

## Science Last Fortnight

### Oxytetracycline in Milk

*Detection made easy*

Antibiotics are widely used in livestock management practices to safeguard the health of the animals. In dairy husbandry, milk producers rely on antibiotics to treat mastitis and other infectious diseases. It is natural that these antibiotics find their way into milk. Some antibiotics, such as tetracycline derivatives, are contraindicated for pregnant women and children, the largest consumers of milk.

Laxmana Naik and team, from the ICAR National Dairy Research Institute, recently developed a rapid, semi-quantitative lateral flow assay to screen oxytetracycline residue in milk samples. The scientists generated and purified polyclonal antibodies against the oxytetracycline molecule. They used colloidal gold nanoparticles as labelling material by conjugating it with the antibody. Oxytetracycline coupled with carrier protein was placed on a test line. Species-specific secondary antibodies were placed on the control line of the membrane matrix. The assay was validated by adding known quantities of oxytetracycline to antibiotic free milk samples.

The results could be seen within five minutes without any equipment. The visual detection limit was 30 parts per billion!

This type of rapid and sensitive visual screening assay has practical applicability. Using such lateral flow assay strips, milk can be tested for oxytetracycline at collection point. For consumer safety, the dairy industry can now take steps to monitor antibiotic residue in milk.

*Food Chemistry*, **219**, 85–92

### Complementing the Immune System

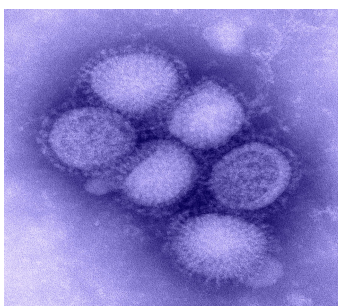
*2009 influenza pandemic*

Immunology never got the boost it deserves as the neurosciences did with the Decade of the Brain in the 90s. However, the discipline seems to be maturing without much international attention.

Last fortnight, scientists from two Pune based institutes, the NCCS and

the NIV, delineated further details in the web of interconnectedness that constitutes the immune system.

Besides the cellular components of the innate and adaptive immune systems, there is the complement system with a more diffused existence which yet exerts control. The scientists in Pune focused on this component in the context of the pandemic influenza virus A(H1N1) that swept through India in 2009.



Through a series of experiments using mice, *in vitro* petri dish studies and clinical data, they bring out the interplay of the classical as well as alternative complement pathways to neutralize the virus.

Usually, antibodies against H1N1 hemagglutinins start appearing on the fifth day and the viral load decreases from the seventh day of infection. But, where the complement system does not work, weight loss and mortality ensue.

Using experiments with mice lacking one or other aspect of the complement system, scientists showed that, in cases of deficiencies in the complement C3, IgM production was significantly reduced; clearance from lungs does not take place; mortality is highly predictable.

Interestingly, they also found that, though complement C3 is primarily produced in the liver, it is C3 from B cells in the spleen that produce the effect.

Using *in vitro* studies, the scientists showed that antibody-coated viruses are effectively neutralized by the complement. The classical pathway of the immune system deposits C3b onto the viral surface. This activates the alternative pathway loop. 'Unlike the

pandemic influenza virus, seasonal influenza virus A(H3N2) is neutralized by the alternative pathway. The difference is in the ability of their surfaces to allow C3b deposition. C3b deposition was efficient on the A(H3N2) viral surface, but not on the A(H1N1) virus unless coated by antibodies', they say.

Besides providing insights into basic immunology, the research has applications. It also shows that immune sera, from the mice without complement system deficiencies, can prevent mortality. Moreover, in humans, IgG1 antibodies in the sera of infected-positive individuals are capable of supporting the neutralization. So if you have deficiencies in your complement system, and are infected with such a virus, supplement the treatment with the right antibodies.

