Science Last Fortnight

Fighting Fungal Infections

A step towards finding the targets

Fungal organisms, especially pathogens, change their vegetative morphology reversibly between unicellular yeast and hypha for survival and proliferation in the host environment. Therefore, it is important to understand the molecular events involved in the morphological transition to target them at a biochemical level for developing different antifungal agents.

Mukund Deshpande at the CSIR-NCL, Pune, focused his attention on understanding the mechanism driving the yeast-hypha reversible transition using *Benjaminiella poitrasii*, a zygomycetous fungus, as model. This fungus produces yeast and hyphal-form cells in the vegetative phase while sporangiospores and zygospores are produced in the asexual and sexual phases. It shows a yeast-hypha transition in response to factors such as temperature, pH, glucose in the medium, etc. just like human pathogenic dimorphic fungi. But it is a non-pathogenic fungus – so safer to work with!

Ejaj Pathan, his student, started screening for morpho-genes, the molecular switches that determine the dimorphism of *Benjaminiella poitrasii*. However, to identify the correct morpho-genes, it is necessary to have the set of dependable reference genes that do not change their expression in the dimorphic transformations.

The team, along with Vandana Ghormade from the Agharkar Research Institute, Pune, has now published a paper that screened a set of 13 genes to check their potential as reference genes to understand the role of morpho-genes in *B. poitrasii*. Out of these, they identified two most stably expressed genes to normalize the expression of ornithine decarboxylase, an important biochemical correlate of the morphological transition. And this, in a way, confirmed that these two genes can be used as reference genes in the morphological transitions.

Now, drug designers can use these two reference genes to easily identify all morpho-genes and target them to block morphological transitions. A significant step in the search for better anti-fungals.

PLoS ONE, **12**(6): e0179454

Hope Springs from Hot Springs

New lead for tuberculosis

Tuberculosis has resurfaced as a life threatening disease. Existing drugs are failing as overuse has led to drug-resistant strains of the pathogens. There is a dire need for new anti-tuberculosis formulations and scaffolds.

Though researchers have isolated microbes from all kinds of extreme conditions, those from hot springs are only recently gaining attention. Hot springs house microorganisms which secrete antimicrobial compounds.

Recently, in a review, researchers from the Research Centre of Piramal Enterprises Limited, Mumbai, reported isolating an anti-tubercular compound, Fusaricidin B, from *Paenibacillus polymyxa* strains. They stumbled upon this eubacterial species while screening for microbes in soil samples around hot springs, in the Uttarkashi district of Uttarakhand.

They identified a compound, MDR-TB, active against tuberculosis. Though the findings are promising, more studies are required to assess the efficacy and safety of the compound before it can be marketed to tackle tuberculosis.

Biochemical Pharmacology, **134**: 35–41

Multiple Diseases, One Drug

A National Institute of Health 2002 report claims that 80% of microbes form biofilms in infecting their hosts. The biofilms are persistent surface-attached microbial communities. They protect the bacterial population by preventing the entry of antibiotics, leading to high morbidity and mortality in hospitalized patients. Scientists are therefore searching for therapeutic agents to control biofilm formation.

Last fortnight, researchers from the Aligarh Muslim University, in collaboration with the National Institute of Immunology, New Delhi, reported developing a nano-conjugate to prevent biofilm formation: undecyl-chitosan. They synthesized this compound by coupling an amine group of chitosan to a carboxyl group of fatty acids. Chitosan is a natural cationic polysaccharide and, in a modified form, a bacteriostatic. It is non-toxic and biodegradable. So it has been used as nanomaterial in many biological applications. The fatty acids attached to chitosan allow its entry into the biofilm to suppress bacterial growth.

The researchers tested the effect of this nano-conjugate and found that it can efficiently penetrate thick layers of biofilm and achieves 98% disruption of the biofilm, by killing the associated bacteria. The conjugate also showed broad-spectrum antibacterial activity against many Gram-positive and Gram-negative bacteria.

Unsaturated fatty acids destroy cancer cells by inducing apoptosis. So such conjugates can be designed to destroy cancer cells, without affecting healthy cells.

Humans are prone to many diseases and various drugs are sometimes administered together to cure different diseases. These drugs interact inside the body and this can produce side effects. One treatment to cure multiple diseases seems a need of the times. This nano-bioconjugate might hold hope to cure many bacterial diseases by overcoming the barrier of biofilms while preventing cancer.

