Science Last Fortnight

De-fluoridating Water

Ionic liquid-functionalized alumina

Fluoride in drinking water causes dental and skeletal problems. Water is defluoridated by precipitation, electrocoagulation, electrodialysis, membrane filtration, ion exchange or adsorption. Adsorption has proved the most promising among these methods. Hydroxyapatite, activated carbon, metal oxide, clays, chitin-chitosan, alum, lime and activated alumina are commonly used as adsorbent.

Last fortnight, Patel and co-workers from the National Institute of Technology, Rourkela, reported synthesizing a new adsorbent: ionic liquid-functionalized alumina. Activated alumina is widely used as adsorbent to remove fluoride. However, it has limitations: at higher pH fluoride adsorption is reduced and there is leaching of aluminium.

The researchers used La^{3+} modified and alum-impregnated activated alumina as well as mesoporous alumina, with an anionic surfactant. They reported an increase in adsorption due to this modification. Since it has affinity to fluoride, it is effective for the removal of fluoride from contaminated water.

The team examined the shape, size, morphology, structure, chemical composition and phase of the material using Fourier transform infrared spectroscopy, X-ray powder diffraction, thermogravimetric analysis, N_2 adsorption–desorption isotherm, transmission electron microscopy, X-ray spectroscopy elemental mapping, field emission scanning electron microscopy, and X-ray photoelectron spectroscopy. These tests validated the adsorbent capacity. The reasons for high adsorption include electrostatic interaction and ion exchange.

'Ionic liquid-functionalized alumina as an adsorbent for fluoride removal has not been demonstrated earlier', says Patel. Alumina release is a major consideration in fluoride removal using activated alumina or alumina-based composites. It leads to secondary aluminium contamination in water. Aluminium exposure is also a risk factor for the Alzheimer disease. 'The amount of aluminium released by this alumina absorbent is far below WHO drinking water standards' add the researchers. This material might prove useful to overcome fluoride contamination in water.

J. Clean. Prod., **151**, 303–318

Cucumber Peels

Removing lead from water

Lead contaminates water bodies and in humans, chronic intake can result in kidney, liver and brain damage. It also leads to dizziness, depression and loss of memory.

Last fortnight, scientists at the Jadavpur University and the Indian Association for the Cultivation of Science, Kolkata, reported a simple method to remove lead from polluted water using cucumber peels. They did a series of analyses to study the moisture, ash, cellulose, hemicellulose and lignin content of the peels to evaluate its use as adsorbent. Thermogravimetric analysis demonstrated that, among the three biopolymers, hemicellulose degraded fastest and lignin slowest with rise in temperature. Zeta potential measurements further revealed that surface charge of cucumber peel biomass is primarily negative at pH above 2. This helps in lead absorption.

Using scanning electron microscopy, energy dispersive X-ray analysis, X-ray diffraction analysis and Fourier transform infrared spectroscopy they studied the morphological properties of the peels. Various chemical modifications of functional groups revealed significant role of carboxyl and phosphate groups in adsorption of lead.

The researchers also tested adsorption of lead by cucumber peels in the presence of cadmium and confirmed that the peels adsorb lead even in the presence of the co-ion. Further, desorption experiments showed that lead can be efficiently desorbed and the peels can be reused, making them a cost effective material.

Entrepreneurs and bioengineers can now develop materials based on cucumber peels for green and clean water filtering units!

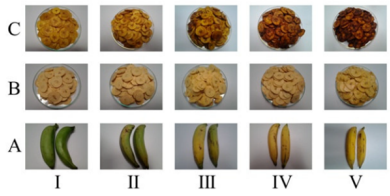
J. Clean. Prod., **151**, 603–615

Safe Banana Snacks

Reducing toxicity in banana chips

Acrylamide is a contaminant in high temperature processed food products such as banana chips. Since banana is a rich source of carbohydrate, acrylamide forms when bananas are deep fried. This depends on whether the banana is ripe or not. However, we lack precise data on how maturity affects acrylamide formation.