[doi.org/10.1371/journal.ppat.1006248](https://doi.org/10.1371/journal.ppat.1006248)

### Probing Memory Loss

*Biosensors for acetylcholine*

A reduced level of acetylcholine in the brain is implicated in neural disorders such as Alzheimer's and Parkinson's diseases. In order to understand the functional and physiological aspects of neural disorders caused by changes in acetylcholine concentration, a sensitive, rapid and accurate detection tool is required. Though several electrochemical biosensors are available for acetylcholine detection, high cost, limited availability, and inaccurate detection deter the use of these sensors in clinical practice.

Nidhi Chauhan and team, from the Amity University, Noida, have now fabricated a low-cost technique: an enzyme-based chemical sensor to convert acetylcholine into a reporter molecule that can be recognized by an electrode. They used a conducting polymer to modify a fluorine-doped tin oxide electrode. This helps in fast electron transfer. Addition of reduced graphene improved the conducting properties of the electrode. They used iron oxide nanoparticles on this composite for the electro-catalytic oxidation of acetylcholine.

The team estimated the acetylcholine content in serum samples and found negligible interference of ascorbic acid which is a major interferent in earlier reported biosensors.

The newly developed sensor claims a very low detection limit. The sensor remained active even after storage for a hundred days. Moreover, this new sensor can be used multiple times.

The researchers claim that the cost of producing the biosensor is lower than that of existing sensors. They are confident that high sensitivity, reusability and low-cost will help translate their lab results into an industrial product for the clinical diagnosis of neural disorders.

*Biosensors and Bioelectronics*, **89**, 305–311

### Encapsulating Fish Oil

*Sage extract is safer*

Omega-3 fatty acids offer many health benefits. These fish oil supplements are available as capsules. But the product goes through slow oxidation. To reduce oxidative degradation, microencapsulation of fish oil is a useful technique.

Spray-drying is one of the cheapest methods for microencapsulation. However, the mechanical shearing involved in atomization destabilizes and collapses the capsule during drying. The stability of the capsules can be improved by using protein cross-linking agents such as formaldehyde, glutaraldehyde and transglutaminase. But these chemicals cause adverse health and environmental effects.

Last fortnight, Binsi and team, from the ICAR-Central Institute of Fisheries Technology, Cochin, identified plant essential oils rich in antioxidants as natural cross-linkers. The emulsions were prepared with sodium caseinate as polymer, gum arabic from *Acacia senegal* as co-polymer and sage extract as wall stabilizer.

The researchers encapsulated two different emulsion formulations: fish oil emulsion and fish oil containing 1% sage extract. Using accelerated storage, they examined emulsion stability, microstructure, encapsulation efficiency, percentage loss of oil and the morphological and physical properties of the

microencapsulates, as well as oil release properties and lipid oxidation.

Incorporating sage extract improved the surface morphology and size uniformity of the encapsulates. The sage extract, at 1% level in the emulsion, prior to spray drying, increased encapsulation efficiency and lowered surface oil content.

Sage extract offered significant protection against fat oxidation and improved shelf life. When stabilized with gum arabic and sage extracts, fish oil capsules exhibit higher encapsulation efficiency than encapsulates with gum arabic alone. So, the scientists recommend the incorporation of sage extract in fish oil before spray drying.

*Food Chemistry*, **219**, 158–168

### Gelled Within

*Seaweed extract for drug delivery*

Curcumin, an active ingredient in turmeric, has remarkable anticancer properties. But poor solubility in water limits its use as cancer therapeutic. Scientists are now looking at different drug delivery agents to boost curcumin's performance within living systems by ensuring sustained drug release.

Balaram Madhan and team, from the CSIR-Central Leather Research Institute, Chennai, now find that a polysaccharide isolated from red seaweed may serve as ideal drug delivery agent for curcumin. The bulk of the polysaccharide content in red seaweed is made up of kappa-carrageenan with excellent gelation properties. The scientists synthesized kappa carrageenan beads through the solvent evaporation method and loaded them with curcumin. They then tested the beads for drug entrapment, drug release, and cytocompatibility in living cells.

The studies show that there was effective interaction between the polymer and the drug in the bead matrix. The researchers also found that drug release from the beads was pH dependent. Approximately twice the amount of drug was released from carrageenan beads at an acidic pH as compared to the physiological pH. Since tumour microenvironment is usually acidic, this finding presents interesting drug targeting opportunities.

