Science Last Fortnight

Pollution Solution

Removing heavy metals from water

Heavy metal pollution makes water toxic. Scientists have been exploring several low cost approaches to improve the quality of such polluted water. Das and his team from the Institute of Mineral and Material Sciences, Bhubaneswar have come up with a solution: pyrophyllite mineral waste.

Pyrophyllite, a mineral of aluminum and silicate hydroxides, has different degrees of purity. While the pure form finds use in industry, large quantities of impure pyrophyllite remain unutilized. Pyrophyllite contains negatively charged surfaces that aid the adsorption of cationic dye ions from water. Researchers figured that this property could also be used to adsorb heavy metal ions.

They tested their hypothesis by using impure pyrophyllite to adsorb lead and cadmium. And they found that the mineral can absorb about 90% of lead and 75% of cadmium from polluted water in just 30 minutes! They found that the optimum adsorption occurred at mildly acidic pH and that the degree of adsorption increases with a reduction in particle size and with increase in temperature.

Shaking the loaded mineral with mild hydrochloric acid could unload most of the lead and cadmium ions. This allows safe disposal of heavy metal ions and prepares the mineral for a second round of adsorption.

Lead and cadmium are extremely toxic. What better way to check pollution than by using a waste product?

Desalination and Water Treatment, **57**(19), 8952–8966

Stress to Strengthen Metal Sheets

Waves pave the way

Metal sheets usually experience fatigue when deformed repeatedly and become weak. So it is surprising that the metal strength actually increases with wave form deformation. Sangal from the Department of Material Science, IIT Kanpur and his peers from IIT Mumbai have developed a simple wave rolling model based on wave-form deformation to strengthen thin metal sheets.

They passed 1 mm thick Austenite steel sheets through rollers having 2 nm wave notches. The sheets underwent up to 4 rolling cycles. After each cycle, the sheets were tested for strength, hardness and microstructure. They discovered that there was almost a 3-fold increase in the tensile strength of the metal sheet after 4 successive cycles. To account for this improvement in mechanical properties, the researchers looked into the metal microstructure.

Microstructure showed presence of several faults in the rolled metal sheet. Strain reduces coarse grains into nano-sized grains. The researchers hypothesized that these changes are due to the accumulation of high strain energy in the metal and that the sub-structural evolution may be responsible for the increase in mechanical strength.

The researchers believe that this simple method of metal strengthening can be up scaled for industrial applications.

Materials and Manufacturing Processes V, **31**(6), 781–786

Solidified Natural Gas

Transportation simplified

The cost of transporting natural gas through pipes to a plant, turning it into a liquid, and then transporting it on specially equipped tankers is too high. So why not change the gas into a solid, which is easier to transport? Researchers at the National Chemical Laboratory, Pune, in collaboration with the researchers in the National University of Singapore and the Chulalongkorn University, report that they have found a way to do just that.

Natural gas, which is mostly composed of methane, can be stored in molecular form by locking it in clathrate cages with the help of hydrates. Clathrate crystals are found naturally in deep sedimentary structures and shallow marine geosphere. These crystals are harvested for methane gas from deep-ocean deposits.

Now scientists have found a technique for the rapid formation of methane hydrate using Tetrahydrofuran (THF). In this process methane gas is turned into solid hydrates. This transforms the odourless gas into small, solid packets. Thus large amounts of natural gas can be stored in a small space and transported.

THF reduces the surface tension of water and acts like a catalyst that enhances the kinetics of hydrate formation. Moreover, mixing natural gas with THF does not lead to loss of methane gas during storage. Scientists think that by the application of surfactants, it is possible to achieve equivalent or greater hydrate conversion than reported, using higher operating pressure.

Use of THF allows such solid natural gas storage at atmospheric pressure. At sub-zero storage conditions, it shows extremely slow hydrate dissociation rates and is stable. Moreover, energy recovery from SNG is relatively simple – just like melting ice using low waste heat or seawater. The flexibility on hydrate formation reduces compression and refrigeration costs, which may provide incentives for commercial scale solidified natural gas production.

Chemical Engineering Journal, **290**, 161–173

Spot the Difference

Flu and Meningitis

Detection of Bacterial Meningitis is a tricky business. Most of its early symptoms are identical to common flu. So, diagnosis is often delayed. And the conventional tests are tedious, time consuming and not very sensitive. To overcome these problems, Gupta from the University of Delhi, has devised an optical biosensor that can detect infection in blood.

The device is based on 'Surface Plasmon Resonance' – a phenomenon that can alter the angle of reflected light according to reactions taking place at the surface. The sensor contains a thin film of zinc oxide layered over core gold coated prisms. Single stranded DNA complementary to meningitidis DNA is attached to zinc oxide. This serves as the probe.

The sensor was found to be specific for its target and could distinguish between complementary and non-complementary DNA strands over a wide concentration range. The results were also replicated in clinically relevant blood serum samples.

There is an added advantage to using these sensors. After detection, the device can be regenerated by subjecting it first to hot and then to cold water. The temperature treatment denatures the hybridized strand resurrecting the sensors for a second cycle of detection. This exercise can be repeated up to 15 times without affecting the efficiency of the sensor.

