Science Last Fortnight

Bacterial Hydrogen Production

Hydrogen is an alternative fuel for the future. It releases three times more energy than gasoline and does not produce any greenhouse gases upon burning, only water. But the current methods for producing hydrogen are unreliable and cost intensive. To optimize hydrogen production, scientists are now looking at biological pathways which require less energy input. In the last fortnight, a team of scientists from the R&D Centre of the Indian Oil Corporation examined whey waste as a potential feedstock for hydrogen production.

Biological hydrogen production suffers from low yield, incomplete substrate conversion and its partial conversion into organic acids. Thus industrial effluents containing low quantities of reducing sugar are found to be attractive sources for commercial hydrogen production. One such source is Cheese whey. It is abundantly available and does not require complex pretreatment like other agricultural waste. The scientists examined hydrogen production from cheese whey upon fermentation using *Clostridium* sp. IODB-O3 – an in-house bacterial strain isolated from sewage. Results show that whey fermentation produced a greater volume of hydrogen than mixtures containing either only lactose or glucose – the main sugars involved in fermentation, suggesting that cheese whey is rich in components that favour hydrogen production. The researchers also compared the hydrogen output in batches containing only the *Clostridium* strain and those containing normal flora along with the *Clostridium* species. *Clostridium* strain IODB-O3 was found to be superior to other strains present in whey for hydrogen production. Finally, carbon distribution studies carried out by the scientists suggest new paths for the conversion of whey metabolites into hydrogen. The time, it seems, is ripe to start developing a new industrial process for hydrogen production along with cheese.

Renewable Energy, **98**, 221–225

Furniture to the Rescue

Deodar wood shavings for biofuel

In the recent past, several studies have reported encouraging levels of fuel production from the barks of various trees. But biofuel yield is sensitive to pyrolysis conditions. Hence, in the last fortnight, researchers from the Indian Institute of Petroleum, Delhi, studied the pyrolysis of Deodar wood under different ambient conditions.

The scientists determined the fuel production under hydrogen and nitrogen atmospheres at different temperatures and pressures. Results show that under a hydrogen atmosphere, wood produces the greatest amount of biofuel at 400 degrees but in a nitrogen atmosphere, the most efficient fuel production was recorded at 350 degrees. Further rise in temperature resulted in a rise in biogas production while the quantity of biofuel and biochar reduced.

The scientists also examined the biofuel and biochar obtained at each temperature–pressure combination. In the presence of hydrogen, cleavage within the macromolecular structure of the biomass was found to be systematic while in the presence of nitrogen, it was random.

The scientists believe that the differences in the composition of products are mainly due to differences in the reaction mechanism. Bio-oils obtained under the nitrogen atmosphere mostly comprised phenolic compounds while those obtained under a hydrogen atmosphere mainly consisted of phenolics and alcohol ethers. An increase in pressure increased saturation among the products.

Deodar trees are an important part of forest cover. The wood sourced from these trees is heavily used for manufacturing furniture. As such, using sawmill shavings as feedstock will also resolve the food versus fuel debates surrounding biofuel production. The findings of this study will help design sustainable solutions for biofuel production.

Renewable Energy, **98**, 238–244

Enzymes for Water Purification

Extending the life of membrane filters

Most modern water purifiers use membrane ultrafilters to keep water pure and free from particles. But many common substances present in water can get embedded in the filter matrix and cause fouling. This compromises the quality of the membrane and subsequently water purification.

A team of researchers led by Vayalam P. Venugopalan has used enzymes to solve this problem. In this multi-institute study, scientists from the Bhabha Atomic Research Center, Tamil Nadu, and the Homi Bhabha National Institute, Mumbai, partnered with scientists at the National Institute of Ocean Technology. Instead of resorting to chemical means that hamper membrane life in the long run, the scientists decided to target an important pollutant – alginate – which causes membrane fouling.

The model consists of a dead end cell fitted with cellulose acetate membrane which is susceptible to fouling and disintegration. The membrane is crosslinked with an enzyme – Alginate lyase – that decomposes alginate.

Water containing alginate was passed through the membrane and it was left to foul for 3 hours. Then they washed the membrane with pure water and examined the effluent for residual alginate. The performance of the membrane was evaluated after each cycle.

Results show that even as raw membranes lost 20% of the flux flow after each fouling cycle, the membranes crosslinked with Alginate lyase were less susceptible to fouling. The activity was enhanced after successive backwashing after fouling. Membrane integrity, studied through microscopy, confirms the formation of cake or debris over raw membranes. The effect was less pronounced in enzyme-linked membranes. The debris could easily be removed by washing with Millipore water.

This method is energy efficient and reduces the need for chemical treatment of membranes that could, in turn,

improve the life and performance of the membranes in the long run. It is expected that membrane technology for water purification will see other similar advances by assimilating enzyme technology.

