

## Science Last Fortnight

### Regeneration of Cardiac Cells

Cardiovascular diseases are a major cause of death worldwide, of which coronary heart disease is most common. In coronary heart disease, the coronary artery that supplies blood to the heart is blocked and due to insufficient supply of blood, cardiac cells suffer death.



Image: Patrick J. Lynch, via Wikimedia Commons

Earlier, it was believed that cardiac cells cannot be regenerated. Now it is demonstrated that cardiac cells can indeed be regenerated, if provided with a suitable scaffold that can render appropriate physical, chemical and mechanical cues for cardiac cell regeneration. Regenerative medicine focuses on the restoring of pathologically altered tissues by transplantation of cells, in combination with supportive scaffolds of synthetic or natural materials.

Recently, Indian researchers from the Ton Duc University, Vietnam, the University of Malaysia, Bharath University, Chennai, the Sri Sakthi Institute of Engineering & Technology, Coimbatore and the Indian Institute of Space Science and Technology, Thiruvananthapuram reported a nanocomposite synthetic polymer as suitable scaffolding material. The new scaffold contains carotino plant oil incorporated into tecoflex EG80A, a polyether-based medical grade polyurethane polymer.

The polyurethane-carotino membrane had lesser fibre diameter, than that made of pure polyurethane. The new material had smaller pore size and high surface area, and could be used as scaffolding. The team reports that the nanocomposites show compatibility with RBCs.

They suggest that the physico-chemical properties and blood compatibility of this nanocomposite make it appropriate for use in the regeneration of cardiac and graft tissues.

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### DNA on Microchip

#### Nanoparticle-based DNA extraction

Globally, waterborne organisms transmit diarrhoeal diseases. To identify the causative organism accurately, DNA is essential. The present methods of DNA extraction take hours and require costly equipment.

Now researchers from the Agharkar Research Institute, Pune report an improved method of DNA extraction: microchip-based cell lysis. The method is capable of lysing cells, as well as extracting and isolating DNA, in a single step.

The method uses positively charged chitosan-coated magnetic nanoparticles. The nanoparticles act as projectiles during mechanical vibrations, triggering controlled cell lysis. The magnetic nanoparticles make it easier to separate DNA from other cellular components.

The researchers imparted mechanical vibrations to the chip using an embedded vibration device. As they increased the frequency of vibrations, the intensity of the DNA band extracted increased. The team could achieve complete cell lysis at a vibrational frequency of 180 Hz.

The researchers extracted the DNA from six waterborne pathogens and quantified the extracted DNA using Nanodrop. Then, they assessed the integrity of genomic DNA using gel electrophoresis. The team achieved an extraction efficiency of nearly 100%.

The team compared the quality of the extracted DNA with DNA obtained by the conventional method. The absorption ratio of the DNA obtained using microchip is comparable to that of the conventional method, confirming the quality of the extracted and isolated DNA. The researchers also checked the quality of the extracted DNA based on 16S rRNA amplification using polymerase chain reaction. The

results confirmed the integrity of the DNA extracted.

Microchip technology is easier, more efficient and robust than conventional methods. The scientists claim that magnetic nanoparticles with positively charged polymeric coating material yield high quality DNA. These nanoparticles make centrifugation and/or packed columns unnecessary. The total time required for the complete process was ~15 min as against >2 h with the conventional method.

Though a small step for genomic studies, the innovation can become a giant stride in pathology labs and clinics, if the technology is developed for commercial exploitation.

*Biosens. Bioelectron.*, **99**: 62–69

### Oral Cancer

#### An early diagnostic tool

Oral submucous fibrosis is a pre-malignant condition caused by tobacco chewing. In some cases it may develop into oral cancer. The procedure for the early detection of oral submucous fibrosis by tissue biopsy is painful. Hence, there was a need to develop a better diagnostic tool.

A group of researchers from the Indian Institute of Technology, Kharagpur in collaboration with the Midnapur Medical College and Hospital, West Midnapur and the Awadh Dental College and Hospital, Tata Jamshedpur have now reported the development of an early diagnostic tool for oral submucous fibrosis, to prevent oral cancer.

They used Fourier Transform Infrared Spectroscopy – FTIR – in combination with chemometric techniques, to distinguish the metabolic differences in serum samples of patients. The researchers observed wavelength peaks typical of increased collagenase which is responsible for tumour formation. The FTIR spectra showed abnormal concentrations of amino acids, carbohydrates, proteins and lipids. The team also found RNA ribose, at  $1171\text{ cm}^{-1}$ , an indication of carcinoma.

