

Science Last Fortnight

Own a Thanjavur Painting?

Try Raman Spectroscopy

A Thanjavur painting typically adorns many a house in the temple towns of Tamil Nadu. The style originated in Thanjavur during the Maratha reign. The paintings usually depict themes from Hindu iconography. The picture is drawn on a wooden plank and is then decorated with motifs made of gold, precious, and semi-precious stones. Owing to its importance as a classical art form, the Thanjavur painting is distinguished with a geographical indication tag by the Government of India. But, due to its fame, bogus replicas abound. Since fakes are common, art connoisseurs are concerned. Sales outlets and auction houses are plagued with the worry: what if this is not real gold?



Dr M. Muthukrishnan, via Wikimedia Commons

Scientists from the Indian Institute of Technology, Varanasi and the SASTRA University, Tamil Nadu have now concocted a way to discriminate fake from real gold in paintings. The researchers devised the setup based on Raman spectroscopy, a diagnostic tool used to distinguish molecules and atoms with rotational and vibrational modes.

When light falls on such molecules, it scatters depending on the type of rotation or vibration present. The major advantage of using Raman spectroscopy is that it is a non-destructive

tool to test the authenticity of gold in the paintings, explains V. Ramanaathan, IIT BHU.

To verify their strategy, the researchers used samples of actual and fake gold collected from some artisans in Thanjavur. They cleaned the samples with acetone and ethanol to remove any dirt that might have accumulated during or after painting.

A 532 nm laser from the spectrometer was then shone on the samples. Gold, being a metal, is devoid of vibrational and rotational modes. So samples of real gold do not alter the frequency spectrum of incident light. Fake gold, on the other hand, scatters. This leads to the appearance of additional peaks in the frequency spectrum.

'The scattering peaks are signatures that the gold used is fake', says P. J. Arathi, SASTRA University.

The researchers used the same technique to identify the genuineness of the precious and semi-precious stones used in Thanjavur paintings. And that is heart-warming news for art aficionados who can now be sure that their painting is genuine.

The researchers say that it would be beneficial to incorporate such a test into the regulations and frameworks of the committee tagging products with a geographical identity.

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Low-cost Soil Moisture Sensor

Game changer in agriculture

Regular monitoring of soil moisture can help improve plant growth and crop yield. To measure soil moisture, there are resistive and galvanic sensors. However, they are affected by diurnal temperature, salt concentration and soil conductivity and are, therefore, unreliable. Other methods are expensive. So, to meet farmer requirements, a low-cost, highly sensitive, and stable soil moisture sensor is needed.

Last fortnight, researchers from the IIT, Mumbai, the Gauhati University, and the King Abdullah University of

Science and Technology, Saudi Arabia reported designing a low-cost sensor which is highly sensitive to soil moisture. The sensor consists of an inter-digitated electrode with chemically synthesised graphene oxide as sensing platform.

The researchers used micro-electro-mechanical systems to design the micro-sensor. To measure relative humidity and soil moisture, they fabricated an inter-digitated electrode structure using microelectronics.

The researchers evaluated the micro-sensor's response to relative humidity, soil moisture, conductivity and temperature on two different types of soils. The sensor shows high sensitivity in red and black cotton soils. The team found that its response time is fast: around 100–120 seconds. Sensor output varied only by 6% with temperature. There was only a minor change in sensor response when salt concentration increased. The sensor is stable for more than 4 months.

The graphene oxide based soil moisture sensor is soil type independent with uniform and constant properties. It has potential to be developed into a low-cost sensor for field measurements.

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Probiotics in Idli Batter

Weissella confusa

Soak one cup of urad dal, and two cups of rice. Grind them, separately. Keep the batter overnight. The volume increases the next day due to fermentation. Now, mix the batter with some salt and steam it to get tasty idlis. Idlis are more nutritious than just dal and rice, because of fermentation. Now, scientists say that the microbes responsible can work as probiotics.

Shivangi Sharma and a team of researchers from the Pondicherry University experimented with the *Weissella confusa* strain, KR780676, from idli batter. They cultured the strain and subjected it to various simulated gastrointestinal conditions.

The bacteria were stable in high lysozyme conditions as seen in saliva, high acidity as in the stomach and also under bile salts without significant loss in viability.