The antitumor properties of the carrageenan–curcumin beads were also explored in lung cancer cells. The drug–polymer complex could induce apoptosis, or programmed cell death in cancer cells. The scientists found that carrageenan could boost the anticancer action of curcumin. Cytocompatibility, ease of use and gelling properties make kappa carrageenan an ideal drug delivery agent for curcumin and other drugs that suffer from reduced bioavailability within living systems.

*Carbohydrate Polymers*, **160**, 184–193

### Design Meets Function

*Liposomes for targeted drug delivery*

Targeted delivery of drugs to tumour cells is a prerequisite for treating cancer. But, because most drug carriers unload the therapeutics in the vicinity of the tumour, and not within the cell itself, the efficiency of treatment is reduced. Recently, Rashid Madhuri and team from the Indian Institute of Technology, Jharkhand, synthesized nano-sized drug carriers that can ensure drug targeting to the cancer cell nucleus.

Liposomes have long been used as efficient drug delivery candidates due to their stability and nontoxic nature. To improve target specificity and cell penetration, researchers added two components to the liposomes: carbon dots to trigger drug release and TAT – a cell penetration peptide to enhance cell permeation. In order to reduce the cost of this process, the liposome itself was prepared from precursors derived from inexpensive laboratory chemicals.

Once synthesized, the liposomes were hydrated using either a phosphate buffer or ammonium bicarbonate. The liposomes were loaded with an anticancer drug, doxorubicin, and assessed for therapeutic efficiency in terms of drug entrapment, drug release, cell compatibility and toxicity.

The scientists found that liposome hydration, in the presence of ammonium carbonate, introduces a bubble within the liposome that increases its drug entrapment efficiency. The cytotoxicity and drug unloading capacity of both normal and bubble containing liposomes were studied in breast cancer cells. Results show that both liposomes

are equally compatible with cell systems and can easily penetrate cancer cells.

Once inside the cell, the drug is released when triggered by near infrared radiation. The targeted near infrared radiation raises the temperature of the afflicted tissue by a few degrees above normal body temperature. This activates the carbon dots, triggering a burst of drug release from both sets of liposomes with bubble liposomes exhibiting a more rapid response. Such activity is not present in liposomes lacking carbon dots, demonstrating the effectiveness of the vehicle architecture.

Due to the presence of carbon dots, these liposomes can also produce bright fluorescence when illuminated with different lasers. This allows scientists to track drug delivery within the cells in real time.

Given the multiple advantages associated with carbon dot-TAT associated liposomes, scientists are confident of their potential for efficient cancer drug delivery.

*Chemical Engineering Journal*, **312**, 144–157

### **Deciphering *Bungarus*' Codons** *Fine-tuning gene expression*

A codon is a series of three nucleotides and codes for a specific amino acid residue in a polypeptide chain. Or for the termination of translation – stop codons. The permutations of three letter words, from four possible nucleotides, give 64 unique combinations. But there are only about 20 amino acids. So there is some amount of redundancy in the code and there are synonymous codes for the same amino acid. However, a particular species may exhibit partiality towards a specific codon. Codon bias can help understand the dynamics of gene expression and evolutionary relationships.

A team led by Supriyo Chakraborty from the Assam University, in collaboration with the Moinul Hoque Choudhury Memorial Science College, Assam, compared codon patterns among four species of the genus *Bungarus*: the many-banded krait, banded krait, blue krait and red headed krait.

The *Bungarus* genus, distributed across South and Southeast Asia, has some of the most poisonous land snakes in the world. The team analysed genes available in public databases to understand evolutionary patterns.

All species showed a similar pattern in nucleotide composition. This indicates that they share similarity in structure and biological function.

The highest mean value of adenosine was observed in all the species except in *B. fasciatus* which had the highest mean value of cytosine. This indicates that compositional constraint under mutation pressure has affected codon usage in different species of *Bungarus*.

The effective number of codon values in the four species ranged from 35 to 60, indicating the existence of almost all synonymous codons for an amino acid in *Bungarus*. The effective number of codons has an inverse relationship with codon bias. And this reflects greater genetic variability. High genetic variability widens the platform for evolution by mutation pressure and natural selection.

