bio-oil.

Babool seeds are a forestry waste produced to the tune of 60,000 tonnes annually. The researchers determined the fuel yield from this source at different temperatures using a pyrolysis chamber. The seeds collected from the outskirts of Delhi were washed, crushed and separated into three different fractions based on size. This was done to study the effect of particle size on fuel yield.

Each group of varying particle size was then fed into a pyrolysis reactor and heated at temperatures ranging from 400°C to 700°C. The vapours were collected and condensed in a separate chamber allowing the scientists to isolate the bio-oil. The researchers analysed the liquid yield, gas yield and oil yield for each group at different temperatures.

They found that smaller particle sizes of the order of 0.4 mm tend to be more efficient for both oil and gas production. The process was most efficient at 500°C – with a liquid oil yield of 49% and a transport grade bio-oil yield of 38.4%. This is comparable to the oil yield of Jatropha – the primary biofuel crop in India. Given that the method used for fuel extraction – pyrolysis – is inexpensive, and that huge amounts of babool seeds are wasted every year, there is an economic feasibilty to using this new source for bio-oil production.

*Renewable Energy*, **96**, 167–171

### Stabilizing Omega-3 Fatty Acids

*Improving human health*

Omega-3 fatty acids are polyunsaturated fats which have many positive effects on our health. The World Health Organization estimates that 80% of cardiovascular diseases are avoidable by following a healthier diet. Increased health awareness and higher incidence of cardiovascular disease has raised the demand for omega-3 fatty acid containing health foods.

Among omega-3 fatty acids, docosahexaenoic acid, or DHA, is considered the most important. DHA is easily oxidizable which makes it unstable and sensitive to environmental stresses. This poses the problem of degradation during transportation and storage. In fact, bioavailability of DHA is poor due to degradation even after consumption.

Karthik and Anandharamakrishnan, researchers from CSIR-CFTRI, Mysuru, utilized nanotechnology based emulsions to protect the DHA from oxidation. Nanoemulsion based delivery of omega-3 fatty acids is becoming increasingly popular because of its ease of preparation, small particle size, relatively high stability and high bioavailability. Despite these advantages, selection of nanoemulsions must be carefully considered to ensure good physical and chemical stability and high bioavailability.

The scientists tested different types of nanoemulsions such as Tween-40 (T-40), sodium caseinate and soya lecithin to stabilize the DHA. The highest physical stability and least oxidation of DHA were observed with T-40 nanoemulsion. Moreover, it also ensures gradual delivery and increased digestibility of biologically active and functional omega-3 fatty acids. Therefore, omega-3 fatty acids can be protected and stabilized better with T-40 nanoemulsion.

Many national and international health organizations recommend that consumption of 250 mg DHA per day improves human health. Therefore, nanoemulsion based delivery of omega-3 fatty acids can be employed to meet the recommendations to improve human health.

*J. Food Engineering*, **187**, 92–105

### Leather for Enzyme

*Waste utilization meets value addition*

The leather industry produces large quantities of degradation-resistant wastes and this poses a problem of waste disposal. A major proportion of pre-tanning leather waste comprises animal fleshing that contains about 40–50% of protein. Recent investigations show that enzyme and fermentation based techniques can help in recovery and utilization of commercially important products from waste animal fleshing.

Recently, researchers from the Sathyabama University, Chennai, and the Central Leather Research Institute, Chennai, collaborated with scientists in Seoul and Hong Kong to study protease production from animal fleshing using a newly isolated bacterial species – *Clostridium limosum*.

Proteases have multiple uses, particularly in pharmaceutical, leather and textile industries. *C. limosum* can produce such enzymes by utilizing animal fleshing as a substrate. To identify the optimum conditions for protease production, the researchers incubated animal fleshing with *C. limosum* in an anaerobic atmosphere for 120 hours at different pH and temperatures. After every 24 hours, a small quantity of media was drawn to estimate the amount of protease produced. The researchers found that the protease yield was highest at 40 degrees and mildly acidic pH of 6. The enzyme was then isolated through column chromatography and assessed for purity using gel electrophoresis and high pressure liquid chromatography. The isolated enzyme was inhibited by metal chelators and stimulated by zinc and magnesium salts, indicating that it is a metalloproteinase. By manipulating purification strategies, the researchers could purify the enzyme 58 fold.

The present approach not only stabilizes leather waste but makes it more prone to microbial degradation by decreasing organic content. It also creates value addition by facilitating the production of a commercially important product. Scientists say that such useful waste disposal strategies can help in the cost-efficient management of industrial wastes.

*Bioresource Technology*, **217**, 150–156

*Reports by:* **Bobby P. Mathew, Manali Datta, K. T. Mufeeda, G. Sharath Chandra, H. M. Mahadeva Swamy, Rekha R. Warrier** and **Sarah Iqbal**

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# Science Last Fortnight

### Arjuna Tree Bark Extract

*Relief for heart failure patients?*

Presently, one in 1000 people suffers heart failure. Its prevalence is growing at 10% every year. Subir Maulik from AIIMS, New Delhi, has now tested a well known Ayurvedic remedy using the methods of modern medicine to reduce congestive heart failure.

*Terminalia arjuna*, is well known for its ability to enhance muscle contraction, anti-oxidative, anti-ischemic, antihypertensive and anti-hypertrophic properties. This plant is widely used in folk medicine for the treatment of heart diseases in humans. But there has been no concerted effort to scientifically validate its use.

Maulik's team utilized aqueous extracts from the dried stem bark of Arjuna with water. After clearance from the ethical committee, the extracts were tested on 100 heart failure patients. Experimental setup of double-blind and randomized methods under clinical trials were executed with a placebo as control. They also considered the patient's history of the left ventricular region, gender, age, physical fitness and so on. Different tests were conducted to monitor the tolerance of patients to the extract. The treatment had twice a day regime and continued for twelve weeks. The scientists found that the quality of life of the patients improved slightly. Antioxidant activity increased as evidenced by the increase in enzymes like RBC-superoxide dismutase, catalase, glutathione, plasma cytokines and other oxidative stress markers.

There was some symptomatic relief related to heart attack indicators. These outcomes acted as a proxy to the expected performance in the ventricular region. However, in the long term, this was not significant. There was not enough evidence to support the long survival of patients undergoing the treatment. Thus, the study challenges the well-entrenched claim about the efficacy of *Terminalia arjuna* to prevent congestive heart failure. However, survival benefits and functional capacity of the heart and survival period need further well-planned and detailed monitoring.

No doubt the Arjuna tree has an inherent medicinal and therapeutic benefit. This makes it worthy of investigation under specific subgroups of patients. Perhaps, positive outcomes from anti-oxidative reserves could be a better target for future research.