Carbohydr. Polym., **166**: 14–23

Chromium Removal from Water

Eco-friendly hybrid membrane

Hexavalent chromium in wastewaters is a hazard to human and environmental health. Now, Geetha Balakrishnan, Mahesh Padaki and other scientists from the Jain University, Bengaluru, in collaboration with scientists from Thailand, report having successfully developed an eco-friendly hybrid membrane to help remove chromium from water. This membrane can also photocatalytically reduce hexavalent chromium to Cr(III). Incidentally, Cr(III) is required in trace amounts for human health.

The researchers used hydrophobic polysulphone, converting it into a hydrophilic polymer by sulphonation. They made it into a composite, incorporating nano titania. Thus, the toxic water is exposed to photoactive TiO_2 which reduces Cr(VI) to Cr(III). The addition of nanofillers improved membrane performance and application. The scientists evaluated the performance of the membranes on the basis of selectivity and time taken for separation. These parameters can be tuned by choosing the right monomer for the polymer or by surface modification of the membrane.

The researchers used spectroscopic and microscopic techniques to characterize the properties of the modified polymer and its composites. The scientists evaluated the performance according to water uptake, contact angle, pure water flux and ion exchange capacity. Their results demonstrate that the composite membranes have enhanced hydrophilicity and flux.

This hybrid membrane reduced Cr (VI) from the concentrated feed completely and photochemically converted it to Cr (III) with good selectivity and productivity. Such an efficient method to separate, reduce, and recover chromium would go a long way to protect humans and the environment.

J. Haz. Mat., **332**: 112–123

Dhapa Landfill Near Kolkata

Predicting arsenic contamination

Dhapa, on the outskirts of Kolkata, is the city's dumping ground. Around 3000 tonnes of solid waste are disposed off daily here. Hazardous materials are often found in these garbage dumps – even those that are banned from open disposal. Including arsenic, present in many solid wastes, from many industrial processes. Its accumulation leads to soil degradation and the land loses natural, agricultural and economic value. Inorganic arsenic from these contaminated soils pollutes adjoining water bodies. It is toxic and carcinogenic.

Bangladesh and West Bengal already suffer soil arsenic contamination. Is the dumping ground adding fuel to fire?

Somsubhra Chakraborty and team from the Indian Institute of Technology, Kharagpur suggests the use of Visible Near Infrared Diffuse Reflectance Spectroscopy for the rapid and cost-effective analysis of soil solid arsenic phases. They claim that it can help study polluted soils.

The scientists collected 200 soil samples from arable land adjoining the Dhapa landfill, where vegetables like cauliflower, ridge gourd and corn are cultivated and supplied to the city regularly.

http://images.indianexpress.com/2016/02/dhapa-dumping-759.jpg

The arsenic pools selected for this research study are associated with several organic and inorganic constituents of soil. So they implemented a model with a Partial Least Squares Regression algorithm in combination with three spectral pre-treatments to predict arsenic as well as five distinct arsenic pools: organic, phosphate, oxide, hydrochloride, magnesium. And they independently validated the results. They find that they can predict redox-dependent solid arsenic phases comprising oxides and sulphides reasonably well using Visible Near Infrared Diffuse Reflectance Spectroscopy. It is fast and works for the simultaneous prediction of easily mobilized and adsorbed arsenic pools in the soil.

Existing methods of soil analysis for arsenic are strenuous, expensive, and time consuming. The Visible Near Infrared Diffuse Reflectance Spectroscopy method for arsenic prediction is faster and more cost-effective. It also has the potential to rapidly screen many soil samples for other solid arsenic phases in broader geographic areas.

Geoderma, **296**: 30–37

Flip Side of Cyanide

Safe and precise monitoring

The word 'cyanide' spells danger to most. The bioaccumulation and biodegradation of this toxic substance pose a threat to human health and the environment. On the flip side, however, it plays a significant role in gold mining, tanning and electroplating.

Hydrogen cyanide, the most common form of cyanide in nature, is released into the atmosphere by the natural biogenic processes of higher plants, bacteria, fungi, etc. Of these, plants are the most significant cyanogens. Sorghum leaves produce about 192–1250 µg/g of cyanide. Other plants such as cassava, peach, pear, almond, potato, and plum are also highly cyanogenic. The most common form, cyanogenic glycoside, is present in over 2000 species of plants. The cyanide cycle in nature is linked to the nitrogen cycle.

A major part of the cyanide absorbed in the human body reacts with thiosulphate and converts it into thiocyanate, which is harmlessly excreted in urine over time. However, exposure to more than 120 mg/m^3 cyanide is dangerous and even fatal. Toxic effects occur at 0.05 mg/dl in blood. Unfortunately, there is, as yet, no sensitive and selective chemosensor to detect this toxic compound.