The researchers conclude that FTIR in combination with chemometric techniques can be used as an early

diagnostic tool for oral cancer. It is easy to handle, and gives accurate and rapid diagnosis. Using this method will help us detect oral cancer early enough to save lives.

*Spectrochim. Acta A: Mol. Biomol. Spectrosc.*, **189**: 322–329

### Skin Care Products

#### Value addition by excipients

To act on the skin, the active ingredients of a product require lipophilicity. But to reach the target, it requires hydrophilicity. Excipients – inert material used to increase solubility, flowability, and bioavailability – are often used to create the hydrophilic and lipophilic balance. However, finding a suitable excipient with active ingredients of natural origin is a challenging task, as natural products are complex in nature.



Image: Eric Hunt, flicker.com

Tea tree oil – essential oil from *Melaleuca alternifolia* – is one such natural product. It is toxic on ingestion but is a highly potent and popular ingredient in skin care products owing to its broad-spectrum antibacterial and anti-inflammatory properties.

To enhance the efficacy of tea tree oil in aqueous medium, Ganguly and colleagues from the Bhabha Atomic Research Centre, Mumbai used a non-ionic surfactant, pluronic P123. Pluronic P123 is a solubilizing agent for various lipophilic compounds due to its self-assembling, thermogelling behaviour. Pluronics also have spherical, globular or elliptical micellar structures such as those formed by lipids.

The scientists used various pluronic P123 concentrations to solubilize tea tree oil at room temperature. However, they did not get useful results due to the slow rate of micelle formation and incomplete solubilization. A complete solubilization of tea tree oil and proper micelle formation took

place on heating the pluronic P123 and tea tree oil in aqueous medium, to 100 degrees C and then cooling the mixture to room temperature. The team found that 1.2% tea tree oil in 10% pluronic P123 gives uniform micelle formation with complete solubilization of the oil along with required viscosity.

Tea tree oil in pluronic P123 retains its antibacterial and cytotoxic activity. The scientists say that the complete solubilization of tea tree oil in aqueous medium is possible with pluronic P123 making it a good candidate for skin care products.

*Colloids Surf. A Physicochem. Eng. Asp.*, **537**: 478–484

### Healthy Sex Life

#### With tamarind extracts

Sexual dysfunction among men is a serious health and psycho-social problem. In the quest for remedies, a few drugs were developed. However, side effects eliminate them from long-term consumption and necessitate the search for alternatives.

Recently, a team led by Amita Rai from the Ecron Acunova and the Manipal College of Pharmaceutical Science found a natural remedy for sexual dysfunction from tamarind fruits. In Africa, *Tamarindus indica*, a tropical tree, is traditionally used for treating sexual disorders. This clue prompted them to inquire into the potential active components.



Image: Petr Kratochvil

They collected fruits from Udupi and authenticated them before testing. They then macerated the fruits with chloroform-water. This softens the tissue to enable easy extraction of the compounds. The researchers dried the extracts in a lyophilizer, a freeze-drying machine.

The team found various proportions of bioactive compounds, such as phenolics, flavonoids and saponins, in

the extract. They used gas chromatography-mass spectrometry to analyse unknown compounds from the mixture and separated 40 different compounds. Their results resembled those from previous studies, where some of these compounds were found to improve sexual dysfunction.

The team went on to test the extracts on male rats. As a comparison, they used sildenafil citrate, a commonly used drug for sexual inabilities, and water, as control. They observed increased sexual desire in male rats treated with the extract. Using histopathological studies, they observed that prolonged treatment with the extracts did not alter the physiology of rat testes. The team checked the safe dose level of the extract on rats and found no significant toxicity even up to 2000 mg/kg.

The scientists noted that rats consuming the extracts had improved productivity and quality of sperm. They suggest that, perhaps, saponins could be behind this effect.

This finding may help improve sex life by natural means. However, further clinical trials are needed to authenticate the reliability of the activity of tamarind on humans.

*J. Ethnopharmacol.*, **210**: 118–124

### Sperm Motility in Cattle

#### Binder of sperm protein as marker

Advances in reproductive technologies have made gamete propagation possible and affordable. However, cryopreservation methods affect sperm motility and, hence, decrease fertilization rates. Frozen bull semen samples tend to have sperms with reduced motility. Although binders of sperm proteins in seminal plasma help in sperm maturation and fusion with oocytes, their role in sperm motility has not been addressed.

Last fortnight, Divyashree and Roy from the ICAR-National Institute of Animal Nutrition and Physiology and the Jain University, Bangalore have reported the role of binder of sperm-5, a protein associated with sperm motility. They collected semen samples twice a week from a total of eighteen Murrah buffaloes, eight Jersey and eight Holstein cattle bulls maintained at the Nandini Sperm Station, Bengaluru.

