

Science Last Fortnight

Detecting Iron

In drinking water

Drinking water contains varying levels of iron. Iron is essential for haemoglobin formation but high consumption causes health issues such as heart disease, arthritis, diabetes, liver disease and risk of cancer. High levels also impart an unpleasant taste and odour to drinking water and the use of such water for household chores can lead to brown stains on utensils and clothes. According to the World Health Organization, the permissible limit for iron in drinking water is 2 mg/l. Unfortunately, current methods to check iron in water are not sensitive and lack specificity.

Now, Kavita Tapadia and team at the National Institute of Technology, Raipur, Chhattisgarh, have developed a sensitive method to determine iron levels in water samples. The scientists first converted ferrous to ferric oxide and then added thiocyanate to form a ferric–thiocyanate complex. To remove non-specific elements, this complex was then extracted with N-octylacetamide at acidic pH. The extracted organic mixture was measured on a nanodrop spectrophotometric machine to estimate iron concentration.

The scientists tested the sensitivity and validity of this method by using it to estimate iron levels in various biological and environmental samples such as food grains, urine, blood and water samples. They also cross checked their results using Fourier Transform Infrared Spectroscopy and Nuclear Magnetic Resonance Spectroscopy analysis.

They claim that this method is cost-effective, sensitive and specific in nature, and will allow the estimation of even low levels of iron in water samples. Municipal corporations and regulatory authorities could use this method to monitor food and drinking water provided to the public.

Food Chemistry, **221**, 1415–1420

Detergent in Milk

Milk is easily available and rich in protein. Since it is always in demand,

vendors often adulterate milk. Water, glucose, urea and detergents such as lissapol are common adulterants found in milk. Lissapol is a harmful anionic detergent containing alkyl benzene sulphonate. It causes skin and eye irritation.

In order to quantify this adulterant in milk, scientists from the Central Institute of Post-Harvest Engineering and Technology, Ludhiana, examined adulterated milk samples and compared them with pure milk.

They used Fourier Transform Infrared Spectroscopy to examine the chemical components of anionic detergent, detected as peaks. And Partial Least Square Software to analyse the data generated. This method is sensitive enough to detect even 0.2% detergent in milk, at a 5% significance level.

Such a tool for detection of detergents at milk collection points in cooperatives would ensure safer milk.

Food Chemistry, **221**, 815–821

Wheat: Facing the Heat

Rising global temperatures are predicted to reduce crop yields. Food shortage looms.

Wheat is hypersensitive to high temperature stress, but like other plants, it has mechanisms to survive such stresses. To look at how well different wheat varieties respond to high temperature stress, N. Chakraborty and team from the National Institute of Plant Genome Research, JNU, New Delhi, grew 9 cultivars – Unnat Halna, Halna, Raj3765, C306, NIAW34, WR544, WH730, HD2877 and PBW343. They grew some plants at 23°C and some others were exposed to 38°C.

The reduction in water content of leaves was least in Unnat Halna and WH730, and greatest in PBW343 and HD2877. Holding water, maintaining membrane integrity and preventing chlorophyll degradation are necessary for photosynthesis, which allows plants to produce sugar, and ultimately, grain. Unnat Halna performed best, and PBW343 performed worst, in most other parameters such as membrane integrity, proline and protein content,

chlorophyll degradation, carotenoid/phytophenol content and production of heat-shock proteins. Heat-shock proteins initiate several cellular pathways involved in surviving high temperatures.

Based on the study, the nine cultivars were divided into three classes according to their heat tolerance. The most tolerant, Unnat Halna, also known as K-9423, was developed by CSAUA&T Kanpur, and is used as a variety sown late in the season. Finding more heat tolerant varieties and popularizing them will be the next challenge in climate change mitigation efforts.

Food Chemistry, **221**, 1077–1087

Spicing up Drugs?

Zerumbone from ginger

The emerging trend of microbial strains turning resistant to existing antibiotics has created the need for alternatives to combat infections. Likely candidates, bioactive compounds from plants and animals also offer little or no side effects. The essential oils of ginger contain a phytochemical, zerumbone. This highly reactive molecule is amenable to conjugate additions and asymmetric reactions – an excellent molecule for tailor made drugs.

Last fortnight, in Mysuru, B. K. Betadaiah, P. S. Negi and team, from the CSIR-Central Food Technological Institute, oxidized zerumbone with selenium oxide to convert it into a zerumbone–bicarbonyl analogue. This new synthetic compound showed bactericidal activity against pathogens such as *Staphylococcus aureus*, *Bacillus cereus*, *Yersinia enterocolitica* and *Escherichia coli*. Antibacterial activity varied: it is most active against *B. cereus*. *Y. enterocolitica* was most resistant.