Nisha and team, from the CSIR-National Institute for Interdisciplinary Science and Technology, Thiruvananthapuram, recently analysed chemical changes during the different ripening stages of the *Nendran* banana and correlated them with acrylamide formation.



The scientists detected and quantified the precursors of carbohydrates, proteins, and polyphenols using the HPLC method. In all five ripening stages, they correlated reducing sugars, amino acids, as well as total phenolic and flavonoid content using Pearson's correlation coefficient.

The team found that reducing sugars, such as glucose and fructose, showed a positive correlation with acrylamide formation whereas amino acids showed poor correlation. The total phenolic content showed a decline. The flavonoid content in the unripe stage is significantly higher than that in the ripened stage of plantain.

The banana chip makers can now select the most appropriately ripened bananas to reduce the level of acrylamide.

Food Chem., **222**, 53–60

Diabetic Retinopathy

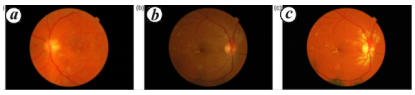
Better image processing

Diabetes, a dreadful disease in itself, also affects vision. Diabetic retinopathy, one such complication, can cause irreparable damage to the blood vessels of the retina. Though it may initially show no symptoms or only appear as

mild vision problems, it can cause blindness if untreated.

Last fortnight a team of scientists, from the Amity School of Engineering and Technology, Noida, proposed an automatic image processing method to efficiently detect and accurately grade the severity of diabetic retinopathy. They took images of the ocular fundus or inner lining of the eye with a special camera. And used an algorithm to do a region-based computation of the image.

Three pre-processing steps are done to detect exudates, protein coagulations in the fundus: first, colour is normalized, then contrast is enhanced, and, lastly, background shade is corrected. This region-based identification of various abnormalities is much faster and has less complexity.



(***a***) Fundus image (reference for normalization), (***b***) input image, (***c***) colour normalized image.

In existing methods, algorithms use the image of the entire fundus. This takes more time and requires additional methods for grading the severity of the disease. In the proposed method, however, the region around the macula, an oval-shaped pigmented area near the centre of the retina, is segmented into various sub-regions. Diabetic retinopathy affects each sub-region in varying degrees of severity. This method provides more accurate, better quality results.

Another important finding of this research is that any future detection algorithm can be adapted to this region-based scheme to reduce excess computational time. This study can also inspire researchers to find methods for classifying other stages of diabetic retinopathy.

Comput. Methods Biomech. Biomed. Eng., **5**(3), 195–207

Diabetic Cardiovascular Diseases

Role of lipoic acid synthase

Diabetes, a major health concern in itself, is also associated with cardiovascular disease, a leading cause of mortality. Research has shown that there is a link between diabetic cardiovascular diseases and oxidative stress which leads to mitochondrial dysfunction and also plays a role in the progression of the condition. An essential cofactor for several mitochondrial enzymes is lipoic acid which participates in glucose metabolism. It also serves as mitochondrial antioxidant. Recently, lipoic acid synthase has been identified in mammals. However, its role is not yet completely understood. Lack of structural information about the enzyme is hurdle to understanding its structure and function.

Last fortnight, researchers at the Prof. M. Viswanathan Diabetes Research Centre, Chennai, studied the enzyme that synthesizes lipoic acid. They predicted the structure of lipoic acid synthase from humans, using lipoyl synthase from the bacteria, *Thermosynechococcus elongatus*. Then, they predicted how the substrate, S-adenosylmethionine, interacts in the active site of the enzyme through molecular docking. Since they did structure prediction and docking studies in the absence of water, the predicted interactions were not reliable. So, they performed molecular dynamics simulation in the presence of water to mimic the environment of living systems.

