Science Last Fortnight

Tilted Solar Still

Basin or wick

Most countries face acute shortage of potable water. Distillation of abundantly available seawater using freely available solar energy can easily solve the problem.

Solar stills use the sun's heat to evaporate polluted or saline water to produce potable water free from salts and pathogens. One such still uses a blackened basin, with small compartments for water to be treated. The other still uses a blackened woolen wick as evaporating surface to distribute water to be treated uniformly over it by capillary action. Both types of technologies are ecofriendly. Which one is better?

Reddy and team from IIT, Chennai, recently reported a comparative study of the distillate productivity as well as the thermal and exergy efficiency of the two types of solar stills. 'To convert brackish water into potable water with tilted solar still designs is an attractive option when compared with other available solar still designs', says Reddy.

They analysed the variation in the temperature profile of the basin water, wetted wick, air–vapour mixture, and glass cover of both the type of solar stills. The researchers also took into account the variation of distillate yield with global horizontal solar radiation intensity.

They found that the annual average yield of the tilted solar still with basin is higher than that of the unit with wick. The team recorded a maximum distillate yield of nearly 5 l/d for the tilted solar still with basin. It was 4.54 l/d for the still with wick. The yearly average thermal and exergy efficiency is also higher for the unit with basin. 'Both the solar stills produced distillate of high quality. But tilted solar still with basin has higher ecological and economic benefits', says Reddy.

The energy payback time of the tilted solar still with basin is nearly three years. And the costs are about 60 rupees for 20 l of distilled water at a 12% interest rate.

Desalination, **410:** 30–54

Purifying water

Best out of agro-waste

Heavy metal waste contaminates lakes and other water bodies. Consumption of contaminated water can impair liver, kidney and nervous system. Unfortunately, current purification methods are costly, lack efficiency and produce toxic sludge.

In a recent study, scientists from IIT Indore, in collaboration with the University of Illinois and the North Carolina Chapel University, reported the use of agro-waste based nanofibres for adsorbing heavy metals from contaminated water. They prepared these nanofibers using a solution of agro-wastes such as lignin, oats, soy protein, sodium alginate and chitosan, with nylon-6. This solution was then pressurized through a nozzle to make nanofibre mats. These mats were efficient in adsorbing lead from contaminated water. They found maximum adsorption of lead on lignin and soy containing nanofibre membranes. The presence of sulfhydryl, amine, hydroxyl, carboxylic acid and phenolic groups allows maximum adsorption of lead ions on nanofibre membranes.

The scientists then studied lead adsorption under through flow conditions. They tested the nanofibre mats in a range of pH variations and found that soy nanofibers adsorbed the highest amount of lead at a pH of 4.5. Doubling membrane thickness on the adsorption pattern, they find, leads to maximum adsorption of lead.

The researchers tested the physicochemical properties of this nanofibre. They found that it has high tensile strength. The use of such inexpensive agro-waste based nanofibers is scalable to industrial level water purification.

J. Membr. Sci., **530:** 250–263

Treating Textile Wastewater

Preventing environmental hazards

The textile dyeing industry is a major cause of water pollution. It uses more than 8000 chemicals. Most of these chemicals are toxic heavy metals and organic materials. They make water turbid and foul. This prevents penetration of light and oxygen into water, thus affecting photosynthesis and marine life. Consuming such water or even coming into contact with it can cause allergies and it is often carcinogenic. Current methods for removing textile wastes from water are expensive and inefficient.

Last fortnight, Pillai and Gupta from the Indian Institute of Technology, Kharagpur, developed a model for the efficient removal of textile waste from water. They configured the reactor with a parallel plate which produced a serpentine flow pattern for the electrochemical oxidation of textile wastewater. The configuration of the reactor plates provides greater surface area so that more wastewater can be treated.

The configuration completely removed textile waste from water. The chemical oxygen demand of synthetic textile wastewater was reduced by 90%. This reactor can be used to treat both synthetic dyes and natural textile chemical pollutants in wastewater.

The World Bank estimates that nearly 20% of industrial water pollution is due to textile dyeing. Producing a pair of jeans leads to the pollution of 1800 gallons of water! The continuous flow reactor efficiently treats textile wastewater pollution and prevents environmental hazards. Moreover, the reactor consumes less energy and is less expensive than available methods.

