

# chemistry



May 2015

*in Australia*

## Faulty communication: the bottom line

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US Army/Wikimedia

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## From the President

People join RACI for a variety of reasons.

I joined in the last millennium (1986) during the Honours year of my degree at the University of Newcastle. The driving force was unusual, but not unique, because all of my fellow Honours students that year did the same. We all had, as a group, spent a lot of time solving the (then) *annual* RACI Cryptic Chemistry Crossword created by Dr Malcolm McCamish from the University of Queensland. We feared that our entry would be invalid unless we were RACI members so we all duly joined. Our entry was correct and we received an attractive certificate in the post, but not the famed 'handsome trophy' for the ultimate winner.

I never knew whether RACI membership was a requirement to enter this competition. Ironically, when I joined the Chemistry Department at the University of Queensland in 1994, I finally met Malcolm face to face and I told him my story. Malcolm admitted sheepishly his membership had lapsed years ago but he was still compiling cryptic crosswords for *Chemistry in Australia*. Now a cryptic chemistry crossword appears in every issue of *Chemistry in Australia* (thanks to the sustained efforts of Graham Mulrone), but almost 30 years on and without all of my colleagues to help I am hopelessly out of my depth!

So, apart from chemistry cryptic crosswords, why have I remained an RACI member all this time? There are significant economic benefits of membership. The many conferences and symposia that RACI runs offer members significantly discounted registration fees, often in excess of annual membership. *Chemistry in Australia* (including its crossword) is another benefit and its engaging content and presentation (hard copy or online) is something I look forward to every month. These are benefits that all RACI members enjoy *passively*.

However, the greatest benefit that I have derived from RACI membership is when I have been *actively* involved. I joined the Queensland Branch Committee in 1995 and for the first time I began to see the breadth and diversity of RACI events (conferences, symposia, career development etc.) outside my

own interests and meet chemists from different sectors (other universities, industry, teachers and government organisations).

An overseas sabbatical in 2000 meant that I stepped down from the Committee and I fell back into passive membership. In 2007, I became Chair of the RACI Inorganic Chemistry Division (2007–10) and joined the RACI Assembly – the elected 14 Divisional Chairs and eight Branch Presidents and the principal advisory group to the RACI Board. Here I saw how the RACI really functioned on so many levels and its role as a national network of professional chemists.

When the opportunity arose to be nominated for the position of RACI President Elect in 2012, I didn't hesitate. Joining (and now chairing) the RACI Board, the group that collectively makes the decisions that shape the Institute, has been, and continues to be, one of the most rewarding experiences of my professional life.

Not everyone wants to be RACI President (it's a lot of work!); involvement in the RACI can be at many of the abovementioned levels. What we need is *your* input, ideas and initiatives. Is there is an area of chemistry (research, education, industry, government etc.) that would benefit from the establishment of a new group (local or national) or even running events that would be of interest to RACI members? RACI will provide the resources and infrastructure to help you get started and gather momentum. That's really what RACI is – a network (or family) of chemists who share a professional interest in chemistry.

If you want to become involved, your first point of contact can be me or perhaps your Branch President. To paraphrase an often quoted speech, ask not what your Institute can do for you but ...



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ISSN 0314-4240 e-ISSN 1839-2539



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Isothermal titration calorimetry (ITC) is a technique used to measure and characterise biomolecular binding interactions. ITC works by directly measuring the heat that is either released or absorbed during a biomolecular binding event. ITC is the only technique that can simultaneously determine binding parameters such as binding affinity ( $K_d$ ), stoichiometry ( $n$ ), enthalpy ( $\Delta H$ ) and entropy ( $\Delta S$ ) in a single experiment. Requiring no modification, either with fluorescent tags or through immobilisation, ITC measures the affinity of binding partners in their native states. Applications range from drug discovery and design, for characterising biomolecular interactions to fundamental research such as the understanding and regulation of signal transduction pathways.

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## Mira M – handheld Raman spectrometers with ORS technology

Metrohm is pleased to introduce the Metrohm Instant Raman Analysers (Mira). The Mira spectrometers are the only handheld Raman analysers available with Orbital-Raster-Scan (ORS) technology. This highly reproducible averaging technique extends the scope of possible samples to any kind of heterogeneous and sensitive materials.

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- Instantly ready to use in any place
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- Point-and-shoot identification – close-range measurements through packaging of different thicknesses (including plastic and amber glass)
- Orbital-Raster-Scan technology – reproducible measurements, even of temperature-sensitive and heterogeneous samples
- Safe – the basic package can be used without any additional safety measures required (laser protection class 1)
- Maximum flexibility – comprehensive spectral libraries
- Robust and maintenance-free
- Wide range of applications – from temperature-sensitive samples to any kind of fluorescent samples
- Automatic calibration in critical applications

For further information, contact MEP Instruments, ph. (02) 9878 6900, email [info@mep.net.au](mailto:info@mep.net.au) or visit [www.mep.net.au](http://www.mep.net.au).





## Hy-Cycle commercialisation

I enjoyed Professor Aguey-Zinsou's article on a hydrogen fuel cell bicycle, and learned a lot about the storage of hydrogen using borohydrides (March issue, p. 16). However, I have some doubts about the commercial viability of such a product. Note that I am not questioning the technical aspects at all, nor am I questioning the project as a valuable learning exercise for students. I guess if someone were to come to me and ask me to fund a commercial venture to manufacture these vehicles, I would want to ask at least three questions up front.