The scientists found that the predicted structure of human lipoic acid synthase and its interaction with substrates is reliable. This knowledge might serve as starting point to design and develop drugs for diabetic cardiovascular diseases.

J. Theor. Biol., **420**, 259–266

Effective Drug Delivery

Alginate–gelatin polymer blends

The mode of administration of a drug can greatly affect its therapeutic action: pills, injections… Rate of release of the drug is also a governing factor. Various polymers, synthetic and biological, for the controlled delivery of drugs have been studied. Biopolymers have advantages over synthetic polymers and are also more suitable for oral administration. However, it is a challenge to maintain superior drug adsorption capacity, stability and sustained release with a single polymer.

Last fortnight, a team of researchers from the Indian Institute of Technology, Kharagpur, developed a blended polymer from alginate and gelatin with better adsorption, stability and sustained release. The alginate provides excellent absorption capacity while the gelatin gives mechanical strength.

To obtain the polymer blend, the researchers mixed sodium alginate and gelatin in distilled water and cooled it to 4°C in the presence of a surfactant for 12 hours. The consequent crosslinking of one of the polymers ensures that the entire mixture forms a uniform gel matrix.

The researchers soaked this matrix with vitamin B12 and tested it for controlled release at different temperatures and pH. The drug-coated matrix showed better adsorption and controlled release. Variation in temperature did not affect rate of release and stability.

There is a growing need to formulate dosage forms for the controlled release of drugs. The alginate–gelatin matrix offers a prolonged therapeutic effect at reduced dosing frequency. Drugs can thus be effectively delivered orally to cure many diseases.

J. Appl. Polym. Sci., **134**(18), 44787

Salve for Skin Cancers

Increased interest in skin cancer has focused attention on drug delivery. While many ailments can be cured by popping pills, in skin cancer, delivery via skin is the preferred mode. It is effective and its action is localized. Thus, side effects need not impact the whole body. However, such delivery has to penetrate several skin layers.

Last fortnight, Sahu and team from the Dr Harisingh Gour University, Sagar, used eucalyptus oil to coat a biodegradable nanogel polymer, entrapping 5-fluorouracil, a cancer drug, to increase penetration to the stratum corneum. The scientists assessed penetration efficiency, drug release capacity and drug release patterns on both human keratinocyte cell lines and pig skin. Their results showed that neither the coated nanogel nor drug release impacted the eucalyptus coating.

These findings indicate that this modification has the potential to overcome problems of drug penetration during skin delivery. Further validation with clinical trials can lead to better formulations for therapy.

J. Control. Rel., **253**, 122–136

Linen Shines Whiter

Linen, a bast fibre from flax, is gaining popularity as textile. It has natural gum and wax-like impurities that need to be removed before it can be used as textile. It is a difficult fabric to pre-treat for desired levels of absorbency and whiteness. Bleaching and scouring with chemicals during pretreatment often damage the fabric. The reduction in the fabric's tensile strength and texture needed addressing by researchers.

Abhishek C. Jadhav and Sanjeev R. Shukla from the Institute of Chemical Technology, Mumbai, collaborated with DyStar India Pvt Ltd to achieve a higher whiteness index while retaining the physicochemical properties of the fabric. The scientists adopted a method of cold oxidative bleaching, followed by wet on wet pad-steam scouring and bleaching. The pad-steamed and bleached fabric was then pad-dried.

The combined method of scouring and bleaching cleared the impurities, while maintaining the pH balance of the fabric. The scientists used an optical bleaching agent to consistently obtain a base whiteness at industrially accepted standards. The whiteness was also higher on a wash fastness rating with a lesser drop in tensile strength.

This process proved cost effective since it consumed less water and electricity. Moreover, it needed less labour. Linen can thus be made more economical and eco-friendly.