*Phytomedicine*, **23**, 1211–1219

### Weeds to Weed out Bacteria

A wonder drug of its time, Penicillin, was accidentally discovered by Alexander Fleming in 1928 from a mould that killed bacteria. It soon became popular as it cured deadly infections. But in a few decades, it became ineffective as bacteria became drug resistant. Finding new antibiotics has become a continuous challenge for scientists.

Researchers in the Cochin University of Science and Technology have now isolated new antimicrobials from six species of seaweeds from the coasts of Kerala, as crude water-soluble extracts. They found that these antimicrobials are phycosugars (phyco: seaweed or algae). Phycosugars are different from common sugars in being sulphated. Phycosugars kill a wide variety of bacteria and have antioxidant properties. Scientists found that they were as effective as Tetracycline and Chloramphenicol, but less toxic and more cost effective.

For over eighty years, scientists across the globe have been struggling to find new antimicrobials. With seaweeds to our rescue, it could now be reality.

*Carbohydrate Polymers*, **151**, 584–592

### Better Plastics

We have been using plastics for more than 100 years now. They seem to be irreplaceable because of long shelf life and high durability. Sadly, plastics pollute the environment because most plastics are non-biodegradable and cannot be managed by recycling.

A ban on plastics could be a short term solution but bioplastics will perhaps be a longer term solution. However, bioplastics are costly, have lower strength and higher water absorption.

Researchers at IIT Kanpur have improved bioplastics by changing a method of cross linking them. Cross linking is the same method that hardens rubber; the more bonds a plastic has, the more its strength and durability.

The new method uses easy-to-get, eco-friendly and water soluble citric acid as the cross-linker for agarose. The research team has filed a patent to claim exclusive rights for using and selling the method because it is new and useful.

*Carbohydrate Polymers*, **151**, 60–67

### Uranium Remedies in Jaduguda

People in uranium mining areas like Jaduguda, Jharkhand are exposed to radiations from radioactive uranium. This causes genetic mutations and diseases. Removing minor amounts of uranium from soil is not economically feasible with the available physico-chemical methods.

Uranium accumulation has been recorded in terrestrial and aquatic plants. It is usually fixed in the roots of plants grown in older mining areas. Although it is naturally present in plants in small quantities, uranium has no known functional role in plant nutrition. The absorption of uranium by plants is dependent upon the degree of contamination in the soil and water, pH, temperature, soil ions and organic matter content.

Scientists at the Periyar University, Salem, Tamil Nadu and the Calcutta University in collaboration with scientists in other countries, explored aquatic as well as terrestrial plant species systematically using fluorometry. They found significant variation in absorption and accumulation of uranium between different plant species and also between different organs of the same species.

The maximum accumulation was in roots followed by leaves, stem, flowers and fruits. They found the concentration to be greater in terrestrial plants like *Integrifolia* than in aquatic species such as *Riccia fluitans* and *Lemna minor*. Terrestrial plants have much longer root systems with fibrous adventitious roots covered with root hair. This creates more surface area and leads to higher accumulation of trace elements in roots.

This study opens up the possibility of using such terrestrial plants to clean up uranium from the soil. However, the

plant biomass would now contain excessive uranium, caution the scientists. Methods for safe disposal of the uranium so accumulated by plants need to be explored further.

*Sci. Total Environ.*, **568**, 350–368

### Controlling Chromium

*PANI: a ray of hope for Odisha*

Rub a comb on your dry hair: it can now pick up bits and pieces of paper. Using this simple principle of electrostatic attraction, scientists from the Harisingh Gour University, have prepared a nanopolymer which can separate lethal hexavalent chromium from drinking water.

Chromium primarily exists as trivalent chromium which is not dangerous and does not contaminate water. On the other hand, hexavalent chromium is highly toxic. Drinking water containing hexavalent chromium above the permissible limit of 0.05 ppm, lead to skin irritation, lung cancer, stomach ulcers, and kidney, liver and gastrointestinal tract damage. About 85% of deaths were caused by chromite-related diseases.

We often find silica gel in shoes and electronics boxes. Here the silica gel acts as a drying agent that adsorbs moisture. Likewise, scientists prepared a nanopolymer composite of polyaniline (PANI) and graphene on the surface of magnetic nanoparticles. They demonstrated that the combined effect of electrostatic interaction and electro-reduction of this polymer could adsorb hexavalent chromium effectively from water. The new composite could also convert most of the hexavalent chromium to trivalent chromium. Through this method, they removed 86% of chromium from contaminated water, in just 20 minutes.

The method is easy. The polymer could be produced in bulk and stored in a powder form. After removal of the contaminant, the polymer powder could be easily removed from the water. The user-friendly and cost-effective nature of this technique makes it special as compared to sophisticated water treatment processes.

In chromite mining areas like Sukinda in Odisha, 60% of the drinking water contains hexavalent chromium. Effluents can now be treated with this method to reduce the levels of chromium to permissible levels before discharging it into water bodies. This could prevent groundwater contamination to some extent.

Recently, BARC has developed a toolkit for onsite determination of hexavalent chromium in drinking water and groundwater. These two findings could, perhaps, go hand in hand to solve major contamination problems in chromite mining areas.

*J. Appl. Polym. Sci.*, **133**(39), 44002

### Polyol from Tobacco Stems

*New source for polyurethane*

Polyol is a raw material to make polyurethane, an inevitable plastic in this age. It is used in the production of flexible and rigid foams, coatings, sealants, elastomers and adhesives. The polyurethane industry is presently dependent on the petroleum industry which provides two major feedstocks – polyols and isocyanates. The polyurethane industry is unstable because of depleting petroleum resources and increasing costs of petroleum processing. This is forcing the industry to explore the possibility of production of polyurethane from renewable sources.

Now, M. P. Chirag and others from the Sardar Patel University, Gujarat, have new source of polyol: tobacco stems, a waste material that is usually burned. They liquefied tobacco stalk using crude polyhydric alcohol, an organic solvent. Then they used castor oil in the presence of lithium hydroxide to get polyol. It was further tailored to the required –OH value for improved mechanical and chemical properties by adding natural oil or synthetic diols.

They then synthesized polyurethane foam from these bioderived polyols. The characteristics and physical properties matched the marketed foams. The thermal conductivity, thermal stability and morphology were also similar to marketed foams.

The study marks the beginning of high quality rigid polyurethane foams derived from renewable, comparatively less expensive materials.

*J. Appl. Polym. Sci.*, **133**(38), 43974

### Gaseous Fuel Efficiency

*Reducing vortices*

IIT scientists in a study funded by ISRO are experimenting with the laminar burning velocity of methanol with air.