By SijiR, via Wikimedia Commons

An assay showed that the bacteria had antioxidant activity. Spectrophotometry revealed that the bacteria removed serum cholesterol by binding. So, as probiotic, it may reduce heart-related disorders and prevent cancer.

The researchers say that *W. confusa* showed strong cell surface hydrophobicity and auto-aggregation. It also showed biofilm formation. So, the bacteria can hold on to the host cell as multiple aggregates in the gut.

But is it safe to use as probiotic? Some strains of *W. confusa* have been shown to produce septicaemia. So the researchers screened for haemolytic activity, adding sheep blood to the medium and found that the bacteria do not break down red blood cells. They observed no gelatinase activity. This implies that the *W. confusa* strain does not break down host cell membranes. The team checked for DNase activity of the strain and found none: *W. confusa* does not degrade host DNA.

Can we use the strain in the food industry? *W. confusa* has potential as starter culture for dairy products, say the scientists. The strain exhibited good thermostability, and superior β -galactosidase production. So, it will breakdown lactose. Good news for the lactose intolerant.

The *W. confusa* strain had low proteolytic activity. So it will not affect the shelf-life, flavour and quality of fermented food.

'The strain holds promises for the dairy, fermented food and pharma-

ceutical industries', says Prathap Kumar Shetty, Pondicherry University.

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Diagnosing Breast Cancer

Catching it early

Mammogram images play a vital role in initial screening for breast cancer. But, the accuracy level at early stages is poor. Researchers have tried artificial neural networks, support vector machines and naive Bayes classifiers. But these techniques did little to improve diagnosis, especially in the early stages of breast cancer.

Last fortnight, C. Selvi and M. Suganthi from the Muthayammal Engineering College, Namakkal and the Mahendra College of Engineering, Salem proposed a faster method to identify normal, benign and malignant, accurately and precisely.

They collected images from the mammogram image analysis society database. They then extracted occurrences of grey level and salient areas using a neural network algorithm. The research team used single transition layers to select cases of maximum differences in images.

They used an extreme machine learning method with feature extraction capability to identify and denoise, and segment the images based on saliency and texture. This enhances differences between malignant and benign tumours in mammograms.

Then, the team used different image classifier approaches to classify and detect masses, shapes and marginal features in the textures. They focused on detecting micro-calcification and predicting the growth of cancer cells.

They tested the method's accuracy, sensitivity, specificity and computational time. And found that the method is sensitive enough to produce a positive diagnostic result. It is also specific enough to indicate a negative diagnosis. The researchers say that the method outperforms other neural based classifiers. The algorithm eliminates irrelevant features in images, providing an accuracy of up to 99%.

'The algorithm reduces computational time for mammogram analysis. But, we can tweak it further to improve prediction', says M. Suganthi, Mahendra College of Engineering, Salem.

According to the 2018 WHO report, breast cancer ranks fifth as leading cause of death among women. This can be partly attributed to delay in diagnosis. The research provides a quick way to increase accuracy and performance in diagnosis, even at an early stage.

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Baby Products

How safe is safe?

Commercial baby food products and baby plasticware are assumed to be safe and are used routinely around the world. Baby food products may contain preservatives and additives. Plasticware and baby food packaging also contain chemicals that might cause mutations in DNA. So, how safe are these products?



Donald_Trung, via Wikimedia Commons

Amrita Nepalia and her colleagues from the University of Rajasthan and the Christ University, Bengaluru collaborated to test mutagenicity in popular baby products.

The team bought baby food products and associated plasticware, from

a variety of sources and from different brands. Baby food included mashed fruit pulp in glass jars, powdered cereal in paper packs, paper packed formula milk and canned formula milk. For plasticware, the team selected sippers, milk bottles, water bottles, and feeding bowls.

Now, metal cans may contain lead. And plasticware has bisphenol-A and di-2 ethyl hexyl phthalate. Bisphenol-A is common in food and beverage containers. And di-2 ethyl hexyl phthalate is used around the world as plastic softener. So the team tested for the leaching of these chemicals in baby sippers and metal formula milk cans.

To test for mutagenicity, the researchers chose two strains of *Salmonella typhimurium*, useful to check for different types of mutations.

The team found a low level of mutagenicity in all baby products. Canned formula milk and powdered cereal showed higher mutagenicity than other baby foods.