J. Text. Inst., **108**, 657–663

Eco-friendly Surfactants

The discharge of unprocessed synthetic surfactants into sewage systems or water bodies affects aquatic organisms and ecosystems. These surface-active agents are widely used as detergents. They help remove dirt from solid surfaces and trap it in suspension. Recently, there has been interest in exploring natural surfactants from plants, bacteria and fungi. Amongst plant-based surfactants, saponins are well known.

Last fortnight, researchers from the Sikkim University reported the use of saponins from *Zephyranthes carinata* Herbert, *Pyagi phool* or Pink Rain Lily, and *Sapindus mukorossi* Gaertn, *Ritha* or soap nut. Though we know that the first, an ornamental plant, is used to treat fever in Chinese medicine, and that the second is a cleaning agent, we still lack adequate information on the activity of their surfactants.

The team investigated the efficiency *Pyagi phool* bulbs and *Ritha* pods as natural surfactants by extracting their saponins in an aqueous solution. The scientists tested their foaming ability and stability, surface tension, viscosity, emulsification, wetting, cleaning and dirt dispersion properties. And compared these with those of Henko, a commercial surfactant. Saponins from the plants had better surface activity.

These plant materials are low-cost, biodegradable, renewable and easy to handle. Enhancing such alternative surfactants could make them candidates for industrial applications and reduce environmental problems posed by synthetic surfactants.

J. Clean. Prod., **150**, 127–134

Climate Responsive Architecture
Golconde dormitories

Air conditioners, coolers, fans and refrigerators are unavoidable in India, most regions of which experience a warm and humid tropical climate. This results in huge energy consumption. Ventilated buildings such as the Golconde dormitories, Puducherry, are an example of climate responsive architectural solutions. The 3-floor building has 51 rooms and a semi-basement. The longer axis of the building is oriented north-south with a tilt towards the south. The east and west walls contain small openings to decrease solar heat gain. Both north and south fronts of the building have horizontal asbestos cement louvers adjustable using levers.

Recently, Mona Doctor-Pingel and other scientists at the Centre for Scientific Research (CSR), Auroville, conducted a case-study on the Golconde dormitories. They continuously monitored the thermal performance of the building over one and a half years.

They found that the ventilated double roof, with an air gap of about 10–30 cm, acts as thermal insulator. The basement passage has significantly lower temperatures due to the landscaping strategy in the north and south gardens which creates a pressure difference. This leads to continuous air movement in the passage. The corridors in the north, connecting the rooms, are a buffer zone, reducing temperature inside the rooms. The louvers on the corridors protect the building from sun, wind and rain but allow ventilation.

The findings of this study can be used for constructing climate responsive buildings in other places. A good understanding of local climate and the use of passive design principles can help reduce energy demand and consumption.

Architect. Sci. Rev., **60**(3), 205–214

Waste as Cement Substitute
Efficient use of fluorogypsum

The disposal of fluorogypsum, a by-product of the hydrofluoric acid industry, poses a threat to the environment. Though there is research on repurposing value-added building products from by-products such as fly ash, blast furnace slag and phosphogypsum, we still lack precise data on the effective utilization of fluorogypsum.

Last fortnight, Garg and team from the Central Building Research Institute, Roorkee, developed a cement-free binder from fluorogypsum. They first mixed fluorogypsum with different chemical activators and examined setting time, compressive and flexural strength. The researchers found that the combination of fluorogypsum with anhydrous calcium chloride and sodium sulphate exhibited low setting time, high flexural strength and compressive strength.

They then tested the water absorption and porosity of the cement-free binder. The fluorogypsum binder showed lower water absorption and porosity, as well as higher strength than other cement compositions.

Scanning electron microscopy of the cement-free binder revealed prismatic, needle-shaped crystals with sharp boundaries which make the matrix dense and compact. This change in the morphology of the material explains the reduction in water absorption, porosity, and the enhancement in strength.

The team also tested this cement-free binder for use in masonry mortars, concrete, lightweight blocks and tiles. Masonry mortars prepared with fluorogypsum binder were excellent for use in plastering and masonry works. Fluorogypsum, once a waste by-product, now has potential as a new generation supplementary binder.