Laminar burning velocity is related to the different layers of liquids. How they glide over each other. This velocity is an intrinsic property of any combustible mixture. If they glide smoothly, combustion is better, but, under high pressure, liquids do not glide in a linear fashion. Some eddy currents are formed which lead to imperfect combustion of fuels. These unburnt gases have their own velocity. This difference between the velocity of burnt and unburnt gases gives birth to eddy currents. Scientists are facing the problem of controlling these eddy currents.

This experiment provides a solution to this problem. If combustible liquids are burnt under specific ratios of pressure and with varying external temperature, there are less unburnt gases. This technology is also effective in the case of liquid propelled rockets. Because of the high pressure of liquids the same problem occurs in burning. Laminar burning velocity is determined using mass balance between the channel inlet and flame stabilization location for the planar flames appearing at certain conditions of mixture flow rate and equivalence ratio.

The scientists optimized the ratio between the fluid pressure and the nozzle to reduce eddy currents. They used quartz material channels because they have high heat resistance. And it is easy to create narrower inlets with quartz. The diverging portion of the channel was externally heated using a sintered metal burner to generate a steady linearly varying temperature gradient in discrete mixture flows. The initial result of this experiment has given hope for future clean burning.

The burning of fossil fuels is a prominent issue all over the world. Now scientists are working on technologies to address this issue, to reduce pollution.

*Fuel*, **182**, 57–63

*Reports by* **S. Puspanjali, Pavithra Nayak, Maneesh Shukla, Pandurang Kakatkar, Bhavya Khullar** and **P. Vijisha**

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# Science Last Fortnight

### Nano-Cauliflower to Detect Arsenic

*Cheaper, faster technique*

West Bengal, Jharkhand, Bihar, Uttar Pradesh, Assam and Manipur have reported arsenic contamination in groundwater. Above permissible levels of arsenic contamination – 0.01 mg/l as per WHO – are found in the Ganga and Brahmaputra rivers which flow through these states. Arsenic toxicity causes many serious health issues such as cancer, hypertension, dermatitis, kidney and lung diseases.

Detection of arsenic in water is the first step to tackling the problem. Analytical methods like high-performance liquid chromatography, atomic absorption spectroscopy, and spectrofluorimetry are used to detect arsenic levels in water. The difficulties in sample preparation, time taken to detect arsenic and the cost involved are major deterrents to using these techniques in field conditions.

A group of researchers, from the SASTRA University, Tamil Nadu, has now developed a cheaper, rapid detection sensor for detecting arsenic levels. The sensor has a cauliflower morphology which facilitates high diffusion and mass transport of reactants. This enhances the detection capacity of the sensor. But preparing such a sensor is a great challenge.

The researchers developed fluorine doped cadmium oxide sensing electrodes by spraying a cadmium acetate dehydrate precursor along with ammonium fluoride onto the pre-heated glass substrate. This process produced a thin nanolayered cauliflower shaped non-toxic fluorine doped cadmium oxide sensor. This sensor can detect arsenic rapidly and is more sensitive than currently available sensors.

Arsenic contamination in drinking water threatens more than 150 million people globally. It is urgent to detect even low quantities of arsenic in drinking water. And these nano-cauliflowers may form the basis of technology that can be produced cheaply on a large scale to detect arsenic in water efficiently and rapidly.

*Sensors and Actuators B*, **234**, 426–434

### Beat the Weeds

*Cross resistance sparks old methods*

Even with improved agronomic practices, farmers may still need to use age-old practices to fight weeds. That's the lesson to be drawn from the latest development of resistance to the weed fighting herbicides applied to wheat fields. A weed, locally known as *gehunsa* (*Phalaris minor*) is not much to look at. But the farmers in Haryana have a hard time controlling it.

Having evolved the ability to withstand Clodinafop, a major herbicide, it has developed genetic defenses to survive herbicides. Even increasing the dosage could not control the weed. According to a team, led by Dharam Bir Yadav, a scientist at the Haryana Agricultural University, Karnal, their resistance is metabolic in nature. The more they are exposed to herbicides over the seasons, the more resistant they become. The team warns that herbicide resistances can lead to total crop failure from unchecked growth of the weed.

Yadav notes that it is difficult to identify a specific tolerance trait. The weed population has high molecular diversity. So a multipronged strategy has to be adopted. Cultural methods like crop rotations, along with manual/mechanical weed management are still effective. He suggests that the weed should be attacked using a combination (sequential or tank-mix) of weedicides. This reduces the chances of development of weed resistance strains. However, there still remains a pressing need to develop new herbicide molecules for managing the weed.

*Crop Protection*, **89**, 239–247

### Bitter Pill Kills

*Destroying the dengue vector*

A study[1] in 2013 reported that India contributes to 34% of global dengue infections. The mosquito-borne viral infection may cause mild asymptomatic illness or develop into a lethal haemorrhagic fever. There is no specific treatment. So the only option is to control the vector.

Last fortnight, researchers from the Manonmaniam Sundaranar University, Tamil Nadu, came up with a suggestion: an ayurvedic medicinal plant as anti-vector drug[2].

*Andrographis paniculata*, known as *kalmegh* or *mahatiktha* in India, is used as traditional medicine for the treatment of sore throat, common cold, respiratory tract infections and as antidote against snake or insect venom. The plant extracts have shown anticancer, antibacterial, antiviral, anti-inflammatory and antimicrobial properties. But the efficacy of the plant to control the vector had not previously been evaluated.

The research team extracted a compound, 'andrographolide', known for its pharmacological effects, from the leaves of the plant. They tested it against the dengue vector, *Aedes aegypti*.

In adult females, the drug reduced the number of eggs laid and the hatchability of the eggs. The survival rate, in the first four larval stages, showed that mortality rates are directly proportional to andrographolide concentration. Within 24 hours, the growth of mosquito larvae and pupae is inhibited by up to 90%. Histological and morphological observations reveal a breakdown in the mid-gut section of the larval intestine.

This research offers a clue for developing harmless larvicides. Transforming this bioactive compound into a cost-effective product, however, remains a challenge.

[1]*Nature*, 2013, **496**, 504

[2]*Acta Tropica*, 2016, **163**, 167–178

### Bacteria for Better Soils

*Solution inherent in the problem*

In 1971, Ananda Mohan Chakrabarty engineered a new strain of bacteria that could degrade crude oil and aid bioremediation of oil spills, saving millions of dollars and precious marine life. A lobby of scientists argued that it was genetically modified, and that its long-term environmental impact is unknown. Scientists across the globe have ever since been searching for naturally

occurring microbes and organisms that can degrade pollutants.