They separated sperms from seminal plasma and scored them for their motility using a computer assisted semen analyser and categorized samples into normozoospermic (>70% motility) and asthenozoospermic (<40% motility). They confirmed the presence of the binder of sperm-5 from seminal plasma using chemiluminescence coupled antibody-based antigen detection. The asthenozoospermic samples showed lower expression of the binder of sperm-5 than the normozoospermic samples. The binder of sperm displayed five isoforms in two-dimensional polyacrylamide gel electrophoresis. Using fluorescence microscopy, the team confirmed the localisation of the protein to be dominant in the mitochondria rich region of sperm.

In the last three decades, binders of the sperm family of proteins have been studied extensively. They are ubiquitous in mammals and are multifunctional. To improve conception rates and avoid pregnancy loss, during artificial insemination, normozoospermic samples are always preferred. This study highlights the importance of binders of the sperm-5 protein in bull semen for sperm motility and function.

*Theriogenology*, **106**: 279–286

### Urea Briquettes in Paddy

#### *Reducing greenhouse gas emission*

Urea is the cheapest, most commonly used fertilizer in paddy cultivation. Application of urea raises soil pH and increases NO<sub>x</sub> and CH<sub>4</sub> emissions. Slow release forms of urea and different application techniques were tried out to increase efficiency. Top dressing or surface application is less laborious but not as effective as a basal application. Deep placement or basal application of urea as briquette saves 35% of urea but it is labour intensive.

Last fortnight, thirteen scientists from the ICAR-National Rice Research Institute, Cuttack tried a comparison of basal application and top dressing of urea in lowland rice. They experimented in both wet and dry seasons. The team made urea briquettes with rice husk and karanj oil as additional materials. They also

compared the manual against the mechanized application of urea.

The team measured CH<sub>4</sub> and N<sub>2</sub>O using the manual closed chamber method at 3–7 day intervals throughout the year. They found that N<sub>2</sub>O emission flux was higher in the dry season whereas CH<sub>4</sub> was lower. The trend reversed in the wet season.



Image: McKay Savage, Flickr.com

Irrespective of the season, gas emission from plots where mechanized urea briquette application was used, was minimum and closer to the levels of the control plot. The team attributed the reduction in gas flux to the reduction in reactive surface area of the urea briquettes which slowed the enzyme-catalysed processes.

Mechanized application of urea briquettes proved effective in terms of yield also. The mechanical sub surface application of urea briquettes before flooding rice fields reduces the loss of nitrogen as gases and can thus be recommended to farmers. On the one hand, the technique reduces greenhouse emissions and, on the other, reduces urea usage.

*Agric. Ecosyst. Environ.*, **252**: 78–190

### Urban Biodegradable Waste

#### *Enhancing pigeon pea productivity*

Pigeon pea has good nutritive value. Since it is a legume crop and fixes nitrogen, it also improves soil fertility. Pigeon pea does not require heavy irrigation, and is drought tolerant. However, due to poor organic matter and degraded soil, the average yield is only about 7 quintals per hectare. There is potential to increase yield by 75–200% if organic matter is supplied.

Ansari and Mahmood from the Aligarh Muslim University undertook research on pigeon pea under improved soil conditions using rhizobium, a

bacterium that fixes nitrogen, in combination with municipal waste, goat manure and poultry manure separately.

Rhizobia colonize plant roots as nodules and convert atmospheric nitrogen into ammonia. They fix 15–20 kg of nitrogen per hectare and enhance soil attributes by up to 20%.

The scientists conducted a field experiment in pigeon pea for two years from 2012 to 2014. They evaluated the performance of bio-organics such as *Azospirillum brasilense* and *Pseudomonas fluorescens* and organics such as *Parthenium hysterophorous*, *Ageratum conyzoides*, along with municipal waste, and goat and poultry manure. The team recorded plant height, fresh and dry weight, pollen fertility, nodule density, number of pods and primary branches per plant. They monitored the nitrate reductase activity, peroxidase activity and chlorophyll in the plants as well as nitrogen, phosphorus and potash in the soil. The load of soil microbial biomass carbon, microbial population of fungi, actinomycetes bacteria, and beta-glucosidase were also evaluated.

Using statistical software, such as R i386, Duncan's multiple range test, multivariate and principal component analyses, they analysed two years data of all the 16 experimental plots.