Eur. J. Environ. Civil Eng., **21**(5), 612–628

Freedom from Fossil Fuel

Solar airplanes and cars to solar powered airports! With fossil fuels dwindling, recent years have seen a surge towards solar energy. While solar technologies have been successful for small scale and domestic use, large scale heating processes in industries remain a challenge: the intermittence of sunlight, generation of heat to required temperature ranges for specific processes... These challenges require an understanding of the various parameters involved in collecting and converting solar energy for use in industries.

Recently, a team of researchers from the Centre for Study of Science, Technology and Policy, Bengaluru, developed a new methodology to estimate the potential of solar energy for heating processes in larger industries. N. S. Suresh and Badri S. Rao took various parameters into account to assess the feasibility of integrating solar collectors in industries: process operating temperatures to select the right kind of solar collectors, the size of the solar field along with thermal heat loads, type of working fluid used for heat generation, efficiency of the chosen solar collectors, location-based solar irradiance, etc.

They tested and quantified the potential of implementing the methodology in selected textile, pulp and paper, dairy, leather and automobile industries. These industries are highly energy demanding and depend on fossil fuels for operation. To approximate the viability of solar energy systems in industries, the researchers carried out a techno-economic analysis of the proposed methodology using the System Advisor Model software.

The results have strategic implications in the energy sector and large scale industries dependent on fossil fuels. Contrary to existing beliefs, the results indicate possibilities of integrating solar thermal collectors for process heating in industries and their gross potential. The study recommends the best solar collectors for various purposes and demonstrates the economic benefits in terms of capital cost, fuel oil savings, rates of returns, etc… It highlights environmental benefits in terms of carbon savings. The team also has policy recommendations to reduce the use of fossil fuels.

J. Clean. Prod., **151**, 439–451

Sourcing Fuel from Seaweed

Strange though it may sound, seaweed could now prove to be a viable alternative in the production of biofuel. Seaweed or microalgae thrive on nutrients from the sea. They are mostly cultivated for specialty food products. Seaweed biomass is rich in carbohydrates which can be converted to sugars. Thus they have potential as biofuel feedstock. But the fermentation of these sugars is difficult owing to their chemical composition.

Now, a research team from the MCRC, Chennai, in collaboration with the Alagappa University, Karaikudi, demonstrates that seaweed and its spent biomass can provide a renewable source for bioethanol production. They used spent biomass, from shade-dried red and brown seaweed to produce ethanol by biosaccharification–marine bacterial consortia to convert the complex carbohydrates into sugars and marine yeast for fermentation.

There was significant loss of sugars after the removal of pigments, phycocolloids, and pigment-phycocolloids when compared to its fresh biomass. They used two methods for the saccharification of the spent biomass: mild acid and marine bacterial consortia.

Total carbohydrate was greater in the fresh seaweeds *Gracilaria corticata* and *Sargassum wightii*, than the spent seaweed biomass. The industrial spent samples recorded higher reducing sugar production. The mild acid pretreatment followed by bacterial consortia recorded more sugar conversion and ethanol production than the samples subjected to bacterial saccharification.

The isolated marine yeast, *Meyerozyma guilliermondii*, produced maximum ethanol from spent biomass –2.74 and 1.72 g/l in *Sargassum ilicifolium* and *Gracilaria corticata* respectively. The spent biomass from the agar and alginate industry gave higher amount of ethanol –2.34 and 2.60 g/l of respectively, through saccharification using acid plus bacterial consortia and marine yeast fermentation.

The study concludes that seaweed solid wastes (spent biomass) can also be used as substrate for bioethanol production. Since 2/3rd of the earth is covered by seas, seaweeds appear to be a rich source of ethanol capable of meeting the global demand for transport fuel.

Renewable Energy, **105**, 133–139

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