Heavy metals and polycyclic aromatic hydrocarbons are increasingly polluting our soils. Released by burning fossil fuels, industrial wastes, coal and tar processing, these pollutants settle down in the soil. Are there microorganisms that can tackle this pollution? This is the question that researchers at the Krishnadevaraya University, Anantapur, Andhra Pradesh, asked themselves.

They collaborated with universities from Australia and South Korea to isolate bacteria that were present in polluted soil samples from various sites. They identified these organisms by pyrosequencing: a next generation sequencing technique. Using the data of 16S ribosomal RNA, the researchers classified them into 16 different phyla using bioinformatics tools.

They found that about 80% of Proteobacteria and Actinobacteria are tolerant to metal toxicity and capable of degrading polycyclic aromatic hydrocarbons.

Mass producing these naturally occurring bacteria and using them for soil bioremediation can be an environmental-friendly and sustainable solution, enabling the transformation of polluted areas into cultivable land.

*J. Hazardous Materials*, **317**, 169–179

### Pollution-free Cotton Dyeing

Dyeing of cotton is done in two steps. First, the fibre is 'exhausted' using dyes. This requires a large amount of salts like sodium chloride. Secondly, the dye has to be fixed using alkalies like sodium hydroxide. If the exhausting step is inefficient, the leftover dye leaches into the waste. This leads to water pollution, a serious challenge in tertiary effluent treatment processes. Another problem is salt leaching into groundwater making it saline and unfit for consumption.

Researchers at the Anna University, Tamil Nadu, have now devised a novel and efficient method of exhausting cotton fiber that uses 100% of the dye. Nothing is leached out in the wastewater. In this method, the fabric is first treated with an alkali, followed by CHPTAC, a cationic etherification agent, in a mole ratio of 1 : 2.

Apart from utilizing the complete dye, this deviation from tradition consumes 20% less time and saves almost 30% water. And what's more, the new method of dyeing cotton fabrics is salt-free!

The great success of industrial trials of the method needs to be brought to the attention of knit processing industries in India for immediate implementation.

*Carbohydrate Polymers*, **152**, 1–11

### Better Brooms for Algal Mess

Water bodies are often covered with algal blooms. They exploit the nutrients and oxygen in water and suffocate aquatic life. This algal mass can be clumped by flocculation using chemicals which makes it easy to remove. But this is not popular because the chemicals used are expensive and end up polluting water.

Dharani and Balasubramanian from the University of Madras, Tamil Nadu, now report a novel flocculant that is inexpensive, eco-friendly, easy-to-make and highly efficient. The highly water-soluble flocculent is a copolymer of two monomers: DMC and MACPPC. The polymer is grafted on a modified acryloyl chitosan moiety. The resulting flocculent is named AC-g-P (DMC-MACPPAC).

The researchers tested it on a common species of microalgae, *Chlorella vulgaris.* The material is found to be highly efficient: it can flocculate approximately 73% of algae when used at concentrations as low as 20 parts per million.

This gives us an effective agent that can be used for algal biomass isolation at a mass scale. The properties of the isolated biomass remain unchanged. Thus, this flocculant works both as a method to generate cattle feed and as source of biofuel.

*Carbohydrate Polymers*, **152**, 459–467

### Video Coding for Internet Security

*Steganography: blow to hackers*

A team led by Ramakrishna Hegde, at the SDM Institute of Technology, Karnataka, found a new way to convey secret data by concealing its existence using multimedia as a carrier.

The secret data is encrypted using Elliptic Curve Cryptography. This is convenient as it reduces storage and transmission requirements, enhancing processing speed.

The encrypted cipher is again embedded in the H.264 video format. The pixels in the video are optimized by using an optimization algorithm called, Artificial Bee Colony, to reduce the distortion of the encrypted data.

The digital media acts as cover media or host for transferring highly confidential data with minimum cognizable degradation. The digital medium can be a text, audio, video or image, depending upon the size of the message to be transferred. The secret message is invisible and inaudible.

This technique proved its robustness when implemented on Matlab and MPEG video files. Steganography, using video format, brings a revolution in terms of security levels, carrier capacity and embedding efficiency of the classified data. It is a challenge to internet hackers.

*Computer Standards & Interfaces*, **48**, 173–182

*Reports by:* **Pavithra P. Nayak, Bhavya Khullar, G. Sharath Chandra, Manish Kumar Tekam** and **S. Puspanjali**

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# Science Last Fortnight

### Soil Quality in the Deccan Plateau

The Deccan Plateau is large, forming most of the southern part of India. A diversity of dryland crops, including cereals, pulses, oilseeds, vegetables such as beans, gourds, onions and commercial crops such as ginger, turmeric and chillies, sustain the agriculture sector in the semi-arid regions of the plateau. However, the growing conditions on the Deccan plateau are poor. The soil is low in organic carbon. It has low nitrogen content and phosphorus fixation capacity. Hence it has poor response to fertilizer application and is, thus, low in productivity. So it requires the implementation of scientific farming strategies to produce enough food throughout the year.

Scientists from Maharashtra, Assam and Tamil Nadu have now come up with a tool – Soil Quality Index – to evaluate crop productivity in the semi-arid Deccan plateau. They collected soil and subsoil samples from various localities. They evaluated the soil quality using parameters such as hydraulic conductivity, degree of modifications of soil properties due to pedogenic processes and weathering, pH and $CaCO_3$ content. They then related the crop productivity of the study area to these parameters.

The study shows that the large variation in soil quality in this region is due to soil heterogeneity and soil degradation caused by subsoil sodicity. The soils of the Chegunta series are of better quality. The soil quality of the Gummagonda series is very poor and is not suitable for deep rooted crops like cotton and pigeon pea because these soils are very shallow, poor in organic matter content and water holding capacity.

The soils of Koduparthy are also low in productivity. But this is due to the leaching of nutrients in the sandy layers along with percolating water. Lack of root anchorage impairs the capacity to support optimum plant growth. Crop productivity in Nerelapally and Avancha is low because the soils here are sodic with a pH of 8.5.

Based on these results, scientists recommend adoption of suitable soil management practices for better agricultural productivity in this semi-arid region. They hope that the study will pave the way for reformulating agricultural strategies in the Deccan Plateau.

*Geoderma*, **282**, 70–79

### 3D-Imprinted Membranes

*Removing arsenic from water*

Parts of West Bengal, Jharkhand, Bihar, Uttar Pradesh, Chhattisgarh, Assam and Manipur are facing high arsenic levels in ground water[1]. This has led to adverse public health issues in these states. The permissible limit of arsenic in water should be below 10 ppb or 0.01 mg/litre. But, in these regions, the level, in water used for human consumption, exceeds the WHO and BIS guidelines.