Both natural selection and mutation pressure affect codon usage pattern. Natural selection was greater in *B. fasciatus*, *B. multicinctus* and *B. candidus*. But less in *B. flaviceps* in which mutation pressure was higher compared to that in other species. This suggests that, in *B. flaviceps*, three headed krait, the rate of evolution has been faster compared to that in the other three species.

Codon bias is a unique property of the genome of an organism. It is species-specific and may vary among the genes within the same organism. Natural selection plays a major role while mutation pressure has a minor role in the codon usage pattern of the genes in the *Bungarus* species. The scientists have thus improved our understanding of the molecular biology and evolution of the *Bungarus* species.

*Gene*, **604**, 48–60

### **Quantum-cells for Solar-energy** *Efficient energy production*

Fossil fuels are limited. And their use damages the environment. To meet growing energy needs, sunlight, a major renewable source, is an alternative.

However, current technologies to harvest solar energy are not very efficient.

Researchers from the Sri Venkateswara University, Tirupati, collaborated with foreign universities to develop a quantum dot nanomaterial for the more efficient harvesting of solar energy. The nanomaterial was doped with ytterbium and zirconium oxides. These rare earth elements enhanced the photo-conversion efficiency of quantum dot solar cells.

Quantum dot solar cells, doped with rare earth elements, block the leakage of photogenerated electrons from the electrode. This suppresses charge recombination effects – the dissociation of an excited electron pair into free collectable charge carriers. So the doped quantum dot solar cells show enhanced photon-to-electron conversion efficiency: more solar energy fixing with fewer photons. In fact, these cells show 55% higher photo conversion efficiency than the currently available solar cells.

Quantum dot solar cells, doped with rare earth elements, are cheaper than other solar cells. The scientists claim that solar panels with such cells can change the economics of renewable energy production.

*J. Alloys and Compounds*, **698**, 433–441

### **Sugar Coating Steel** *Anti-corrosion effects of Isabgol*

Metal–acid interaction is a major cause of steel corrosion that leads to huge economic losses each year. Most industries use synthetic chemical inhibitors that can be coated on metals to reduce corrosion. But these chemicals are expensive and toxic. Now, Mohammad Mobin from the Aligarh Muslim University, suggests the possibility of using a carbohydrate isolated from the Isabgol plant as an effective corrosion inhibitor.

Mobin and his team reasoned that the sugar in the Isabgol plant – arabinosyl rhamnosylxylan – is highly branched and contains several hydroxyl groups which can form stable interactions with iron. Because the molecule is large it may offer enhanced protection by coating the metal to a greater extent. To test this hypothesis, the scientists isolated Isabgol mucilage

by soaking it in water. Next, they isolated arabinosyl rhamnosylxylan from the solution which was then tested for anti-corrosion properties in an acidic solution.

The researchers applied increasing concentrations of Isabgol carbohydrate extract to washed low carbon steel coupons in an acidic environment. Uncoated coupons exhibited greater metal loss and showed more signs of damage as opposed to steel coupons coated with arabinosyl rhamnosylxylan. Metal-carbohydrate interaction studies reveal that this is due to the formation of stable metal-arabinosyl rhamnosylxylan interactions at the interface, strengthening anticorrosion properties.

Given that the source is natural, inexpensive and readily available, scientists are confident that arabinosyl rhamnosylxylan could be developed into a nontoxic, anticorrosive material for industrial applications.

*Carbohydrate Polymer*, **160**, 172–183

### OLED in the Lead

#### Improved light extraction

OLED – Organic light-emitting diode – is fast replacing LED LCD technology. High-end smartphones, digital cameras, tablets, laptops, and television sets use OLED.