- 1 Who do you see as the market?
- 2 What is the competition?
- 3 How much is it going to cost?

In terms of question 1, I would be asking such things as: who is the likely purchaser, what is an estimate of the likely commute distance, where and when is it likely to be used?

Concerning competition, this is a product that clearly already has competitors in the marketplace. Looking at just bicycles (and not other vehicles on the road), I would nominate the common push bike, and bicycles fitted with battery-powered electric motors or small petrol motors. The fuel cell electric bike is clearly most similar to the battery-powered bike, and should be compared to that product first up. How many battery-powered bikes are sold per year? What percentage of this market would a fuel-cell bike be expected to capture? Alternatively, would a fuel-cell bike be expected to grow the auxiliary motor bicycle market, and if so, by how much? I would note that the battery-powered bike has the advantage of an established infrastructure in the form of mains power to charge

the battery, although in Australia both types rely on mainly coal-fired power stations as the ultimate source of their energy.

The cost of the product is another factor. Here, the fuel-cell bike runs up against the not-so-humble push bike as a competitor, especially as this vehicle requires no power supply infrastructure. Bear in mind that Aldi sells bikes with 21 gears for around \$125, and you start to get an idea of the competition. For well under \$1000 you can get a comprehensively featured commuter bike that will, with a modicum of care, last for many years. With 30 gears and weighing about 11 kilograms, a cyclist with a reasonable level of fitness can tackle virtually any hill and ride for long distances. Compare this to the Hy-Cycle. It's a heavy-looking clunker, without even considering the 2.5-kilogram hydrogen pack. From what I can see, you'd spend little time pedalling, and most of the time letting the electric motor tow you around. From the few battery-powered bikes I've seen around, most seem to be used on battery power only (and mostly on the footpaths!)

I must declare a prejudice against motorised bicycles. I simply can't see the need. At 73, I have been riding a bike for exercise (an hour a day) for the past 35 years or so. My old Cannondale Headshok mountain bike weighs 12 kilograms, and with 27 gears, I can climb virtually any hill, although a little more slowly these days.

Tom Smith FRACI CChem

I also enjoy riding my bike to go to work. It is a hybrid bike with an aluminium frame and thus very light. However, when I have important meetings I prefer to use my hydrogen bike because I can still easily go through Sydney's traffic and arrive fresh at my meetings. Some of my colleagues also enjoy the flexibility of bicycles and take their kids to school in a bike trailer on their way to work. Once again, electrical assistance transforms the experience.

Bicycles have become more than a means to exercise. In busy cities, they are now a very effective way to commute. The electric bike market is a multibillion dollar industry. China for obvious reasons is one of the biggest markets for electric bikes (about 200 million in 2014) – and India is projected to be a bigger market. In developing countries, electric bikes provide power to move goods around. But the number of electric bike users is also rapidly increasing in other parts of the world. Electric bikes are now 45% of the sales in Germany, 21% in the Netherlands, and 5% in France ([www.insg.org/%5Cdocs%5CINSG\\_Insight\\_23\\_Global\\_Ebike\\_Market.pdf](http://www.insg.org/%5Cdocs%5CINSG_Insight_23_Global_Ebike_Market.pdf)).

Our main reason for building the Hy-Cycle is to demonstrate how simple the technology is. Obviously it can be adapted to run anything that requires power, including a house. Previous demonstrations of hydrogen use for transport have been done on buses because of the space needed to host the pressurised hydrogen tanks (up to 700 bar) and this poses obvious safety concerns in case of failure and hydrogen escape. With the technology (metal hydrides) that we have implemented on the



Hy-Cycle, the use of hydrogen becomes safe because only a small amount of hydrogen will be released upon rupture of the canister (way below the flammability limit of hydrogen).

Often, when thinking of implementing new technologies, one adopts current centralised models, and thus in the context of energy, major investments will be required to build large central infrastructures and distribution networks to deliver the hydrogen. In fact, such an approach is not necessary because hydrogen can be produced from locally available resources, i.e. solar, wind, waves or even organic wastes in the near future. Many Australians are now equipped with solar panels, and with a combined electrolyser/hydrogen storage unit it is very easy to produce and store some hydrogen for a Hy-Cycle or a hydrogen car – and thus provide people with the ability to produce their own clean energy. Considering the alternative of electric vehicles, current infrastructures in Australia and in particular the electrical grid are not capable of taking the extra load and this will require major investments in addition to the development of relatively complex ‘intelligent grid concepts’.

In the commercialisation phase, the Hy-Cycle will come with its own hydrogen generator to refill the canisters from tap water and electricity in 30 minutes. The estimated retail price is \$5000 for a range of 125 kilometres and unlike a battery the hydrogen canister will still safely store hydrogen after 25–30 years. Cheaper bicycles can always be produced. However, in a world where the availability of resources is going to be a major issue, it is time that we shift our society towards more sustainable models where resources are used wisely, products become better designed so they can be repaired and recycled, and people are treated fairly for the work they produce.

Kondo-Francois Aguey-Zinsou

## Climate change and thermodynamics

A recent letter to Your Say (March 2015) by B.F. Gray contains several misleading criticisms of my response to the letter of Richard Corbett (Dec 2014/Jan 2015), which I feel I cannot leave without reply. First of all, B.F. Gray objects to the application of the laws of thermodynamics to an animal organism on the basis that animals are open systems. Of course every living organism is an open system, as is the Earth as a whole. This doesn’t mean thermodynamics doesn’t apply. For example, as we get older it becomes increasingly clear to all of us that we can’t escape the second law of thermodynamics. Entropy always wins in the end.

