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

Reports by: **Sarah Iqbal, Chinmay Hemant Joshi, Amit Narendra Landge, H. M. Mahadeva Swamy** and **Pavithra P. Nayak**

scienceandmediaworkshops@gmail.com