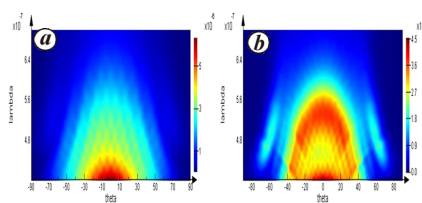
In LED LCD display screens, pixels are illuminated using a back-light. In OLED, however, pixels produce their own light. Better brightness, contrast, viewing angle, colour distinction and range, as well as quicker refresh rates are other advantages. Moreover, OLED screens are ultra-slim, stretchable and transparent.

These diodes consist of two organic layers, embedded between two electrodes. One emits and transports electrons while the other transports holes. The electrode above is a metallic mirror with high reflectivity. The bottom electrode, a transparent anode layer, is on top of a glass substrate.

Vidhi Mann and Vipul Rastogi, from IIT Roorkee, recently used dielectric nanoparticles to improve the light extraction efficiency of OLED. Indium tin oxide acted as anode on top of the glass substrate. Aluminium was used as cathode. An organic layer of N,N'-di(naphthalene-1-yl)-N,N'-diphenyl-

benzidine acted as hole transport layer. Another, tris(8-quinolinolato) aluminium (Alq3), as emissive layer. There was also a lithium fluoride electron transport layer.

The researchers used the Finite Difference Time Domain method and Mie Theory to analyse the effects of these dielectric nanoparticles. The nanoparticles were assumed to be spherical and optically lossless. Parameters such as diameter, inter-particle separation and the refractive index of the nanoparticles were optimized to improve light extraction efficiency.



A comparison of far field intensity distribution for (a) conventional OLED and (b) OLED with nanoparticles.

Nanoparticles, in OLEDs, scatter light. The researchers found that this phenomenon depends on index contrast. Simulation showed that light extraction efficiency did not increase with larger diameter nanoparticles because of the decrease in the number of scattering sources. Maximum enhancement, approximately 1.7 times, is seen with nanoparticles of 100 nm diameter, with no inter-particle spacing and a refractive index of 1.1, at around 500 nm wavelength.

Dielectric materials, such as mesoporous silica, aluminium oxide and zirconia, can be used as nanoparticles in OLEDs. The researchers suggest that the use of appropriate dielectric nanoparticles can further boost the amount of light from optical structures. This can be utilized for enhancing user experience of OLED screens.

*Optics Communications*, **387**, 202–207

### Software for Easy Trading

The price of a stock fluctuates. The nonlinear nature of stock price movements makes forecasting difficult. Timing of buy/sell decisions becomes a challenge. This risk keeps many from trading in stocks.

Binoy Nair and team from the Amrita School of Engineering, Coimbatore, recently analysed clustering stock price time series data to generate stock trading recommendations. They considered twenty stocks for evaluating these recommender systems. This helped keep the computation inexpensive. The stocks were chosen to represent markets from four different geographies: BSE from India, NYSE from the USA, LSE and FTSE from the UK and BOVESPA from Brazil. Stocks from aircraft manufacturing, banking, communication, food, petroleum, consumer retail, textile, travels, etc. were considered.

The researchers considered 16 variants of the recommender system. The economic performance of these systems was evaluated on eight different performance measures.

The performance was based on profit generated by the recommender system. The system was trained using a cyclic component. Weekly trading was done using regression tree-based feature selection and sliding window-based adaptive learning. Regression trees are useful for reducing dimensionality and Self-Organizing Maps are used to cluster data.

Taking cyclic components helped the recommender system capture short-term fluctuations in stock prices better. This produced better results than working with the entire dataset. Soft computing-based systems can extract relevant information from large sets of data by discovering hidden patterns.

Historical stock price data can be used to forecast future trends and recommend when to buy/sell stocks. Using such systems, anyone might be tempted to invest in equity markets.

*Expert Systems with Applications*, **70**, 20–36

Reports by: **Sanghamitra Deobhanj, G. Sharath Chandra, P. K. Udham, G. Manoj Praveen, H. M. Mahadeva Swamy, A. C. Surya Prabha, S. Malarvannan, Prashant Kumar Parida, V. Subashini, Shumaila Afrin and Sarah Iqbal**

ACKNOWLEDGEMENT. Science Media Centre, IISER Pune.

scienceandmediaworkshops@gmail.com