Thermodynamics applies universally to all systems, open or closed. For open systems, if one wishes to calculate their temperature, it is necessary to consider the rates of heat flow in and out. For an animal, this means the rate of heat dissipation to the environment and the rate of heat generation via metabolism. This was already explained in my original article ‘When the going gets hot’ (June 2013 issue, p. 20), which, based on the contents of his letter, B.F. Gray obviously didn’t

read. Further evidence of this can be found in his later comments concerning mechanisms of body cooling (sweating and panting, for example), which although correct, were also already described in my original article. These thermoregulatory mechanisms allow animals to survive at ambient temperatures above their body temperature for a period of time and delay the onset of heat-stress. However, there is no denying that prolonged exposure to high temperatures inevitably leads to death, an important reason for taking global warming seriously.

Naturally I apologise profusely to B.F. Gray for not citing his 1972 article published in *Combustion and Flame*. However, before writing another letter to the editor, B.F. Gray might also like to consider reading the original article on which the letters he criticises were based.

Ronald J. Clarke

## Climate change and professional duty

Jim Bonham’s concise, lucid and logical letter (March issue, p. 5) makes me proud to be a chemist. One can only wish that the thinking was as clear at our upper levels of government. A question not often discussed is why the populace is not marching on Canberra. I have distilled the following about public opinion from my reading, which includes several books and many of the official reports.

- It’s hard to accept that just 1°C can be causing so much bother.
- The whole climate thing is very complex and too darned hard to understand (this is fanned by lobbying and a huge disinformation campaign and a media that gives too much space and time to ratbags) – but for a quick summary see also ‘The science of climate change’ from the Australian Academy of Science (2010 and 2015 update).
- Science generally has been downgraded, so some are reluctant to accept scientists’ advice.
- The present population is not trained to think in really big terms such as the cosmos, or in geological time periods or about whole ecosystems.
- Australia is too small to make any difference (but not too small to host the G20 or chair UN committees).
- The idea of any international agreement to take drastic action seems cloud nine (though agreements have been signed between various groups of countries and the movement is building).
- And, even for those who begin to understand, climate change is just too threatening to face up to.

I believe that we professionals have a duty to make the real situation known whenever we can and even to seek out audiences that we can reach.

Bruce Graham FRACI CChem

## New Prime Minister's Prize for Science

The Australian Government will recognise the practical and commercial successes of Australian scientists with a new award to be added to the 2015 Prime Minister's Prizes for Science.

Minister for Industry and Science Ian Macfarlane said that Australians make a significant investment in science through an annual government budget of \$9.2 billion.

'The new prize, the Prime Minister's Prize for the Commercial Application of Science, will promote building better links between researchers and industry and encourage entrepreneurship in our business and research communities.

'Developments in Australian science have the potential to drive the innovations that create jobs and improve our quality of life.'

In their 15th year, the Prime Minister's Prizes for Science recognise outstanding achievements in science

research and excellence in science teaching, and are Australia's pre-eminent annual science awards.

The new prize for commercialisation of science complements the other prizes which have recognised discoveries such as the cervical cancer vaccine; technology that made wireless computing fast and reliable; evidence of dark matter and dark energy in the universe; and technologies that help to make the oil and gas industry safer and more efficient.

Last year's recipients of the Prime Minister's Prize for Science were Laureate Professor Sam Berkovic and Professor Ingrid Scheffer of the University of Melbourne, who led the way in finding the genetic basis for many types of epilepsy.

The introduction of the new prize means the Government has increased the total prize money to \$700 000 across the six prizes to be awarded in 2015.

The Prime Minister's Prize for Science recognises a significant advancement of knowledge through science.

The Prime Minister's Prize for the Commercial Application of Science is awarded for the translation of science knowledge into a substantial commercial impact.

The Frank Fenner Prize for Life Scientist of the Year and the Malcolm McIntosh Prize for Physical Scientist of the Year acknowledge the work of our best early to mid-career scientists.

The Prime Minister's Prize for Excellence in Science Teaching in Primary Schools and the Prime Minister's Prize for Excellence in Science Teaching in Secondary Schools recognise excellence in science teaching with prize money shared equally between the recipient teacher and their school.

MINISTER FOR INDUSTRY AND SCIENCE

## Does chemical exposure in the workplace affect hearing?

With one in six Australians recording some form of auditory loss, a new study by the University of Queensland is examining how exposure to chemicals in the workplace can affect employee hearing.

Led by Dr Adrian Fuente of the School of Health and Rehabilitation Sciences, the study aims to identify the most effective hearing tests to detect problems caused by chemical exposure, and the safe levels of exposure to maintain healthy hearing at work.

Fuente said certain occupations were more at risk than others, including painters, spray-painters, those working in textile, clothing and footwear factories, and aviation and lab workers.

'While much is known about the dangers of noise exposure in the workplace, the public is often unaware of the role that certain chemicals can play in causing early hearing loss,' Fuente said.

The study is currently seeking employees working in the painting, spray-painting, textiles, clothing, aviation and jet fuel, footwear and histology lab industries to participate in the research.

As part of the study, participants will have their hearing tested via non-invasive procedures.

'There is still not enough understanding of which levels of chemical exposure are safe for our ears,' Dr Fuente said.

'I encourage people working in these industries to participate in this vital research, the outcomes of which could have a definitive impact on the Australian workplace in the pursuit of healthy hearing for all.'