This derivative compound also exhibited antimutagenic activity against *Salmonella typhimurium* tester strains. Thus, it reduces the chances of the emergence of resistant strains.

With the potential for use in synthetic drugs, this natural compound, zerumbone, when structurally and chemically modified, can be used to treat various bacterial diseases.

Since the derivatives of zerumbone have applications in food preservation and in cancer treatment, pharmaceutical companies can now use it to tailor compounds for effective therapeutic and preservative properties.

Food Chemistry, **221**, 576–581

Laser Technique

To identify minerals in cucurbits

Cucurbits are used in salads, sweets, desserts and soups. However, seeds and rind, a large part of the cucurbit, are discarded. This waste is rich in minerals. Yet, so far, we lack precise data about the contents and their distribution in this nutritional treasure chest. Existing techniques for their detecting and identifying nutritional components are time-consuming and sample preparation is tedious.



Last fortnight, a research team from the University of Allahabad used a rapid technique, Laser Induced Breakdown Spectroscopy, to quantify minerals in cucurbit seeds. The technique analyses the spectral lines emitted from the plasma generated by the interaction of the laser pulse with the sample. The scientists used a setup with a laser source, a spectrometer, and a detection system. They used a Q-switched Nd:YAG laser at 532 nm with pulse width 4 ns at 2 Hz.

They calibrated the system for quantitative analysis and recorded the spectra of the seed samples. The Laser Induced Breakdown Spectroscopy spectra revealed the presence of calcium, nitrogen, hydrogen, carbon, sodium, potassium and magnesium.

They then compared the results obtained from Laser Induced Breakdown Spectroscopy with that from the existing Atomic Absorption Spectrophotometer method. The two methods showed very slight difference, ranging from 1.78% to 10.9%.

The scientists also applied Principal Component Analysis to the spectral data for categorizing the seed samples. They found four distinct groups.



Cucurbit seeds could now be used to enrich food products with mineral nutrients. The adoption of this simple rapid technique can help us identify more such wasted food resources.

Food Chemistry, **221**, 1778–1783

Keeping Coriander Fresh for Longer

Coriander leaves are a staple in most Indian households: an essential ingredient in many chutneys, salads, curries, etc. Sadly, unlike many veggies, coriander leaves are very susceptible to spoilage. Sourcing fresh crisp coriander leaves is, thus, inconceivable for many.

Cut fruits and vegetables spoil much faster than their uncut counterparts because tissue injury results in enhanced respiration rates, enzyme activation and consequent microbial overgrowth. This is more so with leaves such as those of coriander. Food scientists have been searching for minimal processing techniques to improve the shelf life of such foods without compromising on their nutrient value or taste.

Last fortnight, Ranjitha and colleagues, at the Indian Institute of Horticultural Research, Bengaluru, devised a method to improve the shelf life of cut coriander leaves while retaining flavour, taste and antioxidants levels. They soaked freshly uprooted, cut and washed coriander leaves in various chemical solutions, known for their antibrowning and antimicrobial properties, for five minutes each. In the following days, they observed the leaves for wilting, browning, etc. Treatment with kinetin showed the best results in terms of freshness. Kinetin, a major plant hormone, is approved of by the US Environmental Protection Agency as a ‘Generally Recommended as Safe’ chemical for post-harvest applications in fresh produce.

The researchers then proceeded to investigate the best packaging option, using a variety of plastics. The plastic bags helped maintain the treated leaves in a ‘modified atmosphere’ and helped prevent spoilage. They analysed various parameters including antioxidant levels, microbial growth, flavour, etc. Pretreatment with kinetin at 50 ppm, followed by packing in 25 μ m polypropylene bags was shown to produce the best result, extending the shelf life of the leaves to 21 days when stored at 8°C.

A practical, healthy solution such as this would be a boon to the average urbanite, who cannot afford to maintain an herb garden at home. That being said, we can only hope that the results of this study hit the market soon. Vegetable traders, are you listening?

Food Chemistry, **221**, 844–854

Carp Roe Powder

No longer a bitter pill

Fish eggs (roe) are a popular source of high protein. Their amino acid and essential fatty acid content provide great nutritional value. This content enhances their flavour and taste. However, it also facilitates rancidity and a bitter taste quickly develops during processing and storing. So, processing plants remove fatty acids before marketing fish roe. And this reduces the nutritional value.

P. K. Binsi and team from the ICAR-Central Institute of Fisheries Technology, Cochin, collaborated with scientists from the ICAR-Indian Institute of Natural Resins and Gums, Ranchi, to devise a stable and non-conventional method for processing and preserving fish roe. The scientists stabilized the roe by emulsification with gum arabic. Then they spray dried this to powder form. This process encapsulated the lipid fraction of the roe mass of the *Rohu* fish – *Labeo rohita* – so that the oil droplets were trapped in a layer of protein. Now the fish roe are protected from oxidation and rancidity.