Last fortnight, researchers from the Indian School of Mines, Jharkhand, reported a new filtration method. They used integrated molecular level arsenic adsorption: membrane technology molecularly imprinted for a specific target molecule[2].

They synthesised the membranes using cysteine@ZnS : $TiO_2$ nanoparticles and tested the efficiency of these membranes with water samples collected from arsenic-affected areas. They found that 96% of arsenic could be easily removed through this method.

This membrane exhibits high adsorption capacity and selectivity for arsenic removal in comparison to currently available conventional membranes. It is also stable, reusable and highly resistant to breakage. What is more, it is antibacterial.

Membrane-based methods have been used for water purification for decades. However, recently, a combination of membranes with metal nanoparticles has become popular due to better performance, improved permeability, fouling resistivity and selectivity. Moreover, these are commercially viable because of the low-cost involved in production.

This new filtration system has the potential to be the next-generation technique for removal of arsenic from water. It is an economical and effective alternative to the existing membranes for drinking water. Perhaps, the public health problem in the north, east and north-east of India, caused by arsenic toxicity, could be solved with this new method.

[1]*J. Trace Elem. Med. Biol.*, **38**, 33–45

[2]*Chem. Engineering J.*, **304**, 259–270

### Nano Alarms for CO Sensing

Carbon monoxide (CO) is formed as a result of the incomplete burning of fuels such as gas, oil, coal or wood. The gas is commonly found in our houses in central heating systems, boilers, water heaters, and next to open fire chimneys. Breathing increased levels of CO can cause poisoning. CO binds to haemoglobin in the blood forming carboxyHb that restricts the supply of oxygen to the tissues of the body, leading to nausea, dizziness, stomach pain, shortness of breath and even death.

The human body cannot sense CO because it is odourless, tasteless and is non-irritating. Hence, we need CO sensors in our homes and industries to prevent CO poisoning.

Researchers at the Institute of Chemical Technology, North Maharashtra University, in collaboration with the University of Mumbai, Maharashtra, have developed a nanocomposite sensor for CO by grafting the nanoparticles of cobalt oxide ($Co_3O_4$) in a polyaniline matrix (PANI), an intrinsically conducting polymer known for its modifiable electrical conductivity, low cost and ease of synthesis.

The method of synthesizing cobalt oxide ($Co_3O_4$) nanoparticles is easy. NaOH is added to cobalt chloride ($CoCl_2$) drop by drop under ultrasound. The cobalt hydroxide thus formed is sonicated, centrifuged, washed with water and rinsed with acetone. And you get 23 nm wide $Co_3O_4$ nanoparticles. These are then grafted in PANI and doped with hydrochloric acid to form the resulting nanocomposite, PANI/HC/$Co_3O_4$.

The researchers found that the biosensor efficiently senses carbon monoxide with a short response time of 40–45 seconds. Scientists say that the

sensor's response reduces under high humidity and they are trying to improve its performance under different field conditions. Despite this shortcoming, the biosensor can be used for homes and factories to prevent accidents and death due to carbon monoxide leakage.

*J. Applied Polymer Sci*., **133**(42), 1–8

**Biosensor Identifies Suspect**:
*Bacteria that poison food*

Food poisoning due to *Salmonella typhimurium* infection accounts for the maximum number of deaths from contaminated water and food. *S. typhimurium* is a category-B bioterrorism agent because the infection is rapid and, if untreated, fatal.

Researchers at the CSIR Institute of Microbial Technology, Chandigarh, have identified and purified a surface antigen protein, OmpD, specific to the *S. typhimurium* species. They immunised rabbits with purified OmpD protein and extracted the antibodies specific and non cross-reactive to other species of *Salmonella*. They then developed a biosensor by conjugating the OmpD-specific antibodies to a matrix that was composed of reduced graphene oxide on a screen-printed carbon electrode.

They tested the biosensor on contaminated litchi and orange fruit juice and found that it could detect *S. typhimurium* as low as 10 CFU per ml of bacteria.

The biosensor can be used for making clinical kits to detect *Salmonella typhimurium* contamination in food and water. It can also detect infection in patient samples with high specificity and sensitivity.

*Biosensors & Bioelectronics*, **85**, 707–713

**Spices to Combat Cancer**

Two of the most popular ingredients of spicy Indian curries – nutmeg and mace – are members of the *Myristica* spp. family. The other members of this family are used in Unani and Ayurveda medicines. In addition to their peculiar flavours, members of the family have antimicrobial, aphrodisiac, memory enhancer, psychotropic, hepatoprotective, anticancer, anxiogenic, and antidepressant properties. Screening and isolating the bioactive components from these plants may therefore lead to the discovery of useful drugs.

Researchers at the Central Drug Research Institute, Lucknow, and the Academy of Scientific and Innovative Research, New Delhi, in collaboration with the Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Kerala, screened 21 compounds from *Myristica beddomeii* and *M. fatua*. They were successful in identifying five bioactive components.

Using Sulphorhodamine B assay which detects cell density and toxicity based on the response of a fluorescent dye, they tested the active compounds in five human cancer cell lines from lung, colorectal, prostate, pharynx and breast tissues. The results show that these compounds have anti-proliferative activity. Hence, they can be used to treat cancer – unregulated cell growth and division.

These compounds are natural and nontoxic and, thus, better alternatives to conventional cancer treatments such as chemotherapy. A series of animal testing and clinical trials is, of course, needed. So for the moment, we might have to depend on the *jaiphal* and *jaivatri* plant family merely as neutraceuticals.

*Food Chemistry*, **211**, 483–493

**Healing Human Tendons**
*Insect exo-skeleton to rescue*

Injuries to tendons, tissues connecting muscles and bones, result in joint pain and, in severe cases, permanent loss of function. The present treatments do not restore the tissue completely. This results in complications: joint stiffness, reduced strength and risk of repair rupture.

Jayakumar and his team of scientists from the Amrita Centre for Nanosciences and Molecular Medicine, Amrita University, Kochi, have designed an innovative scaffold that may provide a solution. They used poly (lactic acid) fibres, collagen and chitosan, a derivative of insect exoskeleton, in a hydrogel form to design a substitute of tendon and coated it with calcium alginate to prevent peritendinous adhesion. Tissue thus engineered was biocompatible, cost-effective and suitable for cell immobilization and encapsulation.