Now, Kuwar and other scientists from IIT, Mumbai; NMU, Jalgaon; SVNIT, Surat report designing and synthesizing a new biocompatible, reversible receptor for the online monitoring of cyanide ions in environmental and biological systems.

The researchers synthesized a supramolecular optical chemosensor using diaminomaleonitrile and benzothiazole. This is a dual purpose reversible abiotic molecular device which uses hydrogen bonds to bind cyanide and produces a change in light absorption and fluorescence.

The chemosensor is selective to cyanide ions even in the presence of other anions. The researchers used L292 cell lines to demonstrate that the sensor can be used to detect cyanide ions in biological systems without any toxic effect.

This supramolecular device will help environmentalists and biochemists monitor small amounts of cyanide ions entering a system. The reversible nature

of the chemosensor makes monitoring economic, safe and precise.

Biosensors & Bioelectronics, **92**: 95–100

Bioactive Fruit Wastes

From dumping to development

India, fruit basket of the world, is a major contributor of waste worldwide. Fruit wastes are rich in bioactive compounds such as pectin, lipids and dietary fibres. The solid remains and seed fractions of fruit processing wastes can be refined to extract many valuable chemicals. After extracting the chemicals, the wastes can be used to produce biofuels and biofertilisers. However, in practice, fruit waste is generally considered 'general waste' and discarded. Fruit processing industries use it as landfill where it contributes to pollution. Since it is rich in nutrients and moisture, it fosters microbial growth. Recent studies show that fruit wastes are a major environmental burden.

Last fortnight, scientists from the IIT Bombay and the Monash University, Australia, proposed an eco-friendly and economic model of a biorefinery for using fruit wastes. Their goal was to use this waste as starting material for the recovery and production of various co-products.

Lipids and proteins, derived in the first stage, can be used as polymers in pharmaceuticals. And the bioactive polyphenols are used as preservatives in the food and pharmaceutical industries. Recently, they have also attracted the attention of cosmetics manufacturers. Dietary fibres find value as nutritional supplement for hypertension, obesity and in antidiabetic formulations. The residue, rich in carbohydrates, can be used for the production of biofuels.

The scientists did a techno-economic evaluation to show that extraction of bioactives from fruit wastes is economically more sustainable than the traditional solid–liquid extraction methods. It consumes less energy and extracts useful products faster.

Developing countries, accustomed to use fruit processing wastes only as soil improvement additive, can now tap the potential of such waste to transform their economies.

Food Chem., **225**: 10–22

Nano Globules from Pineapple Juice

Detecting toxic metal ions

Most existing methods for detecting toxic metal ions lack the requisite sensitivity and are time-consuming. To easily detect toxic metals with high sensitivity and stability, several nanomaterials have recently been developed. Recently, S. K. Kansal and team from the Punjab University, Chandigarh, along with scientists from Saudi Arabia, reported a new candidate material: carbon nano globules from pineapple juice.

They used a simple one-step hydrothermal process to synthesize the carbon nano globules from pineapple juice. They used various analytical and spectroscopic techniques to determine the structural, morphological, thermal and optical properties of the carbon nano globules. The globules had a spongy structure and exhibited fluorescence.

They claim that fluorescent carbon nano globules from pineapple can be used as a probe to detect several hazardous metal ions, particularly chromium hexavalent ions. These nano globules drastically quenched hexavalent chromium ions with high selectivity over a range of concentrations. They are highly stable and can be used to fabricate biosensors to detect hazardous metals with ease.

This alternative means of monitoring toxic chromium ions is eco-friendly, cost effective and the raw material is readily available. It can be used for analytical, toxicological and bioremediation purposes.

Ceramics Int., **43**(9): 7011–7019

Super Hydrophilic Surface

Water does not wet the lotus leaf. Why?

Because the surface contact angle between water and leaf is high.

If the contact angle becomes zero, liquid sticks to the surface strongly making the surface super hydrophilic.

This principle has applications in solar energy conversion, heat transfer, gas sensors and anti-fogging coatings.

Last fortnight, Prakash and team, from the Pondicherry University fabricated zero contact angle surfaces by using the effects of UV illumination on the surface of titanium.

First, they used electrochemical surface modification and optimized the contact angle of the titanium surface to 3.25 degrees. Then, they coated the surface with titanium dioxide nanoparticles and that changed its hydrophilicity: the contact angle increased to 5.63 degrees. The researchers then used UV radiation to reduce the contact angle to zero.