The device is biocompatible and stable for about 12 weeks. With low limit of detection, high specificity and reusability, the prospects of the biosensor in clinical diagnosis for spotting the difference between meningitis and flu are highly encouraging.

Biosensor and Bioelectronics, **78**, 106–110

Treating Tuberculosis

Simulating resistance

Pyrazinamide is one of the first line treatments against tuberculosis. But recently, there has been an increase in cases of strains of *Mycobaterium* which are resistant to pyrazinamide. The threat of Tuberculosis which is unresponsive to treatment with drugs may be countered by understanding the process by which the mycobacterium acquires resistance. Studies reveal that a mutation in the gene called *panD* gene causes resistance. *PanD* codes for L-aspartate α-decarboxylase, an enzyme which is involved in formation of β-alanine. But its role in resistance is not known. Grover, from the Jawaharlal Nehru University, partnered with other scientists in New Delhi, Chandigarh and Tonk, to analyse the link.

Since the crystal structure of the protein coded by mutant *panD* is not known, they resorted to molecular modeling and computer simulations. First, they created models of mutated protein and compared it with native enzymes in terms of structure, conformation and stability. The altered mutant proteins were found to be greater in size and less stable as compared to native protein. The mutation also caused re-arrangement of the drug binding cavity and reduced its volume. This could partly explain the restricted pyrazinamide-protein interaction in the mutated form of the enzyme.

To validate their hypothesis, the researchers studied the nature of association between drug and protein through bioinformatics tools. They docked both pyrazinamide and its derivative, pyrazinoic acid, to computer generated protein models. And they found that the binding affinities of both were reduced in the mutated proteins. There was reduction in the number of hydrogen bonds formed. Other stabilizing associations such as hydrophobic interactions and electrostatic forces, were also weaker than in native-drug complexes.

By performing computer based interaction studies, the scientists have elucidated a strategy for the discovery of novel therapeutic approaches. They have 'virtually' worked out the mechanism for bacterial resistance too.

Gene, **581**(1), 31–42

All Eggs in One Basket

Achilles' heel in Leishmania

How important is a single amino acid in the vast scheme of a protein? Turns out, if the unit has been conserved during evolution spanning decades, it may even sustain life. Recently Singh and her team from the National Institute of Pharmaceutical Education and Research came across one such amino acid – Leucine-684. This particular unit is present in an enzyme of *Leishmania donovani*.

L. donovani causes the most severe form of leishmaniasis. To curb the deaths caused by this disease, scientists are continuously looking for new drug targets. Earlier studies had revealed that AMP acetyl coA synthetase, an enzyme that participates in central carbon metabolism, is absolutely essential for *L. donovani*. While studying this enzyme, scientists noticed a highly conserved leucine residue at the 684th position and decided to probe further.

Through site-directed mutagenesis, they first replaced Leucine with Proline and then compared the kinetics of the mutated protein with the native form. Mutation altered the affinity for its substrates – acetate and ATP. Moreover, acetylation, a step that regulates enzyme activity, was completely abolished.

Although elucidation of the mechanism warrants further investigation, one thing is certain: Leu-684 of the enzyme is involved in substrate recognition, catalysis and acetylation.

AMP acetyl coA synthetase isolated from *L. donovani* shares high sequence identity with other *Leishmania* species and differs significantly from its human counterpart. This makes it attractive as a drug target. Blocking its function can serve to control leishmaniasis. To think that all of this could be achieved just by targeting a single amino acid! This is what they mean when they say: do not keep all your eggs in one basket.

Gene, **580**(2), 125–133

Sensing with Paper

Diagnosis with biomarkers

Engineers in the Indian Institute of Technology, Gawahati have created paper sensors to detect α Amylase – an enzyme. The levels of Alpha Amylase, found in saliva, blood and urine, are altered in response to kidney damage, duct blockage, cancer, salivary gland infection, pregnancy and toxicity. Even though there are several methods to detect α amylase activity, the most accurate results involve the use of spectrophotometry – which is expensive, non-portable and requires skilled personnel.

Technologists in Gawahati have now created a paper sensor that can detect enzyme activity involving a simple point-of-care device that can be used by anyone.

Starch–iodine solution on paper gives a rich Prussian blue colour. Light does not go through the paper. α Amylase breaks up starch and that reduces the colour. The fading of color is directly proportional to enzyme activity. The intensity of light passing through the paper changes accordingly. The signal can be converted to a digital output: a physical readout of amylase levels.

The engineers tested their device for estimating amylase levels in human blood serum. Vitamin C, a blood constituent, was found to interfere with detection. But once Vit C was oxidized with potassium iodate, the device corroborated the serum enzyme levels estimated through standard procedures.

Health monitoring using biomarkers is believed to be the next tipping point in health industry. The paper sensors may become the next big thing in personal healthcare. This particular amylase sensor might just be the beginning.

Biosensors & Bioelectronics, **78**, 447–453

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