Spectroscopic studies indicated that the scaffold so formed contained a blend of chitosan and collagen. Microscopic studies confirmed porosity of the construct required for cell and nutrient infiltration. The mechanical strength of the construct increases with the layers of poly (lactic acid) fibres. The adsorption pattern indicated alginate coating on the scaffold prevented protein adhesion on the surface. High DNA retention on the scaffold confirmed progressive increase in cell concentration. Confocal microscopy showed cell passage through the scaffold layers, enabling efficient regeneration. Alamar blue was used to test cyto-compatibility and no toxicity was found.

Biodegradability rate was 50% after 21 days – ample time for the natural regeneration process. Thus, this tissue therapeutic may play an important role in regenerative and rehabilitation medicine.

*Carbohydrate Polymer*, **153**, 492–500

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*Reports by* **Pavithra P. Nayak, P. Vijisha, Manali Datta** and **Bhavya Khullar**
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# Science Last Fortnight

### Bacterial Hydrogen Production

Hydrogen is an alternative fuel for the future. It releases three times more energy than gasoline and does not produce any greenhouse gases upon burning, only water. But the current methods for producing hydrogen are unreliable and cost intensive. To optimize hydrogen production, scientists are now looking at biological pathways which require less energy input. In the last fortnight, a team of scientists from the R&D Centre of the Indian Oil Corporation examined whey waste as a potential feedstock for hydrogen production.

Biological hydrogen production suffers from low yield, incomplete substrate conversion and its partial conversion into organic acids. Thus industrial effluents containing low quantities of reducing sugar are found to be attractive sources for commercial hydrogen production. One such source is Cheese whey. It is abundantly available and does not require complex pretreatment like other agricultural waste. The scientists examined hydrogen production from cheese whey upon fermentation using *Clostridium* sp. IODB-O3 – an in-house bacterial strain isolated from sewage. Results show that whey fermentation produced a greater volume of hydrogen than mixtures containing either only lactose or glucose – the main sugars involved in fermentation, suggesting that cheese whey is rich in components that favour hydrogen production. The researchers also compared the hydrogen output in batches containing only the *Clostridium* strain and those containing normal flora along with the *Clostridium* species. *Clostridium* strain IODB-O3 was found to be superior to other strains present in whey for hydrogen production. Finally, carbon distribution studies carried out by the scientists suggest new paths for the conversion of whey metabolites into hydrogen. The time, it seems, is ripe to start developing a new industrial process for hydrogen production along with cheese.

*Renewable Energy*, **98**, 221–225

### Furniture to the Rescue

*Deodar wood shavings for biofuel*

In the recent past, several studies have reported encouraging levels of fuel production from the barks of various trees. But biofuel yield is sensitive to pyrolysis conditions. Hence, in the last fortnight, researchers from the Indian Institute of Petroleum, Delhi, studied the pyrolysis of Deodar wood under different ambient conditions.

The scientists determined the fuel production under hydrogen and nitrogen atmospheres at different temperatures and pressures. Results show that under a hydrogen atmosphere, wood produces the greatest amount of biofuel at 400 degrees but in a nitrogen atmosphere, the most efficient fuel production was recorded at 350 degrees. Further rise in temperature resulted in a rise in biogas production while the quantity of biofuel and biochar reduced.

The scientists also examined the biofuel and biochar obtained at each temperature–pressure combination. In the presence of hydrogen, cleavage within the macromolecular structure of the biomass was found to be systematic while in the presence of nitrogen, it was random.

The scientists believe that the differences in the composition of products are mainly due to differences in the reaction mechanism. Bio-oils obtained under the nitrogen atmosphere mostly comprised phenolic compounds while those obtained under a hydrogen atmosphere mainly consisted of phenolics and alcohol ethers. An increase in pressure increased saturation among the products.

Deodar trees are an important part of forest cover. The wood sourced from these trees is heavily used for manufacturing furniture. As such, using sawmill shavings as feedstock will also resolve the food versus fuel debates surrounding biofuel production. The findings of this study will help design sustainable solutions for biofuel production.

*Renewable Energy*, **98**, 238–244

### Enzymes for Water Purification

*Extending the life of membrane filters*

Most modern water purifiers use membrane ultrafilters to keep water pure and free from particles. But many common substances present in water can get embedded in the filter matrix and cause fouling. This compromises the quality of the membrane and subsequently water purification.

A team of researchers led by Vayalam P. Venugopalan has used enzymes to solve this problem. In this multi-institute study, scientists from the Bhabha Atomic Research Center, Tamil Nadu, and the Homi Bhabha National Institute, Mumbai, partnered with scientists at the National Institute of Ocean Technology. Instead of resorting to chemical means that hamper membrane life in the long run, the scientists decided to target an important pollutant – alginate – which causes membrane fouling.

The model consists of a dead end cell fitted with cellulose acetate membrane which is susceptible to fouling and disintegration. The membrane is crosslinked with an enzyme – Alginate lyase – that decomposes alginate.

Water containing alginate was passed through the membrane and it was left to foul for 3 hours. Then they washed the membrane with pure water and examined the effluent for residual alginate. The performance of the membrane was evaluated after each cycle.

Results show that even as raw membranes lost 20% of the flux flow after each fouling cycle, the membranes crosslinked with Alginate lyase were less susceptible to fouling. The activity was enhanced after successive backwashing after fouling. Membrane integrity, studied through microscopy, confirms the formation of cake or debris over raw membranes. The effect was less pronounced in enzyme-linked membranes. The debris could easily be removed by washing with Millipore water.

This method is energy efficient and reduces the need for chemical treatment of membranes that could, in turn,

improve the life and performance of the membranes in the long run. It is expected that membrane technology for water purification will see other similar advances by assimilating enzyme technology.

*Chemosphere*, **165**, 144–151

### Effective Ocular Delivery

Bacterial eye infections lead to low vision and blindness. According to the WHO, twenty million Asians are blind. There are treatments to prevent or delay vision loss. But drug delivery to the eye is a challenging task. Topical eye drops are the most convenient and patient compliant route of drug administration. However, the absorption of drugs in the eye is severely limited because of the anatomy, physiology and biochemistry of the eye.

A group of researchers from the Bundelkhand University, Jhansi, and the Sam Higginbottom Institute of Agriculture, Allahabad, developed a gelatin nanoparticle loaded with moxifloxacin, a fourth-generation antibacterial agent, effective in curing bacterial infections of the eye. The scientists used a simple two-step process. First, acetone was mixed with moxifloxacin. Then, glutaraldehyde was added to crosslink the nanoparticles.

They checked the biocompatibility and safety of this formulation on the corneal surface using ocular irritation test and assessed drug release on the cornea layer *in vivo*, using rabbits.

The results show that drug loaded nano-formulation is non-irritant to the ocular tissues. It is safe and biocompatible. Moreover, the formulation facilitates sustained release of the drug and shows enhanced antibacterial activity against *Staphylococcus aureus* compared to commercially available drug delivery products.