Chemosphere, **165**, 144–151

Effective Ocular Delivery

Bacterial eye infections lead to low vision and blindness. According to the WHO, twenty million Asians are blind. There are treatments to prevent or delay vision loss. But drug delivery to the eye is a challenging task. Topical eye drops are the most convenient and patient compliant route of drug administration. However, the absorption of drugs in the eye is severely limited because of the anatomy, physiology and biochemistry of the eye.

A group of researchers from the Bundelkhand University, Jhansi, and the Sam Higginbottom Institute of Agriculture, Allahabad, developed a gelatin nanoparticle loaded with moxifloxacin, a fourth-generation antibacterial agent, effective in curing bacterial infections of the eye. The scientists used a simple two-step process. First, acetone was mixed with moxifloxacin. Then, glutaraldehyde was added to crosslink the nanoparticles.

They checked the biocompatibility and safety of this formulation on the corneal surface using ocular irritation test and assessed drug release on the cornea layer *in vivo*, using rabbits.

The results show that drug loaded nano-formulation is non-irritant to the ocular tissues. It is safe and biocompatible. Moreover, the formulation facilitates sustained release of the drug and shows enhanced antibacterial activity against *Staphylococcus aureus* compared to commercially available drug delivery products.

Compared to conventional topical drops, this gelatin-based nanoformulation surpasses ocular barriers and associated side effects. Moreover, the formulation is easy to prepare. Further clinical trials are necessary to bring the formulation to the market.

J. Colloid Interface Sci., **483**, 132–138

Cinammoum verum from Mizoram

Is essential oil healthy?

Cinnamon bark is a widely used spice. It is used in the preparation of chocolates, sweet dishes, rices, savory non-vegitarian dishes. A number of species such as Ceylon cinnamon, Indonesian cinnamon, Vietnamese cinnamon, Chinese cinnamon and Indian cinnamon are being used worldwide. Ceylon cinnamon – *Cinnamomum verum*, is the most important source of cinnamon bark and leaf oil in the world trade.

India also produces *C. verum*, especially in Kerala, Karnataka and Mizoram. Lydia Malsawmtluangi from Mizoram collaborated with scientists in Garhwal and Italy to study the essential oil composition of *Cinammoum verum* of Mizoram and they found variations in essential oil composition of the trees growing naturally in Mizoram. Ceylon cinnamon has negligible amounts of coumarin. But compounds like borneol, a terpene which easily oxidized to ketone, and styrene, a hydrocarbon, are two toxic chemicals found in stem, bark and leaf oil of *C. verum* from Mizoram.

Scientists also found that *C. verum* from Mizoram is rich in methyl cinnamate and eugenol derivatives. These are important for cosmetics and can be used as flavouring and food additives. Scientists suggest more studies on eugenol and cinnamaldehyde content and the effect of plant age on their concentration. This will help in assessing the commercial viability of harvesting essential oil constituents from *C. verum* of Mizoram.

J. Essential Oil Res., **28**(6), 551–556

Predicting Facial Features

Facial features change slowly as we age. These features are also reflected in the images of those faces. This information can be extracted using computer algorithms. But there are constraints. Calculating the age from images is a challenge because ageing varies from person to person depending upon genetics, gender, life style, consumption habits and even external conditions such as weather and climate.

Jayant Jagtap and Manish Kokare, from the Shri Guru Govind Singhji Institute of Engineering and Technology, Nanded, Maharashtra, have found an improved method for determining age. They used facial skin ageing features and Artificial Neural Networks to do this.

Facial skin ageing features are extracted from face images using Local Gabor Binary Pattern Histogram, a non-statistical approach for face modelling, where histograms of all the local regions are linked to model the face as a sequence. These are more efficient than conventional binary features. Then they used wrinkle analysis. Wrinkles are a good indicator of loosening of the skin, which shows the ageing process.

Artificial Neural Networks help the machine mimic brain activity and learn. Artificial Neural Network, in this case, is designed as a two layer feedforward back propagation neural network. In the feedforward network, the information travels from the input nodes to the output nodes. In the back-propagation algorithm, the output is calculated against the desired result. If the result is not satisfactory, then the connections between layers are modified and the process is repeated to minimize the error.

The scientists tested the system with 120 male face images and 240 female face images from the face database of the Park Ageing Mind Laboratory. The system showed an accuracy of 94.17% for male and 93.75% for female – a significant improvement over the existing method.

Human age classification has potential application in Age Specific Human Computer Interaction, Intelligent Intensive Care Unit as well as in Electronic Customer Relationship Management.

Cognitive Systems Res., **40**, 116–128

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Reports by **Sarah Iqbal, P. Vijisha, G. Sharath Chandra, S. Pushpanjali**
scienceandmediaworkshops@gmail.com