J. Environ. Manage., **193:** 524–531

Bora Glutinous Rice

Slow digestible starch

These days, diabetes, heart disease and obesity are on the rise. And quite often sugars and carbohydrates are

blamed. Are sugars and carbohydrates bad?

Starch is a naturally occurring dietary carbohydrate. It occurs in a granular form with a semi-crystalline structure, and a major portion of it may be rapidly digestible. Slow digesting starch takes longer to break down and is considered low-glycaemic: it provides energy without spiking the blood sugar.

The nutritional quality of starch depends on its structure and processing. Last fortnight, a research team from the Department of Food Engineering and Technology, Tezpur University, Assam, reported the effects of repeated cycled crystallization on digestibility. They studied the molecular structure of glutinous Bora rice starch. This rice has high amylopectin content and is popular as snacks: flat rice, puffed rice, etc. It is also used to make rice beer.

The research team standardized the repeated cycled crystallization conditions. The best method for slow digestible starch product development, they found, is to soak Bora rice in double the amount of water, and subject it to cycles of 24 hour heating and cooling between 4°C and 45°C. The slow digestible starch content increases from about 18% to more than 80%.

Fourier transform-infrared spectroscopy and X-ray diffraction studies revealed double helical reorientation within crystalline domains in the slow digestible starch product. This confirms an increase in imperfect crystallinity and molecular order in the optimal slow digestible starch product. The research team observed an increase in crystallinity and molecular weight along with resistance to digestion, in the slow digestible starch product. The repeated destructuring and restructuring of amylopectin enhances molecular interactions within and amidst adjacent amylopectin structures. This confers protection against enzyme digestion.

These results indicate that cycled crystallization is an appropriate procedure to produce slow digestible starch. This technique can be used to develop food and pharmaceutical products for tackling obesity, diabetes and cardiovascular disease.

Food Chem., **223:** 31–39

Biosensor for Jaundice

Bilirubin, a yellow compound, breaks down heme in our body. It is useful in clearing the waste products of haemoglobin breakdown in aged red blood cells. The normal level of bilirubin in human blood is < 25 μmol and, in jaundice, it increases to >50 μmol/l. This increase may explain the yellow colour of skin in jaundice.

Bilirubin is considered a biomarker because its concentration is associated with mortality and liver-diseases. Therefore, accurate detection of bilirubin concentration in human serum is important. Available clinical methods measure conjugated and total bilirubin using a classic spectrophotometric method based on endpoint diazo reactions. These methods have drawbacks such as low stability, degradation, decolouration, etc.

Last fortnight, scientists from the Madurai Kamaraj University and the Biotechnology Division, DRDE, Madhya Pradesh reported designing a fluorescent biosensor, based on an imine molecule, which helps determine bilirubin at two different pHs – 7.4 and 9.0. The scientists used the biosensor to detect bilirubin in human blood and urine samples.

The biosensor is sensitive and selective towards bilirubin, even in the presence of other interfering biomolecules and metal ions. From the results, it is clear that this biosensor is an excellent analytical tool for the diagnosis of jaundice.

The synthesis of the sensor is simple and cost effective. And it takes about 10 minutes to make it. Commercial scale production of the sensor may simplify tedious lab procedures and hasten diagnosis.

Biosensors Bioelectronics, **91:** 82–88

Gold Nano-clusters

Boon in cancer diagnosis

Gold nanoclusters are promising carriers of biomolecules like proteins, peptides, nucleic acid and drug molecules. Their low physical, chemical and photophysical properties impart unique attributes with implications in cancer diagnosis, bacterial diagnosis and drug delivery. However, the activity of an enzyme carried by the nanoparticle is lost when its secondary structure is lost.

Last fortnight, a research team from IISER, Bhopal in collaboration with IACS, Kolkata studied the enzymatic activity of α-chymotrypsin after binding to gold nanoclusters. They investigated whether α-chymotrypsin activity was restored after the addition of glutathione or oxidized glutathione.

The researchers used circular dichroism spectroscopy for analysing changes in the α-chymotrypsin structure. They observed that the α-chymotrypsin structure changed on binding to gold nanoclusters. Upon addition of glutathione or oxidized glutathione, α-chymotrypsin, freed from the surface of the gold nanoclusters, showed that enzyme activity was restored.