Compared to conventional topical drops, this gelatin-based nanoformulation surpasses ocular barriers and associated side effects. Moreover, the formulation is easy to prepare. Further clinical trials are necessary to bring the formulation to the market.

*J. Colloid Interface Sci.*, **483**, 132–138

### *Cinammoum verum* from Mizoram

*Is essential oil healthy*?

Cinnamon bark is a widely used spice. It is used in the preparation of chocolates, sweet dishes, rices, savory non-vegitarian dishes. A number of species such as Ceylon cinnamon, Indonesian cinnamon, Vietnamese cinnamon, Chinese cinnamon and Indian cinnamon are being used worldwide. Ceylon cinnamon – *Cinnamomum verum*, is the most important source of cinnamon bark and leaf oil in the world trade.

India also produces *C. verum*, especially in Kerala, Karnataka and Mizoram. Lydia Malsawmtluangi from Mizoram collaborated with scientists in Garhwal and Italy to study the essential oil composition of *Cinammoum verum* of Mizoram and they found variations in essential oil composition of the trees growing naturally in Mizoram. Ceylon cinnamon has negligible amounts of coumarin. But compounds like borneol, a terpene which easily oxidized to ketone, and styrene, a hydrocarbon, are two toxic chemicals found in stem, bark and leaf oil of *C. verum* from Mizoram.

Scientists also found that *C. verum* from Mizoram is rich in methyl cinnamate and eugenol derivatives. These are important for cosmetics and can be used as flavouring and food additives. Scientists suggest more studies on eugenol and cinnamaldehyde content and the effect of plant age on their concentration. This will help in assessing the commercial viability of harvesting essential oil constituents from *C. verum* of Mizoram.

*J. Essential Oil Res.*, **28**(6), 551–556

### Predicting Facial Features

Facial features change slowly as we age. These features are also reflected in the images of those faces. This information can be extracted using computer algorithms. But there are constraints. Calculating the age from images is a challenge because ageing varies from person to person depending upon genetics, gender, life style, consumption habits and even external conditions such as weather and climate.

Jayant Jagtap and Manish Kokare, from the Shri Guru Govind Singhji Institute of Engineering and Technology, Nanded, Maharashtra, have found an improved method for determining age. They used facial skin ageing features and Artificial Neural Networks to do this.

Facial skin ageing features are extracted from face images using Local Gabor Binary Pattern Histogram, a non-statistical approach for face modelling, where histograms of all the local regions are linked to model the face as a sequence. These are more efficient than conventional binary features. Then they used wrinkle analysis. Wrinkles are a good indicator of loosening of the skin, which shows the ageing process.

Artificial Neural Networks help the machine mimic brain activity and learn. Artificial Neural Network, in this case, is designed as a two layer feedforward back propagation neural network. In the feedforward network, the information travels from the input nodes to the output nodes. In the back-propagation algorithm, the output is calculated against the desired result. If the result is not satisfactory, then the connections between layers are modified and the process is repeated to minimize the error.

The scientists tested the system with 120 male face images and 240 female face images from the face database of the Park Ageing Mind Laboratory. The system showed an accuracy of 94.17% for male and 93.75% for female – a significant improvement over the existing method.

Human age classification has potential application in Age Specific Human Computer Interaction, Intelligent Intensive Care Unit as well as in Electronic Customer Relationship Management.

*Cognitive Systems Res.*, **40**, 116–128

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# Science Last Fortnight

### Crude Oil Spill

*A delicacy for bacteria*

Fossil fuel ignited human progress. But this progress comes at a cost. All fossil fuels are obtained from crude oil. During crude oil extraction and transport, there are often accidental oil spills. Oil spills endanger marine life and pollute soils.

Sunita Varjani from the Indian Institute for Advanced Research and Vivek N. Upasani from the M.G. Science Institute, Gujarat, devised a way to tackle the issue. Bacteria need a carbon source for survival. *Pseudomonas aeruginosa* is known to feed on a variety of carbon sources, including the hydrocarbons. This bacterium is often found near oil refineries and soils polluted with crude.

The scientists isolated *P. aeruginosa* from soil samples collected near the Oil and Natural Gas Corporation's central tank farm, Ankleshwar asset, Gujarat. The bacterium was cultured in their laboratories. They introduced the bacterial culture into a mixture of water and 500 ml of crude oil from ONGC oil fields. Crude oil degradation was monitored, using gas chromatography and colorimetry. The researchers found that about 60% of the total crude oil was degraded in 60 days.

Current methods to tackle oil spills involve surfactants that speed up natural degradation. However, surfactants pose a threat to marine life. Now we have an innovative, cheap and benign alternative to tackle the issue. Using genetic modification to strengthen the natural propensity of *P. aeruginosa* to consume hydrocarbons, we might even be able create a faster, more economical and ecological way to clean oil spills.

*Bioresource Technology*, **222**, 195–201

### Going Down the Drain

*Yeast-based arsenic nanofiltration*

Arsenic contamination in water is a problem, worldwide. Long-term exposure to arsenic in drinking water increases the risk of cancer and other public health problems. Last fortnight, a research team at the Bharathiar University and the PSG Institute of Advanced Studies, Coimbatore, reported a new technique to remove arsenic: magnetic bio-nanocomposite.

The researchers developed a nanocomposite using iron oxide yeast cells. They functionalized the surface of the iron oxide nanoparticles with diethylamine and cross-linked them with the yeast, *Saccharomyces cerevisiae*.

The As (V) removal studies were done using contact time, adsorbent dosage, adsorbate concentration, and pH as variables. The efficiency of arsenate adsorption was determined based on batch mode experiments.

The researchers found that magnetite nanoparticles cross-linked with yeast have 99% arsenate removal efficiency. Diethylamine functionalized iron oxide nanoparticles have only 83.33% arsenate removal efficiency. Pure yeast has only 15%. Combining them offers the intrinsic advantage of removing a higher concentration of the metalloid.

Researchers found that yeast cross-linked $Fe_3O_4$ nanoparticles have the highest arsenate removal efficiency in a shorter duration.

The study provides scope for the development of low cost, microorganism-based, arsenic nanofiltration units. Other heavy metals of social concern might also be tackled using similar strategies.

*J. Colloid Interface Sci.*, **484**, 183–195

### Chitosan-Nanoparticle

*Fortifying finger millets*

Finger millet, popularly known as ragi in India, is an important cereal crop in developing countries. However, the crop is prone to infection by *Pyricularia grisea*. The resulting blast disease reduces biomass and yield. Last fortnight, researchers from the Bharathidasan University, Tamil Nadu, came up with a solution: chitosan nanoparticles to induce plant resistance.