According to the scientists, this super hydrophilicity is not only due to a reduction in contact angle but also the porous nature of the surface. Both play a critical role to increase hydrophilicity.

The scientists used a composite-drop theoretical model to deduce the interrelationship between the surface structural factors that influenced the super hydrophilic surfaces. This approach can help optimize thermal hydraulic and self-cleaning surfaces. A trick that many industries are looking for.

J. Colloid Interface Sci., **496**: 300–310

Gel Electrolytes for Solar Cells

Absorbing light from both sides

Dye-sensitized solar cells are the next big step in solar technology. The dye coats the surface of titanium dioxide (TiO_2) nanoparticles, mimics plant chlorophyll in absorbing light energy and converting it into a flow of electrons. The existing models use liquid electrolytes to allow better mobility. But they have stability issues due to evaporation. Solid-state electrolytes show better stability but register lower efficiency.

A team of scientists from the National Institute of Technology, Trichy, Karaikudi and collaborators from Italy made progress to improve efficiency and stability. The group focused on the electrolytes of the dye-sensitized cells. The electrolytes carry the charged particles to the counter electrodes. Thus, tweaking the electrolytes may help improve the performance of dye solar cells. Liquid electrolytes can be trapped in a polymer matrix as gelators. Gel polymer electrolytes, in between solid and liquid, have the advantages of both liquid and solid-state electrolytes. This helps retain the

conductivity of liquids and the stability of solids. Thus, gel electrolytes result in better efficiencies of the solar cells.

The scientists prepared a transparent gel electrolyte by incorporating thiourea, a not-so-distant derivative of urea, into a polymer of ethylene oxide. This improved the ionic conductivity and photovoltaic efficiency of the gel.

The dye-sensitized solar cells are bifacial: they can use light from both sides of the solar cell. Transparent solar cells have potential application in photovoltaic-like power generating windows that continue to work at night when you switch on lights inside the room. Further, the transparent cells can be coated with dyes of different colours to give an aesthetic feel.

J. Power Sources, **353**: 245–253

The Perfect Mix

Cement technology bolsters real estate, roads, railways and public structures. This ever growing sector propels a search for better concrete mixes. This has led to the production of high performance cement called Reactive Performance Cement or RPC. RPC has low water to cement ratio, greater binding strength, higher density and better resistance to corrosion. There are various ways of mixing cement, sand, quartz powder, silica, steel fibres, etc. to yield different types/strengths of RPC. These approaches are often indigenous and do not follow any particular methodology.

Last fortnight, Parameshwar N. Hiremath and Subhash C. Yaragal from the National Institute of Technology Karnataka, Surathkal, reported optimizing mixing methods for RPC. The mixing method, speed and duration affect the quality of RPC produced and its properties after hardening. They propose a four-stage sequential mixing of cement and silica fume, sand and quartz powder, and then water.

The scientists optimized speeds to produce a fresh mix of high quality RPC in the shortest time. They claim that this method produces RPC with better flow, strength and denser microstructure. Thus, it resolves issues in existing methods of preparing RPC.

This methodology is yet another feather in the cap of Indian scientists working on cement technology. It is economic and eco-friendly and promises to reduce civil engineering costs and benefit stakeholders.

Construct. Build. Mat., **141**: 271–288

Crossing Lingual Boundaries

A new method for text detection

Separating text from the scenery in photographic images automatically is not simple. If there are scripts of different languages and they have different orientations, the problem becomes even more complicated.

Last fortnight, researchers from the Indian Statistical Institute, Kolkata, the University of Malaya, the Nanjing University, China and the University of Mysore, Karnataka, reported a simple method for text detection from images of natural scenes. They used ring radius transform to achieve this. The method provides low radius values for pixels that are near edges, constant radius values for pixels that represent stroke width, and high radius values that represent holes created in the background as well as convex hull because of the regular structures of text components. They also applied k-means clustering on the radius matrices to group such spatially coherent regions into individual clusters. The scientists successfully used this method to separate Chinese, Bangla and English texts from a natural scene image.

They claim that this method of text detection can be applied to other multilingual scripts and plan to increase its sensitivity for text detection.

Neurocomputing, **242**: 96–112

Reports by: **D. Kavya, G. Sharath Chandra, Neeta Shrivastava, R. Baskar, Sanghamitra Deobhanj, Ashwathy Nair, Jinsu Varghese, Pudi Venkatesu, P. K. Udham, Manish Kumar Tekam, Sudarshana Dhar** and **Aditi Jain**

ACKNOWLEDGEMENT. Science Media Centre, IISER Pune, for access to scientific databases.

scienceandmediaworkshops@gmail.com