Matrix-assisted laser desorption/ionization mass spectroscopy showed that 10 mM glutathione or 5 mM oxidized glutathione restored lost activities of α-chymotrypsin in gold nanoclusters by 30–45%.

In cancer cells, elevated levels of glutathione could increase the effect of enzyme-coated gold clusters. The researchers suggest that this result may have implications in diagnosis, drug delivery and cancer treatment.

J. Colloid Interface Sci., **494:** 74–81

Terribly Tiny Tales

Silver nanoparticle toxicity

Silver nanoparticles are toxic to plants and human beings. To date, most research focuses on chemically synthesized silver nanoparticles and there is insufficient material discussing the toxic effects of biologically

reduced silver nanoparticles. To fill this lacuna, Gupta from the Indian Institute of Technology, Kharagpur, constructed silver nanoparticles using Chirata leaves and studied the toxicity of these biogenic silver nanoparticles on plants.

Chirata is a medicinally important plant with amarogentin and swertiamarin, constituents that can act as phytoreductants. When scientists incubated a solution of silver nitrate with Chirata leaf extract, the colourless solution turned brown in a few minutes signifying the synthesis of silver nanoparticles. The nanoparticles were then washed, separated and characterized through spectroscopic techniques.

The researchers found that the nanoparticles produced through this method were about 20 nm in diameter and had a crystalline nature as confirmed by transmission electron microscopy, atomic force spectroscopy and X-ray diffraction studies. Next, the scientists studied the toxicity of these nanoparticles on plants and compared it with that of chemically synthesized silver nanoparticles and ionic silver.

The results reveal that, when incubated for 4 hours, these nanoparticles could introduce chromosomal aberrations in onion root cells in a dose-dependent manner. The researchers noted genotoxic defects when pollen mother cells were incubated with the nanoparticles. The results from chemically synthesized silver nanoparticles and silver ions were similar. Biologically reduced nanoparticles were less toxic to mitotic cells. However, the results mimic those obtained when plants are incubated with silver ions.

Nanoparticles tend to accumulate in cells. Thus, they can affect plant growth, development and reproduction. To address this, the scientists suggest research on signal proteins and regulations on industrial practices to minimize the release of nanoparticles into the environment. The results also highlight the need for labs to formulate safety rules that take nanoparticle toxicity into account.

J. Hazardous Materials, **330:** 18–28

Breaking the Mould

Fungus for biofuel production

Sweet sorghum bagasse contains 75% carbohydrates and can be utilized for biofuel production. But a large part of these sugars remains trapped in a lignin network which reduces fermentable sugar yield. To solve this problem, scientists at the Dr B. R. A. National Institute of Technology, Punjab explored the possibility of using fungus variants to release unused carbohydrates by digesting lignin.

The research team collected sweet sorghum waste. They washed, dried and ground it to a fine powder. Based on existing literature on lignocellulolytic activity, the scientists accessed eight different fungal strains from microbial culture facilities. Then they tested these fungal strains on sorghum waste. They checked for lignin digesting enzyme activities, sugar release, and carbohydrate consumption. Of the eight strains tested, *Coriolus versicolor* turned out to be the most efficient in terms of lignin digested for every unit of carbohydrate consumed.

Since enzyme activity could be enhanced by certain metallic and non-metallic factors, scientists incubated a sorghum waste solution containing *C. versicolor* with different additives to identify the optimum culture composition for fermentable sugar production. The researchers found that a combination of syringic acid with copper sulphate exhibited maximum lignin digestion by the 20th day with a minimal loss in cellulose content.

FTIR spectrometry and X-ray diffraction studies confirmed a decrease in the crystallinity associated with biomass due to this treatment. The scientists noticed that this shift occurs due to enhanced enzyme activity that leads to greater utilization of hemicelluloses instead of cellulose. This, in turn, improves sugar extraction.

Use of the right fungus species increases lignin degradation almost two fold and improves fermentable sugar production almost five fold. With the addition of supplements, the system becomes twice as efficient. These are highly significant results and the scientists are confident that such combinations can make commercial scale fuel production from agricultural biomass attractive.

