In this issue

Going bananas over fire

A child hops on a sofa again and again. Each time her feet land on the cushion, the cushion spews a burst of flame retardants. And she inhales...

SUDDENLY, your fishing rod hooks a bite. The rod curves flexed by the weighted struggle of the baited fish. You heave, the line tenses, and the hooked fish – a herring – breaches the water, and flails gasping in the air. But you don't roast it over the campfire, instead you head straight to the laboratory, milk the herring for its sperm, isolate the DNA molecules, and embed them into the fabric of your clothes. *Why?* Because herring DNA is a flame retardant – a substance artificially added to materials to enhance their fire safety.

Flame retardants fire-proof the world in which we nest. *They are everywhere*. In the gear of defence personnel. In the nightdresses of children. In the space suits of astronauts. In our curtains. Our clothes. Our carpets. But, unlike herring DNA, which are non-toxic biomolecules, most of these fire sentinels are toxic chemicals.

Unhygienic.Carcinogenic.Mutagenic.

Regrettably, *they indeed are everywhere*. In the stomachs of infants. In the milk of breastfeeding mothers. In the serum of blood donors. No wonder, given the negatives of chemical retardants, researchers have now begun to synthesize 'green' flame retardants composed of animal biomolecules, such as herring DNA and dairy protein.

These biomolecules, although non-toxic and biodegradable, however, are unmarketable because of two constraints. First, they suffer from poor durability, a wash would scrub them off. And second, their synthesis demands a high capital – herring DNA, for instance, costs four times more than chemical flame retardants. Thus, considering such disadvantages of animal biomolecules, one would not be naive to assume that many years will pass before we can sport clothes coated with green retardants.

Research Article, **page 372**, begs to differ.

This study breaks new ground and reports the synthesis of a green[er] flame retardant tailored not from animal biomolecules but from plant biomolecules. Non-toxic. Durable. Cheap. This retardant is extracted from a crop residue disposed of as waste in farms: the banana plant's pseudostem.

What factors influence R&D success?

'R&D is creative work undertaken on a systematic basis in order to increase the stock of knowledge...'

10 FEBRUARY 2020. Imagine you are the new chairman of ISRO, and the Indian government has just sanctioned 950 crore rupees to fund a new R&D project. This R&D project marks the beginning of a new epoch in India's timeline. A *project of dreams*, whose objective is to soft-land a mechanized rover on Mars. NEWS flashes ping everywhere; the media have christened the project as Mangalyaan III. And you, in only your first year as chairman of ISRO, spearhead this space mission.

The clock ticks. You need to gather a team. You need to create new departments. You need to meet deadlines. But most important, you need to deliver. The pressure is immense. Billions of eyes are fixed on India. You stare into the night sky; Mars appears to be so close that you think you can reach out and pluck it. *You simply have to deliver.* Mangalyaan III must succeed.

But you realize that the odds are stacked against you; the risk of failure, high. So, before you set the wheels of the project in motion, you wish to – like a General readying his battle formations – understand the lay of the land. You spend hours in your office, seated in a rocking chair, curtains drawn, forehead furrowed, and draw a mental map to understand what ***factors*** would most influence the success of Mangalyaan III?

Factor #1: *Esprit de Corps* – the morale of your team. *Factor #2*: The technology transfer from developed countries. *Factor #3*: The resources, both human (skilled labour and scientists) and non-human (laboratories, funding). *Factor #4*: Your sway as a leader. Does your team respect you? *Factor #5*: Organizational setup. *Factor #6*: Creativity. *Factor #7... Factor #8... Factor #9...*

Soon you realize – as Review Article, **page 357**, delineates – that the success of your project derives strength from all these factors, and more. The clock ticks. Rain drips. You close your eyes and begin to dream about the launch.

The countdown: *10...9...8...7...* The rocket blasts off. The solid propellant tanks are jettisoned. Escape velocity. The spacecraft cruises towards Mars. Fifty five million kilometres of vacuum. It pierces Mars's atmosphere; its heat shield glows white-hot. Parachutes – to slow the craft's descent – are deployed, and the rover, cocooned in air-bags, is dropped from 40 feet above the surface. Soft landing! It carves its first tread-trail on the Martian sand. The applause and cheers at command control. The tears.

You wake up, and sigh; you still have a long way to go... *Factor #10:* Work atmosphere. *Factor #11:... Factor #12:...*

Molecular thumbprint

How does the invisible look like?

TWO powerful molecular imaging techniques – Raman and infrared (IR) spectroscopy – allow us to peel the fabric of the invisible, and *see* molecules.

In Raman spectroscopy, the spectroscope beams a UV/visible laser through the sample. The photons of this laser collide inelastically with the sample molecules, and suffer a change in energy. A computer depicts this change in energy of the photons as 'peaks'.

In IR spectroscopy, the spectroscope beams an infrared laser through the sample, and the sample molecules, unlike Raman, don't scatter the photons but instead absorb them, owing to which the intensity of the laser passing through the sample decreases – represented as 'dips'.

These 'peaks' and 'dips' comprise the image spectra of the molecules, and are their veritable thumbprints: *the spectra of no two molecules are congruent.* Thus, the analysis of the image spectra can indeed reveal the true identity of the molecule.

In other words, *seeing* invisible molecules is similar to *seeing* something as palpable as, say, a ball. The difference being, we actually *see* the ball, because the photons reflected off the ball strike our retina; but in Raman and IR spectroscopy we *see* only the ghost of the molecule, a proxy: the peaks and dips of the molecule's image spectrum. Hence the name spectroscopy: '*spectre*' meaning ghost; '*scope*,' to see.

Other than being equipped with keen noses for molecules, IR and Raman spectroscopy, unlike most other imaging techniques, are also rapid, non-invasive, and can probe multiple targets simultaneously in a sample. Not surprisingly, therefore – Review Article, **page 341**, explains – a number of diverse research fields wear the photonic lenses of Raman and IR to delve into the invisible.

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