As a result, the shelf life of the powder is longer and, hence, it can be used in various forms of cuisines.

The scientists also did *in vitro* experiments with the encapsulated fish roe and showed that the fatty acids

were released in the intestinal tract. The results indicate that this nutritionally rich roe powder with high quality lipid composition can be used effectively in health formulations.

This method is timely given the dearth of research in India on the processing and storing of fish roe. With worldwide demand for this delicacy, industrialists and entrepreneurs can now net rich returns using this method.

Food Chemistry, **221**, 1698–1708

Agar–Agar Biopolymer

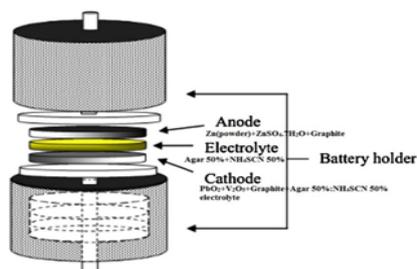
Electrochemical cell application

Agar–agar, a naturally occurring polysaccharide, has excellent film forming properties. Abundant, low cost and easy to process. Though agar–agar based electrolytes show promise for many applications, so far, they have not been used in electrochemical batteries.

Now, a research team from the S.F.R. College for Women, Sivakasi, in collaboration with the Materials Research Centre, Coimbatore, has devised an agar–agar based polymer electrolyte. They used ammonium thiocyanate and agar–agar. With distilled water as solvent, they used the solution casting technique to prepare the electrolyte.

FTIR revealed the formation of a complex of the salt with the polymer. XRD analysis showed the amorphous nature of the polymer complex.

A 50 mol% agar and NH_4SCN film showed maximum conductivity at ambient temperature. The scientists studied the conductivity with alternating current impedance spectroscopy. The highest conductivity sample had low activation energy – only 0.25 eV. The Wagner's DC polarization technique revealed that the conductivity in Agar– NH_4SCN films is due to ion transport.



Schematic diagram: Electrochemical cell

The researchers also determined the glass transition temperature of the electrolyte. Differential Scanning Calorimetry analysis indicated that the temperature range of pure agar decreases with the addition of NH_4SCN . This helps soften the polymer backbone and increase its segmental motion. These parameters ensure that the prepared polymer electrolyte is a good candidate for low-cost biopolymer electrolyte membranes in fuel cell applications and solid state devices.

Given the low cost components and the simple procedure, and that the electrolyte is highly scalable, and nontoxic, there is hope that it will soon find real life applications.

J. Appl. Polym. Sci., **134**(15), 44702

Seaweed to Clean Water

Alginate nanocomposite

An unlikely magic bullet has emerged in the race to protect our increasingly threatened environment: alginate, from brown seaweed. This non-toxic, biodegradable, and biocompatible material is the basis for the design of a nanocomposite ion exchanger.

Last fortnight, Deepak Pathania and team from the Shoolini University, Himachal Pradesh, in collaboration with the University of South Africa, reported synthesis of an ion exchanger that can separate heavy metals and remove organics as well as microbial contaminants from wastewater.

The researchers prepared the nanocomposite ion exchanger using alginate, zirconium oxychloride, orthophosphoric acid and nitric acid. The team determined the physicochemical properties of the ion-exchanger such as ion exchange capacity, thermal characteristics, elutant concentration, elution behaviour, pH titration and the distribution of metal ions. The scientists also checked its capacity to separate heavy metals, degrade organic dyes as well as its antimicrobial activity. They found that the nanocomposite ion-exchanger was highly selective for Al^{3+} and Mg^{2+} ions.

This ion exchanger is more efficient than chemical precipitation, complexation using natural and synthetic reagents, reverse osmosis, electro dialysis, electrochemical membrane

reduction, coagulation, flocculation, adsorption and chemical deposition. Besides, it has thermal and mechanical stability. Reproducibility and higher selectivity for metal ions make this new material even more attractive.

Since the alginate–Zr(IV) phosphate nanocomposite has the potential for diverse applications in the removal of metals, organic and microbial contamination from the environment, the team hopes that it may, one day, help industrialists better comply with environmental regulations.

J. Alloys Compounds, **701**, 153–162

Early Detection of CNS Disorders

Central nervous system disorders like Alzheimer's, schizophrenia, Huntington's, AIDS, Dementia Complex, etc. reduce the quality of life. Early diagnosis can help us better deal with these disorders.

In the human body, an increase of 10–40 micromolars in the levels of quinolinic acid indicates the onset of these disorders. This excitotoxin, present in less than 100 nM concentration in healthy humans, is a metabolite of the kynurenic pathway. This pathway has a link with neurodegenerative disorders. It metabolizes tryptophan to produce nicotinamide adenosine dinucleotide (NAD). Any disturbance in this pathway results in increased levels of quinolinic acid. Early detection of increase in quinolinic acid thus helps deal with these disorders.