Chitosan is a hydrophilic biopolymer. It is biodegradable, biocompatible, antimicrobial and non-toxic. It is also found to elicit plant defense. It induces changes in membrane permeability. It increases the production of reactive oxygen species, defense-related enzymes, biosynthesis of jasmonic acid and lignification. Yet there existed no *in vitro* studies to provide evidence for chitosan's ability to facilitate and reinforce the natural defense mechanisms in finger millet crop.

The research team treated finger millet seeds with chitosan nanoparticles. They performed an antifungal assay and found that the treated plants had reduced incidence of disease on leaves and increased yield in comparison with untreated control.

Chitosan-nanoparticles inhibit the growth of *P. grisea*. The leaves of treated plants showed accumulation of reactive oxygen species and peroxidase.

Using Western blot analysis, the scientists found three new isoforms of peroxidase polypeptide which peaked on day 50. Symptoms of blast on finger millet leaves were delayed for 25 days in contrast to 15 days in control plants. But the symptoms reappeared after this period. However, the treatment with chitosan nanoparticles showed 64% protection from fungal invasion. These results imply the utility of chitosan nanoparticles for the retardation of blast symptoms on finger millet plants.

This low cost chitosan nanoparticle technology provides hope to farmers. The same technology might also offer help with other vulnerable crops, such as rice.

*Carbohydrate Polymer*, **154**, 241–246

### A Covert Affair

*Bacteria boosts phytoremediation*

Smooth stem turnip is known for its heavy metal absorbing prowess that can restore soil fertility. But, in some cases, the plant succumbs to metal and drought stress. Scientists from the Central University of Tamil Nadu collaborated with scientists in Portugal and China, to improve the phytoremediation potential of this crop.

Certain bacteria are known to colonize the roots of various crops and boost their survival in adverse soil conditions. The scientists reasoned that bacteria capable of surviving in the

improve the growth of smooth stem turnip under stress. To test their hypothesis, they isolated bacteria from the roots of Boehmer's cat's tail and white clover – both of which are capable of growth in extreme soil conditions.

The bacterial species isolated from these plants were grown in the presence of heavy metals (copper and zinc), extreme temperatures, high salinity and low moisture to select the most resistant variety. The scientists then incubated the selected bacterial varieties with turnip seeds. The seeds were sown in soil containing heavy metals and subjected to drought stress.

At the end of the growth period, the scientists compared the health of the bacteria-inoculated plants with those that were sown without bacterial interaction. Plants incubated with bacteria exhibited an increase in photosynthetic efficiency and heavy metal accumulation. They even displayed reduced markers of stress.

Further investigation revealed that the bacterial variants used could promote the production of plant growth products and foster resistance in turnip crop. The exact mechanism still remains elusive. Scientists are, however, confident that the bio-inoculation of the bacterial species with seeds can serve as an economical way to improve the phytoremediation potential of smooth stem turnips.

*J. Hazardous Materials*, **320**, 36–44

### Determination of Time of Death

*A smartphone-based approach*

One of the most important tasks of a forensic specialist is the determination of time since death. An accurate estimate of the time since death is important for police investigations. There has been extensive research on this question. However, estimating time of death with accuracy remains a challenge. It gets harder as period of time after death increases.

Last fortnight, Niha Ansari and Shobhana K. Menon from the Gujarat University along with Anand Lodha of Ahmedabad University, reported a new and easy method for the determination of time since death. They used silver-nanoparticle based sensors for the quantification of cysteine in vitreous humor, a fluid found behind the eye lens. The amount of cysteine, an amino acid, goes up in vitreous humor after death, in a time dependent manner. The researchers used this idea to estimate the time of death.

Cysteine changes from yellow to pinkish red when silver nanoparticles are added. This can be measured accurately using a spectrophotometer. In a bold move, the researchers used a smartphone-based approach. They used the built-in camera of iPhone 5S as detector. And processed the images using Adobe Photoshop CS6.

They found that using this approach, cysteine levels as low as 0.007 μg/ml can be detected. The level of cysteine increases in vitreous humor till about 96 hours after death, and it correlates with time since death. The smartphone-based approach has limitations but can be used to accurately determine time of death for 24 hours satisfactorily.

*Biosensors Bioelectronics*, **86**, 115–121

### Titania and Chitosan

*For multifunctional cotton fabrics*

For nearly a decade, the incorporation of nanomaterials in textiles for new functionalities has gained traction. It has been used to overcome traditional problems in textiles to reduce microbial growth, and flammability and for UV protection. Last fortnight, researchers from the University of Delhi and IIT Delhi, reported the use of chitosan in combination with Titania nanoparticles to produce multifunctional cotton fabric.

Chitosan is a polysaccharide with an amine group. It develops positive charge in an acidic environment. The study found that this property of chitosan is useful in cationic dispersion and stabilization of the Titania nanoparticle in aqueous media. This improves its durability on cotton textiles. The utility of the $TiO_2$ nanoparticle is enhanced due to its self-cleaning activity and non-toxic nature.

The research team first checked the use of chitosan as a stabilizing agent for the stable dispersion of Titania nanoparticles in water. They evaluated the dispersion stability of $TiO_2$ nanoparticles, of various particle sizes and zeta potential, for long-term storage. They also looked into the effect of the molecular weight, chitosan concentrations, and the use of non-ionic polymers – polyvinyl alcohol and polyethylene glycol – as co-dispersants. The long-term storage stability and dispersion of the nanoparticles improved with increasing concentration and molecular weight of chitosan. The scientists used 100% cotton, plain weave, scoured and bleached fabric as testing material. They tested $TiO_2$–chitosan coatings on cotton fabric for self-cleaning, ultraviolet protection and antimicrobial activity.

They noticed that photocatalytic self-cleaning activity is not affected by the addition of chitosan in Titania nanoparticle dispersion. They could achieve 89% self-cleaning activity with chitosan on $TiO_2$ after 8 hours of UV exposure, in comparison to 96% without chitosan.

The treated cotton fabric has a moderate value of ultraviolet protection: factor ratings of 30–40. Antimicrobial activities were significant at 65%, even without UV exposure.

Their relatively low cost makes these nanoparticles a potential choice for reducing environmental impact. With antibacterial, UV-blocking, and self-cleaning properties, $TiO_2$–chitosan nanoparticles might contribute to reducing public health issues. Further research on alternative combinations of nanoparticles with biopolymers can help us produce multifunctional cotton fabrics for even higher performance.

*Carbohydrate Polymers*, **154**, 167–175

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