Those interested in participating in the study should contact Laura Sheridan on [l.sheridan@uq.edu.au](mailto:l.sheridan@uq.edu.au) or phone (07) 3346 7489.

UNIVERSITY OF QUEENSLAND



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# How copper forms around volcanoes

Dormant volcanoes, such as this one in a Bolivian desert, may be a future target of copper exploration.

Scientists from the Australian National University (ANU) and University of Bristol have discovered how copper ore forms around volcanoes.

The findings contradict previous theories of how copper forms, and could lead to changes in exploration for copper, which has limited reserves but is crucial for electricity transmission.

Lead researcher Dr John Mavrogenes, from the ANU Research School of Earth Sciences, said the research examined what causes the large copper deposits, known as porphyries that form around volcanoes.

'We found that these copper deposits need rocks containing both copper and sulfur,' he said.

'If you look at the volcanic rocks that typically surround these deposits, they are quite rich in copper but very low in sulfur.

'But the much hotter rocks below them have a lot of sulfur. That sulfur is percolating up and kneading these rocks and causing the porphyries to form.'

Mavrogenes said that this discovery contradicts the existing theory that the copper deposits were caused by water that comes from magma.

The research involved a laboratory simulation of the copper porphyries formation that was able to replicate the natural process.

'We found that it's very likely that this process is crucial to porphyry copper formation,' he said.

Mavrogenes said the research could lead to improvements in the way mining companies search for copper porphyries.


'These porphyries are economically huge deposits. There's a couple of them in Australia from when we had an ancient volcanic arc here around 400 million years ago,' he said.

'What we would suggest that these companies do is to look more at the rock and see if it has the kind of composition we've identified.'

The research may also be used to develop a better understanding of when volcanos might erupt.


The research was published in *Nature Geoscience* (doi: 10.1038/ngeo2351).

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## Molecular blocker could lead to treatments for inflammatory diseases

Scientists at Trinity College Dublin have uncovered a molecule that blocks a key driver of inflammatory diseases. The finding could meet a major unmet clinical need by inspiring new non-invasive treatments for arthritis, multiple sclerosis and Muckle-Wells syndrome, among a myriad of other inflammatory diseases.

In a study published in *Nature Medicine*, the international research team led by Trinity and the University of Queensland showed how the molecule MCC950 can suppress the 'NLRP3 inflammasome', which is an activator of the key process in inflammatory diseases.

Inflammasomes have been identified as promising therapeutic targets by researchers over the last decade. And now the discovery of MCC950's abilities represents a hugely significant development in the effort to find treatments for inflammatory diseases, for which current therapies are either highly ineffective or have major limitations.

Crucially, the finding also confirms that inflammatory diseases all have a common process, even though the part of the body becoming inflamed might differ.

Professor of Biochemistry at Trinity, Luke O'Neill, is the joint senior scientist behind the discovery. He said: 'Drugs like aspirin or steroids can work in several diseases, but can have side effects or be ineffective. What we have found is a potentially transformative medicine, which targets what appears to be the common disease-causing process in a myriad of inflammatory diseases.'

Lead author Dr Rebecca Coll said: 'MCC950 is blocking what was suspected to be a key process in inflammation. There is huge interest in NLRP3 both among medical researchers and pharmaceutical companies and we feel our work makes a significant contribution to the efforts to find new medicines to limit it.'

Professor Matt Cooper, chemist and co-senior author from the University of Queensland's Institute for Molecular Bioscience, added: 'MCC950 is able to be given orally and will be cheaper to produce than current protein-based treatments, which are given daily, weekly, or monthly by injection. Importantly, it will also have a shorter duration in the body, allowing clinicians to stop the anti-inflammatory action of the drug if the patient ever needed to switch their immune response back to 100% in order to clear an infection.'

So far, the results have shown great promise for blocking multiple sclerosis in a model of that disease, as well as in sepsis, where potentially fatal blood poisoning occurs in response to bacteria. However, the target for MCC950 is strongly implicated in diseases such as Alzheimer's disease, atherosclerosis, gout, Parkinson's disease and rheumatoid arthritis, which means it has the potential to treat all of these conditions.

Another disease where the new drug might have significant benefits is Muckle-Wells syndrome, which is a rare and severe auto-inflammatory disorder. Using blood samples from patients, the authors showed that MCC950 can block the rogue gene responsible for repeated inflammatory activation in sufferers.

Dr Dan Kastner of the National Institutes of Health USA, said: 'MCC950 might well be a key addition to the options for treating Muckle-Wells syndrome and similar diseases.'

O'Neill added: 'We are really excited about MCC950. We believe this has real potential to benefit patients suffering from several highly debilitating diseases, where there is currently a dire need for new medicines.'

The above story is based on materials provided by Trinity College Dublin.

LABROOTS

## Deakin's Carbon Nexus to partner with DowAksa

Australia's carbon fibre industry growth strategy has been given a boost with a new partnership between Deakin University and DowAksa – a joint venture between provider of acrylic fibre Aksa and The Dow Chemical Company.

DowAksa will work with Deakin's carbon fibre research centre, Carbon Nexus to advance worldwide market adoption of carbon fibre composites and promote Australian expertise in materials and manufacturing technologies to industrial composite parts makers and end users such as automotive manufacturers in North America and Europe.

Carbon Nexus Director Derek Buckmaster said the DowAksa partnership was a key part of the growth plan for the research facility.