Among plasticware, the baby sipper was most mutagenic followed by baby feeding bowls. Only the baby sipper showed higher migration of bisphenol-A and di-2 ethyl hexyl phthalate. The team also observed an increase in bisphenol-A and di-2 ethyl hexyl phthalate levels with increase in temperature. They found that the baby sipper and metal can did not leach lead.

Microbial and migration assays to detect mutagenicity cannot be extrapolated to human beings. Further risk assessment, using additional tests, is needed to redefine the safety of baby products. Since the report does not reveal which brands were used and which ones turned out to be unsafe, the takeaway from this report is: wait for baby food to reach room temperature before putting it in plasticware.

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Peeling Value

Orange waste to wealth

Citrus fruit peel is a major waste product in food processing industries. Though peel waste has high value chemicals, extraction is energy consuming.

Shital Yadav and Chandra S. Sharma of the Indian Institute of Technology, Hyderabad, devised a process to convert orange peel waste into high-value products. They washed and peeled oranges, keeping the white layer beneath the outer rind intact. They folded and pressed the peel to extract a yellowish liquid. Centrifugation yielded three different layers, each of which the researchers used for different purposes.

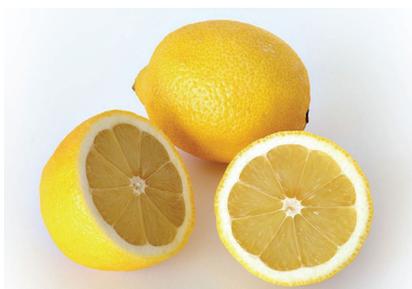
The oil-based top layer served as print transfer solvent. The solvent was as good as alcohol, acetone or xylene. The prints could be transferred on to paper, cloth, skin or nails.

The solvent dissolves thermoplastic polymers like polystyrene. The dissolved polymers could be used to derive yarn for making textiles.

The team pyrolysed the solid particle-based middle layer and got an amorphous, hard, carbon residue that can be used as electrode in batteries.

The water-based bottom layer can be used to electrospin gelatin for biomedical application.

The process not only solves the issue of waste but also generates value products. It is simple, economical and environment friendly.



By André Karwath via Wikimedia Commons

The same method can be applied to other citrus fruits, say the researchers. Sip on the idea when you next guzzle lemonade.

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Cinnamaldehyde as Preservative

With chitosan nanoparticles

Bacterial food spoilage is a major concern for the food industry. Cinnamon, a common spice, is used as food preservative due to its antibacterial activity. It has an anti-quorum sensing effect that stops bacteria from produc-

ing a protective layer against antimicrobials. However, cinnamaldehyde – the active principle in cinnamon – has limitations: it is volatile and not easily soluble in water. Busi Siddhardha and co-workers from the Pondicherry University have now come up with a delivery system for cinnamaldehyde.

They used chitosan nanoparticles. Chitosan nanoparticles are known to provide slow, sustained release of drugs at target sites. The team linked cinnamaldehyde to chitosan nanoparticles using a tripolyphosphate. They found that the encapsulation efficiency of the nanoparticles was about 65%.

To determine the rate of release of cinnamaldehyde, the team incubated cinnamaldehyde-encapsulated nanoparticles in phosphate buffer saline for 24 hours. Using spectrophotometry, they found that the nanoparticles released cinnamon slowly. About 29% was released in the first 12 hours and 60% in the next 12 hours.

Next, they compared the anti-quorum sensing effect. They used *Pseudomonas aeruginosa*, a biofilm-forming bacterial pathogen. They observed that the cinnamaldehyde-encapsulated nanoparticles inhibited the formation of biofilms. This effect was stronger than with cinnamaldehyde alone. The team found that the production of pyocyanin, an important virulence factor of *P. aeruginosa* was also inhibited.

The team foresees the use of cinnamaldehyde-encapsulated nanoparticles as preservative in the food industry.

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Composting Food Waste

Nourishing microalgae for biofuel

Microalgae have been used for biofuel production. We can grow microalgae using industrial process water, or other wastewater. Though environment-friendly, they are expensive to cultivate using artificial medium.

Recently, Shalini S. Arya from the Institute of Chemical Technology, Mumbai collaborated with scientists from Malaysia and Taiwan to investigate substituting the usual medium with food waste compost.