Last fortnight, R. K. Singh and team, from the Banaras Hindu University, in collaboration with the Delhi Technology University, devised a sensitive electrochemical method for early diagnosis of central nervous system disorders.

The scientists fabricated an electrode using bovine serum albumin, quinolinate phosphoribosyl transferase, reduced graphene oxide and indium tin oxide. They coated reduced graphene oxide on an indium tin oxide coated glass plate using the electrophoretic deposition method. Quinolinate phosphoribosyl transferase was immobilized on this. The enzyme forms an amide bond with reduced graphene oxide. This immobilized enzyme binds with quinolinic acid and emits electrochemical

signals that can be detected. Nonspecific sites were blocked by bovine serum albumin, increasing the selectivity of the bioelectrode.

The researchers used differential pulse voltammetry to measure the concentration of quinolinic in patient samples. The excitotoxin concentration is directly proportional to the magnitude of current. The biosensor is capable of detecting quinolinic acid in micromolar to millimolar range. The scientists determined the shelf life of the biosensor and found that it can be kept for 30 days at 4°C.

Selectivity, reproducibility and sensitivity give this electrochemical biosensor an edge over conventional methods for detecting quinolinic acid in biological samples. One day, every diagnostic lab might use this biosensor for the early detection of the onset of CNS disorders.

Biosensor and Bioelectronics, **90**, 224–229

Agents of Contrast

Rod shaped iron oxide

Magnetic Resonance Imaging (MRI) traces the positions of molecules in the body by varying the magnetic field. And shows details of specific organs or blood vessels. MRI scans are generated by radio frequency pulses. Varying the pulse sequences creates a contrast between tissues. This contrast is like a signature for different tissues. Some tissues have a natural contrast on MRI, but for specific types of imaging, a MRI contrast agent is needed to intensify the imaging of target tissue.

Last fortnight, D. Bahadur and team from the Indian Institute of Technology, Mumbai, in collaboration with researchers from the Dr Balabhai Nanavati Hospital and Research Centre reported using nanorod shaped iron oxide nanoparticles as contrasting agent. These have unique superparamagnetic properties.

The magnetic properties depend on the size and shape of the nanoparticles. Instead of using spherical particles, they opted for rods. This gives higher surface area, stronger magnetic field and larger effective diameter than the spherical. And enhances contrast value, thus producing better images. The researchers found that iron oxide nanoparticles produce high contrasts in MRI.

Iron oxide nanoparticles have been used earlier for targeted drug delivery, enzyme immobilization and magnetic bio-separation. The team capped the nanoparticles with silicon to enhance delivery capabilities. They found that these capped particles had good aqueous stability and biocompatibility.

These initial tests show that iron oxide nanoparticles are effective contrast agents. And can also deliver drugs when capped with silicon. Useful properties for imaging of targeted anti-cancer drug delivery.

J. Magn. Magn. Mater., **428**, 340–347

Batteries – Rest in Peace

Supercapacitors for super storage

Smartphones are constant companions but their battery life can be a let-down. Scientists hope that supercapacitors will soon replace lithium-ion batteries in smartphones. However, existing capacitor materials and technologies offer limited energy storage capacity.

Last fortnight, Saptarshi Dhibar and Chapal Kumar Das from IIT Kharagpur reported developing a method to fabricate silver-polypyrrole/graphene nanocomposite electrodes with increased capacity.

They fabricated the material using *in situ* polymerization with ammonium persulphate as oxidizing agent in the presence of silver nitrate and dodecylbenzenesulphonic acid. They added sonicated graphene and pyrrole monomer solution in a stepwise manner to a

silver nitrate solution to create the silver-polypyrrole/graphene nanocomposite. Graphene improved electrical conductivity of silver nanoparticles. The nanocomposite also shows better power density and thermal stability than existing electrodes fabricated with conventional methods.

The team also assessed the difference in performance between this electrode and one made of only silver-polypyrrole. They examined both electrodes using various spectroscopic techniques such as FTIR, UV-visible, and Raman analysis. The silver-polypyrrole/graphene nanocomposite developed has a structure where graphene is uniformly coated with polypyrrole in the presence of silver nanoparticles. It has a special morphology which enhances its electrochemical performance.

The electrochemical properties of the silver-polypyrrole/graphene nanocomposites have implications in the energy and electronics sector. Their properties make them excellent electrode material for next-generation supercapacitors with good energy storage capacities. Soon we might be able to use smartphones for days on end, without charging.

J. Appl. Polym. Sci., **133**, 44724

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