'We are already working in partnership with the world's first commercial maker of single-piece carbon fibre auto wheels, Carbon Revolution, which is based at our Waurin Ponds campus alongside Carbon Nexus, and recently expanded its operations,' Buckmaster said.

'Australian carbon fibre parts manufacturer Quickstep is also setting up a dedicated automotive division at our Waurin Ponds campus to design and develop automotive manufacturing cells and enable the production of customer prototypes and initial production quantities.'

DowAksa is a charter member of US advanced composites consortium award announced last month by President Barack Obama to establish a national advanced composites manufacturing institute.

Subject to final negotiations between this consortium and the US Department of Energy, the new institute being formed, called the Institute for Advanced Composites Materials Innovation, will bring more than US\$250 million in combined federal, state, corporate and academic support to accelerate the development of an advanced composites industry in the US.

Once the new Institute begins operations, the University hopes it will provide an extended platform for collaborative engagement and networking with business and academic leaders in the American market.

DEAKIN UNIVERSITY

# Untangling DNA the simple way

Researchers have long sought an efficient way to untangle DNA in order to study its structure – neatly unravelled and straightened out – under a microscope. Now, chemists and engineers at KU Leuven, in Belgium, have devised a strikingly simple and effective solution: they inject genetic material into a droplet of water and use a pipette tip to drag it over a glass plate covered with a sticky polymer. The droplet rolls like a ball over the plate, sticking the DNA to the plate surface. The unravelled DNA can then be studied under a microscope. The researchers described the technique in the journal *ACS Nano* (doi: 10.1021/nn5063497).

There are two ways to decode DNA: DNA sequencing and DNA mapping. In DNA sequencing, short strings of DNA are studied to determine the exact order of nucleotides – the bases A, C, G and T – within a DNA molecule. The method allows for highly detailed genetic analysis, but is time- and resource-intensive.

For applications that call for less detailed analysis, such as determining if a given fragment of DNA belongs to a virus or a bacteria, scientists opt for DNA mapping. This method uses the longest

possible DNA fragments to map the DNA's 'big picture' structure.

DNA mapping can be used together with fluorescence microscopy to quickly identify DNA's basic characteristics.

In this study, researchers describe an improved version of a DNA mapping technique they previously developed called fluorocoding.

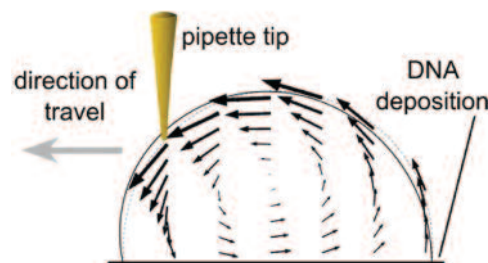
Chemist Jochem Deen explained: 'In fluorocoding, the DNA is marked with a coloured dye to make it visible under a fluorescence microscope. It is then inserted into a droplet of water together with a small amount of acid and placed on a glass plate. The DNA-infused water droplet evaporates, leaving behind the outstretched DNA pattern.'

'But this deposition technique is complicated and does not always produce the long, straightened pieces of DNA that are ideal for DNA mapping.'

'Our improved technique combines two factors: the natural internal flow dynamics of a water droplet and a polymer called Zeonex that binds particularly well to DNA,' explained engineer Wouters Sempels.

The 'rolling droplet' technique is simple, low-cost and effective.

'We used a glass platelet covered with



a layer of the polymer Zeonex. Instead of letting the DNA-injected water droplet dry on the plate, we used a pipette tip to drag it across the plate. The droplet rolls like a ball over the plate, sticking the DNA to the plate's surface. The strings of DNA 'captured' on the plate in this way are longer and straighter,' explained Sempels.

To test the technique's effectiveness, the researchers applied it to the DNA of a virus whose exact length was already known. The length of the DNA captured using the rolling droplet technique matched the known length of the virus DNA.

The rolling droplet technique could be easily applied in a clinical setting to quickly identify DNA features, say the researchers. The technique could eventually also be helpful in cancer research and diagnosis. '

KU LEUVEN

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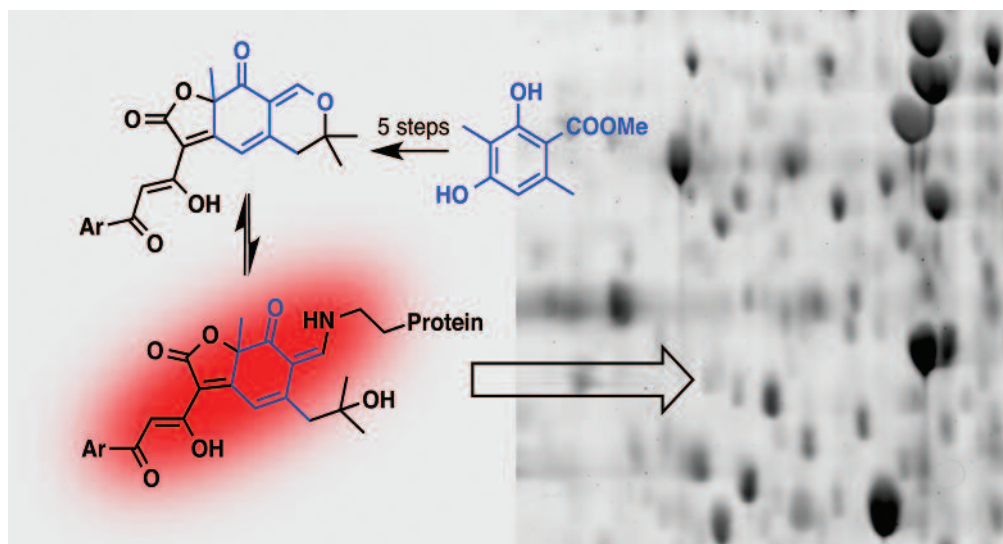