The researchers found that the combination of rhizobium with municipal waste markedly improved the growth and yield attributes of pigeon pea over the untreated control. The maximum number of root nodules was recorded in this treatment. It also markedly improved nitrate reductase activity, peroxidase activity and chlorophyll. Nitrogen, phosphorus and potash in soils also improved. Maximum microbial population was recorded in the rhizobium and municipal waste treated plants. While rhizobium in combination with both goat and poultry manure showed considerable improvement in bacterial populations, nitrate reductase and other parameters, these combinations were not to the extent achieved by the rhizobium and municipal waste combination.

This study suggests that a good source of soil nutrients to enhance

agricultural yield in rural areas lies as waste in urban areas.

*Sci. Hortic.*, **226**: 1–9

### Electro-mechanical Technique To determine concrete ageing

Concrete starts gaining strength with hydration of cement. Therefore, it is important to monitor the early part of hydration to predict the strength and cracking patterns of the structure to be formed.



Image: Wikimedia Commons

Last fortnight, scientists from the Indian Institute of Technology and the Bennett University in Delhi proposed a mechanism to monitor the early hardening of concrete. They used an electro-mechanical technique to study the structural impedance offered by the structure. In the process, they identified a non-dimensional parameter to determine hydration in concrete.

The researchers used sensors and piezo-impedance transducers to determine the stiffness of the steel-bars inside the concrete. They analysed the parameter under different signal frequencies for 28 days. The results showed that the non-dimensional hydration parameter is very effective in monitoring the early stage hydration of cementitious materials.

Besides strength monitoring, the scientists say that the model can also be employed in numerous applications such as determining the system's power and energy consumption. This technique can also be applied to the construction industry, as the model can help decide the suitable time for removing the moulds used to shape and structure concrete.

*Mech. Syst. Signal Proc.*, **99**: 129–141

### Desalination of Seawater Pervaporation for separation

More than 90% of the Earth's water is too salty to drink. To overcome this shortage of potable water, most desalination plants use reverse osmosis. However, reverse osmosis wastes water in the form of brine and also consumes electrical energy.

On the other hand, partial vaporization by passing water through a dense membrane to produce ultrapure water – pervaporation desalination – economises on both water and energy.

The water flux through the membrane, used for pervaporation desalination, is usually hydrophilic. As salts are non-volatile and non-diffusive, they do not pass the membrane.

Scientists from the Central Salt & Marine Chemicals Research Institute, Gujarat, have now developed an efficient material for desalination: poly(vinyl alcohol)–silica film on porous polysulfone hollow fibre. They cross linked the silicon and the poly(vinyl alcohol) to fabricate an active membrane.

The team used an automatic dip coating machine to prepare polysulfone hollow fibre composite membranes, reinforced with the highly water-permeable but continuous barrier of poly(vinyl alcohol)–silica film.

This composite material was successful for salinity feeds of up to 50,000 ppm NaCl. The membranes exhibited 99.9% salt rejection when the pervaporation experiment was operated between 26–60 degrees Celsius. Above 60°, the per cent salt rejection was found to decrease.

The thickness of the active layer of the material is lesser than existing membranes. The scientists attribute this to the free volume of the poly(vinyl alcohol)–silica film. This technology promises to be useful for desalination of sea water and to solve the scarcity of water in the future.

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### Remote Sensing Imagery In fisheries and aquaculture

The vantage viewpoint of satellites to map marine and associated resources is being rapidly adopted for the benefit of fisher people and

coastal dwellers. The Second International Symposium on Societal Applications in Fisheries and Aquaculture using Remote Sensing Imagery (SAFARI-2) was held in CMFRI, Cochin, from 15th to 17th of January 2018 to share the advancements made in the field by countries across the world.

From the initial attempts at deducing fish resources by examining the oceans for the presence of chlorophyll the field seems to have exploded. What are the best places in Maharashtra for crab culture and for fin fish farming? How can we do sustainable agriculture in the river estuaries of Karnataka, especially for clam and crabs? What are the best locations for seed nurseries of fin fish and shell fish? How can we extend the areas for prawn culture? What are the best fishing zones in the Bay of Bengal? Where can we find yellow fin tuna in the coasts of Andhra Pradesh? And which locations can be developed as tourist spots in an eco-friendly manner?

How can we optimize on the harvesting of wind, wave and solar energy in the coastal areas? How can we leverage on communication technologies to provide early warning systems for coastal disasters? The questions that are tackled by scientists looking at the seas from space have grown to encompass many societal issues including reduction of conflicts in marine resource sharing between different stakeholders.

This reporter was overwhelmed by the diversity of issues being discussed in SAFARI-2, but could not help wondering how these scientific and technological advances can be understood and assimilated by fishers, traders, fisheries managers and consumers.

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