J. Environ. Manage., **193:** 558–566

Photocatalysts

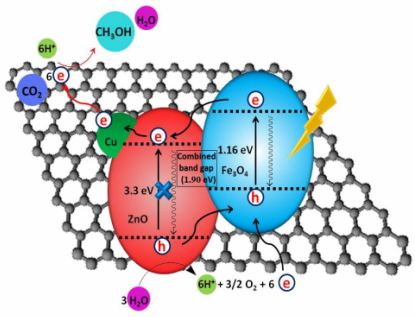
Reducing carbon dioxide

Carbon dioxide emission is increasing with the rise in consumption of fossil fuels. By converting carbon dioxide into useful hydrocarbons we can perhaps better protect the environment. This can be done with chemical, electrochemical, biological and photochemical means. Among these, a photochemical method that mimics photosynthesis has come into prominence recently.

Last fortnight, scientists from the Indian Institute of Petroleum, Dehradun reported the selective reduction of carbon dioxide using a heterogeneous photocatalyst.

Metal oxides such as TiO_2, ZnO, Fe_2O_3, rGO are transparent, have high specific surface area and light absorption capability. They arrange electronic structure with high mobility of charge carriers under stimulation with light energy. The research team examined the photoreduction of carbon dioxide with water to methanol, under visible light irradiation. They tested different combinations of graphene oxide and metal oxides under identical conditions. These were quantified with chemical and structural characterizations to improve photocatalytic performance. The team thus developed a multicomponent photocatalyst with a minimal quantity of graphene oxide wrapped in microspheres of $CuZnO@Fe_3O_4$. The core-shell structured composite – $rGO@CuZnO@Fe_3O_4$ – is effective

in the photoreduction of carbon dioxide with water splitting.



The product combines the higher surface area and electronic mobility provided by graphene, the magnetic property of ferric oxide and the eco-friendliness of zinc oxide to yield higher methanol. The photocatalyst was more efficient, recyclable and low-cost than existing catalysts. Biocompatibility and good mechanical strength are added benefits.

Appl. Catal. B, **205:** 654–665

Supercapacitors

Efficient storage devices

There are two types of high power density electrochemical energy storage devices or supercapacitors: electrical double layer capacitors or pseudocapacitors. Double layer capacitors use carbon materials whereas pseudocapacitors use transition metal oxides. The mechanisms and properties of these storage devices are, therefore, different. Double layer capacitors depend on ion adsorption and pseudocapacitors use redox reactions for storing electrical charges. Double layer capacitors have a longer cycle life while pseudo capacitors have high specific capacitance. For efficient storage and to maintain high power density, both qualities are essential. How can this be achieved?

Last fortnight, researchers from the Osmania University, Hyderabad, reported combining both qualities – high cycle life and high specific capacitance – in a new supercapacitor. They took two types of materials – one that is generally used in double layer capacitors and the other, in pseudocapacitors – to prepare a ternary composite. The team adopted an *in situ* chemical polymerisation method. And they deployed this composite as positive electrode in their supercapacitor. Such capacitors had both high specific capacitance and longer life cycle.

The specific capacitance of the device is 525 F/g, higher than that of double layer or of pseudocapacitors. The team attributes the high power density to the nano-structure of the composite.

J. Ind. Eng. Chem., **49:** 82–87

Synthetic Voice

Individuality of voice is an important aspect of personality. A voice conversion system plays with this to make one voice sound like another and even change the gender of a voice. This system finds application in audio dubbing, audition testing, audio-based learning tools, voice restoration, voice pathology, text-to-speech synthesis and security related matters. While retaining linguistic information, the system modifies various acoustic factors – frequency of utterance, and tone of speech – parameters that determine the quality and clarity of the converted voice.

Scientists from the KJS College of Engineering, Mumbai, the SVNIT Surat and the VJIT Mumbai, collaborated on a new algorithm-based method for better quality in voice conversion. They used two male and two female voices for intergender and intragender voice conversions. That gave four combinations for their conversions – male to male, male to female; female to female and female to male.

All four speakers uttered 70 sentences with similar linguistic information. The researchers used 40 utterances to extract acoustic parameters and 30 for voice conversion.

To evaluate the quality of the converted voice, and its match with the original voice, the scientists used two independent methods: mathematical calculations and assessment by 12 non-expert listeners. Both revealed acceptable quality that matches the original.

With the help of this technology, soon we may all be able to sing in Madonna's voice.

Neurocomputing, **237:** 39–49

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