## A natural fluorophore finessed

The natural product epicocconone was discovered by researchers at Macquarie University in 2003 (Bell P.J.L., Karuso P. *J. Am. Chem. Soc.* 2003, **125**, 9304–5). As the first reversible-covalent-latent fluorophore, it has since found wide biotechnological applications in proteomics, live cell imaging and enzyme assays. The masked aldehyde of epicocconone reacts with amine residues (e.g. lysine) to create a red-fluorescent enamine that is acid-stable but reverts back to the non-fluorescent masked aldehyde in a base-catalysed reaction, providing a unique ‘turn-on/turn-off’ capacity. However, epicocconone suffers from photobleaching and a low quantum yield. These challenges inspired the researchers at Macquarie, along with collaborators at Rouen University, France, to investigate the design and synthesis of new fluorophores that encompass the advantages of the natural product but with improved photophysical properties

(Peixoto P.A., Boulangé A., Ball M., Naudin B., Alle T., Cosette P., Karuso P., Franck X. *J. Am. Chem. Soc.* 2014, **136**, 15248–56). This group has made the first approach to the total synthesis of the natural product, and concurrently

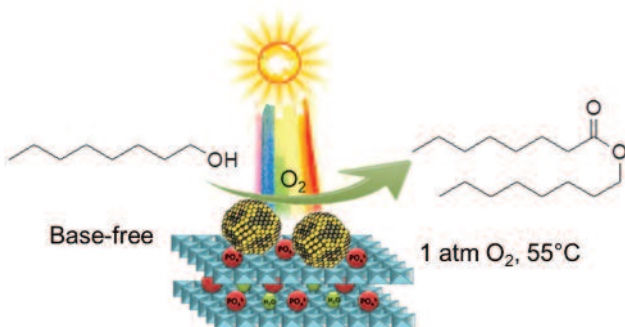
prepared several analogues that have better quantum yields and stability. The synthesis is general and straightforward, providing access to libraries of fluorophores with long Stokes’ shifts, based on the lead from nature.



## Efficient esterification under visible light

Direct oxidative esterification of aliphatic alcohols under mild and base-free conditions is challenging, especially if it is to be achieved using a recyclable catalyst. PhD student Qi Xiao, working with Professor Huaiyong Zhu at the Queensland University of Technology, has addressed this challenge by devising a one-pot process for the catalytic transformation of aliphatic alcohols to the corresponding esters by visible-light

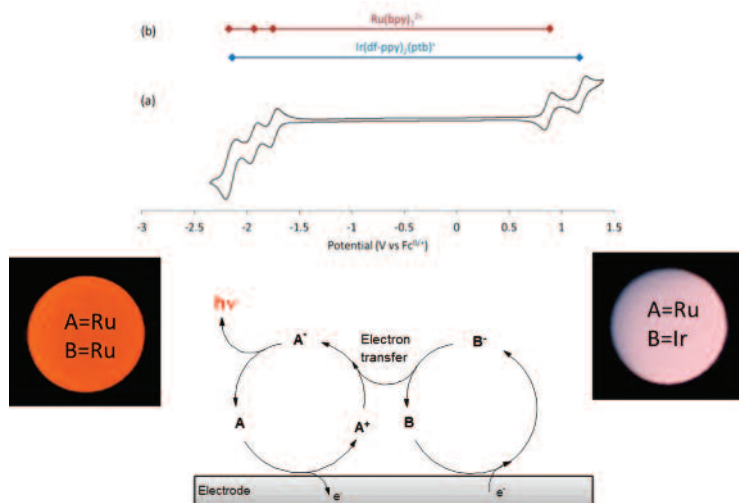
irradiation at ambient temperature (Xiao Q., Liu Z., Bo A., Zavahir S., Sarina S., Bottle S., Riches J.D., Zhu H.Y. *J. Am. Chem. Soc.* 2015, **137**, 1956–66). The new methodology uses recyclable heterogeneous photocatalysts comprising gold–palladium alloy nanoparticles on a phosphate-modified hydrotalcite support and molecular oxygen as a benign oxidant. The catalyst effectively couples the basic sites of the support material with the photocatalytic properties of the alloy nanoparticles. Thus, the direct esterification of aliphatic alcohols can be driven without any additives under visible-light irradiation using benign reaction conditions. These heterogeneous catalysts can easily be recycled and reused, which is important in developing practical and cost-effective catalytic oxidation processes. This is the first example of ‘green’ oxidants and light energy being used to drive direct oxidative esterification of aliphatic alcohols under mild, base-free conditions.