The scientists used various percentages of waste compost to replace the artificial media and grew *Chlorella vulgaris*. They measured algal growth and the biochemical composition of the medium to evaluate efficiency.

The scientists report that using a 25% compost mixture with inorganic medium yields higher biomass concentration. They say the compost mixture helps produce 11% higher biomass concentration with better lipid and protein composition.

Using food waste compost can save on costs for microalgae cultivation. It can also help us manage the environmental issues caused by food waste.

The technology can be extended to grow other species of cultivable microalgae, say the scientists.

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Degrading Paper Mill Sludge

Fungi and earthworms as bioagents

While they sustain the information society, paper and pulp industries also produce large amounts of solid wastes, toxic to health and environment. Researchers have explored anaerobic digestion, ethanol production and vermicomposting for safe disposal and to convert sludge to useful products. These processes are time consuming.

Besides water, sludge from such industries contains cellulose, lignin, wood cuttings and ash. Researchers from the Doon University, Dehradun realised that earthworms alone were not enough to degrade cellulose and lignin. So, they decided to try brown-rot fungi, known to break down cellulose and hemicellulose in wood, when combined with earthworms. To speed up the process further, they added cow dung. Cow dung has bacteria that break down cellulose and it also serves as food for earthworms.

The team prepared five combinations of the sludge and cow dung. They created three experimental setups. In one, they used only earthworms. In the second, they inoculated fungi with the waste and, in the third,

they used both fungi and earthworms. After 28 days, the researchers observed that the treated wastes were alkaline due to microbial activity. There was a decrease in total organic carbon and cellulose. The team also noted an increase in total nitrogen, phosphorus, and potassium – attributes of well composted manure.

'A 50–75% sludge-cow dung combination showed the best results', says Surindra Suthar, Doon University. The researchers found a high rate of mineralisation and microbial populations where the fungus was incubated with waste.

'A combination of earthworms and brown-rot fungi on sludge mixed with cow dung produces superior fertilisers and saves time. What is more, earthworms bioaccumulate heavy metals from sludge and help reduce environmental toxicity', says Renu Negi, Doon University.

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Bioelectricity from Sewage

Microbial fuel cell

Of the 38000 million litres of sewage generated daily by Indian cities, only about 12000 million litres is treated. The untreated wastewater pollutes rivers, contaminates drinking water and threatens public health. This threat can be turned into an opportunity to generate electricity, says a team of Indian scientists. They employed microbial fuel cell technology to convert the chemical energy of biodegradable sewage waste into electricity.

Certain anaerobic sewage bacteria – exoelectrogens – break down organic matter and, in the process, electrons are released. A microbial fuel cell traps these electrons at its anode and directs them to the cathode through an external resistor, generating electricity.

Debajyoti Bose and colleagues at the University of Petroleum & Energy Studies, Dehradun fabricated a two chambered microbial fuel cell with carbon cloth electrodes separated by a Nafion-117 membrane. They charged the anode chamber with

wastewater as fuel and filled the cathode chamber with phosphate buffer. The semipermeable Nafion-117 membrane separates the solutions. And selectively allows H⁺ ions through, but restricts fuel crossover.

On open circuit analysis, the researchers found that the cell could generate a peak voltage of 750 to 850 mV. The voltage increased to 1.45 V by adding small amounts of sucrose. Once a resistor is attached to the electrodes, the cell generates electricity. The system produced a peak power density of 817 mW/m² with a 1000 Ω resistor.

Once there is a flow of current in the circuit, the decomposition of organic waste is hastened. Besides reducing the bulk of sewage, the technique improves the quality of wastewater. After about two weeks of operations, the chemical oxygen demand and total dissolved solute reduce to about one-fifth. The organic load of the sewage water, as indicated by biological oxygen demand, also decreases to almost half. At these levels, current flow stops and the fuel chamber needs recharging.

Under the microscope, the scientists found that the bacteria formed stable biofilms. The bacteria donated electrons to the anode, through conductive nanowires, as well as directly, through surface blebs.

Producing bioelectricity, while treating wastewater, is the major advantage of the technology. The method also avoids aeration during sewage treatment and reduces sludge production. Upscaling the lab scale reactor to commercial dimensions remains a challenge.

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