## Colour control in electron transfer-induced light emission

Researchers from La Trobe and Deakin universities have demonstrated for the first time the ability to finely control the emission colour of annihilation electrochemiluminescence (ECL) in mixtures of luminophores by varying the applied potential. Annihilation ECL is the emission that results from highly energetic electron transfer reactions between electrochemically oxidised and reduced precursors. The many closely spaced redox processes of the mixed systems enable fine tuning of the reaction energetics and hence control of the resulting emission colour. The team led by Conor Hogan and Paul Francis showed in their recent paper (Kerr E., Doeven E.H., Barbante G.J., Hogan C.F.,

Bower D.J., Donnelly P.S., Connell T.U., Francis P.S. *Chem. Sci.* 2015, **6**, 472–9) that, by using different combinations of luminophores and applied potentials, emission colours varying from red to green to blue, as well as magenta and close to white, could be achieved. These studies are an important step towards the development of novel voltage-controllable light-emitting devices, and provide interesting fundamental insights into electroluminescent systems. For example, the observation of efficient HOMO-to-HOMO electron transfer pathways in these mixed systems sheds light on whether the reduced or oxidised partner becomes the excited state in classic annihilation ECL experiments.



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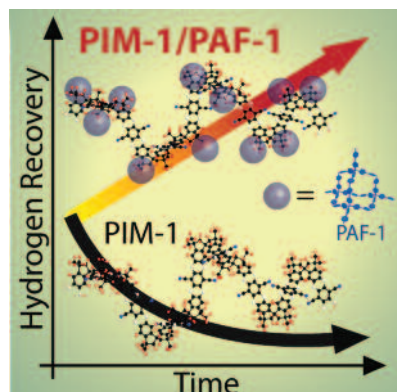
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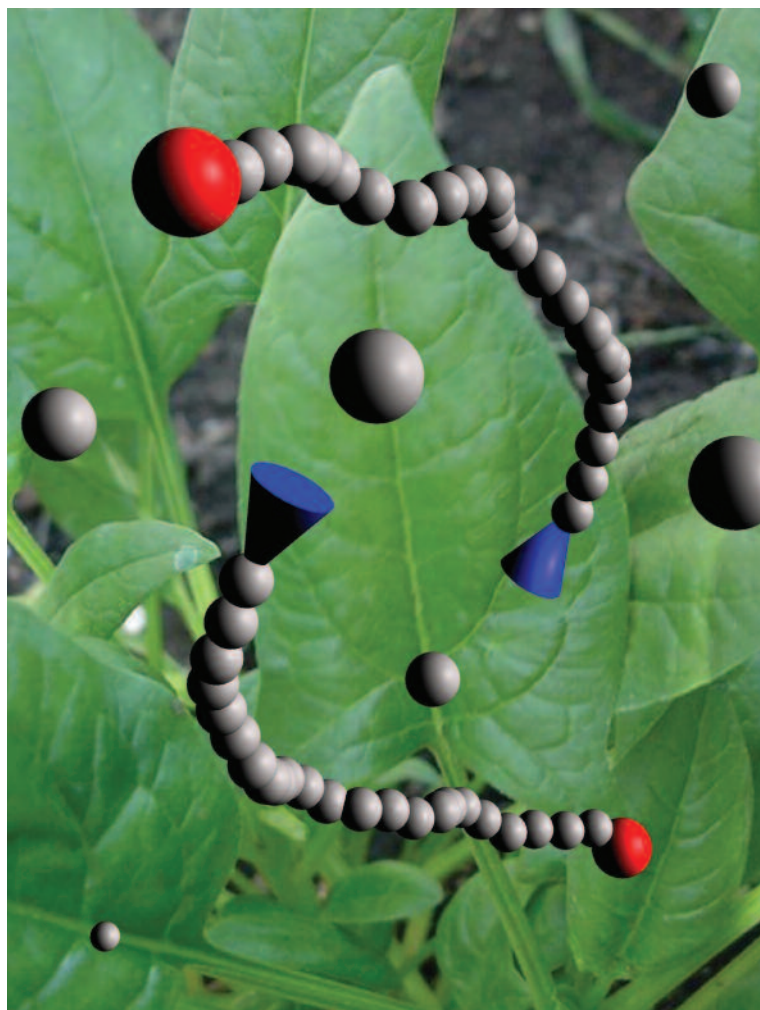
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## Like fine wine, gas separation membranes improve with age



The key to exploiting ammonia cracking for a hydrogen economy is hydrogen recovery through green approaches. Researchers at the CSIRO led by Dr Cher Hon (Sam) Lau and Dr Matthew Hill have recently published unprecedented  $H_2/N_2$  separation efficiencies of 98% using polymer membranes as a green alternative to energy-intensive separation techniques (Lau C.H., Konstas K., Thornton A.W., Liu A.C.Y., Mudie S., Kennedy D.F., Howard S.C., Hill A.J., Hill M.R. *Angew. Chem. Int. Ed.* 2015, **54**, 2669–73). The key to success is the selective ageing of polymers with intrinsic microporosity (PIMs), which reduces nitrogen permeability over time without sacrificing high hydrogen permeability. This is achieved by adding an ultraporous additive, porous aromatic framework PAF-1, which physically tethers side chains of the polymer within its pores to stop the smallest gas transport pathways taken by hydrogen from closing. The study advances membrane use for alternative energy production. The CSIRO team is expanding this study with alternative PIMs for separating other gas pairs.

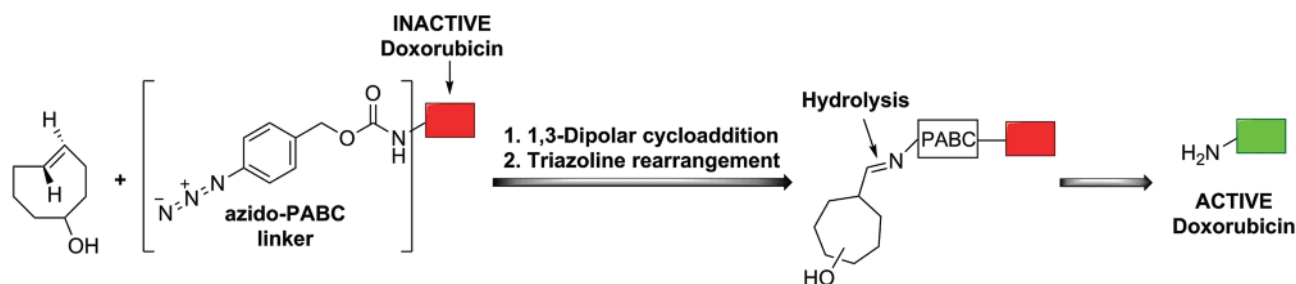
## Living polymerisation catalysed by spinach



Transition metal catalysts have recently been used to achieve spatial and temporal control of radical polymerisation. But these catalysts are highly toxic and so the polymers produced require several purification steps before they are safe to use. In addition, they are derived from metals that exist in trace amounts in the Earth's crust and are therefore extremely expensive. Working with Associate Professor Cyrille Boyer at the University of New South Wales, PhD student Siva Shanmugam has instead used spinach-derived chlorophyll A, one of nature's most abundant photocatalysts, to perform sustainable green photopolymerisation to produce polymers with myriad potential biomedical applications (Shanmugam S., Xu J., Boyer C. *Chem. Sci.* 2015, **6**, 1341–9). This work harnesses the ability of chlorophyll A to undergo photoinduced electron transfer under light to activate chain-transfer agents such as dithioester or trithiocarbonate reagents, which are then able to initiate and mediate radical polymerisation of a wide range of monomers with excellent control over molecular weights and molecular weight distributions.



## Pro-drug activation using bioorthogonal chemistry



Bioorthogonal chemistry, or the ability to perform selective chemical reactions in a complex biological environment, has rapidly developed into a tool for chemical biology. However, its use in disease-targeted pro-drug activation remains limited. Dr Allan Gamble and co-workers from the University of Otago recently discovered a novel method of pro-drug activation using a bioorthogonal

1,3-dipolar cycloaddition (Matikonda S.S., Orsi D.L., Staudacher V., Jenkins I.A., Fiedler F., Chen J., Gamble A.B. *Chem. Sci.* 2015, **6**, 1212–18). The approach involves the use of a strained *trans*-cyclooctene and an azide-functionalised pro-drug, resulting in rapid formation of an unstable 1,2,3-triazoline that undergoes rearrangement to an imine via extrusion of diatomic

nitrogen. The imine is then rapidly hydrolysed at physiological pH to yield the active drug via a spontaneous 1,6-elimination of the *p*-aminobenzyloxycarbonyl (PABC) linker. Ways to further increase the rate of cycloaddition and drug release are currently being investigated, with the optimised pro-drugs to be tested in a mouse model.



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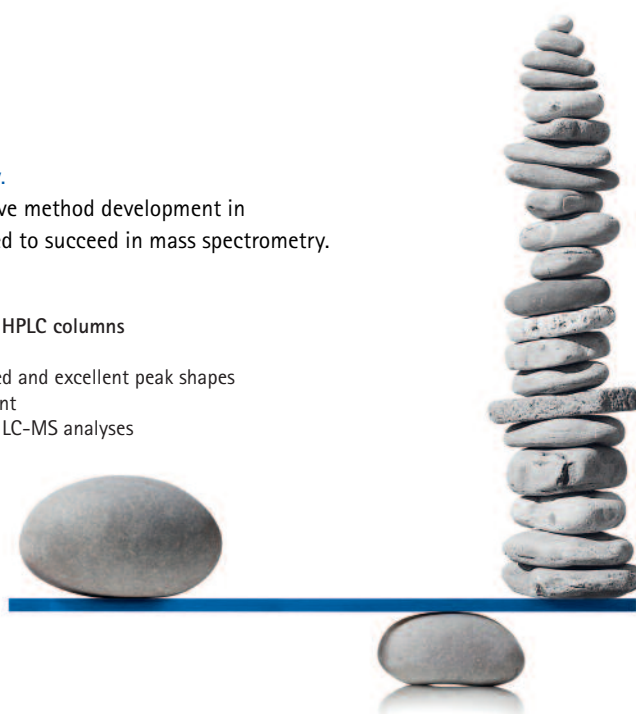
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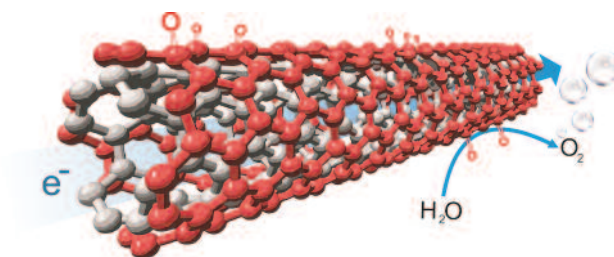


Plasticware



## Surface-oxidised carbon nanotubes are catalysts

Carbon-based nanomaterials such as carbon nanotubes have found significant applications as substrates for supporting metal and metal oxide nanoparticle catalysts in energy devices such as water-splitting cells and fuel cells. Oxygen-containing groups are omnipresent on the surface of carbon materials, but until now their role in catalytic activity has been unclear. The group of Associate Professor Chuan Zhao at the University of New South Wales has shown that, upon mild surface oxidation, hydrothermal annealing, and electrochemical activation, multiwall carbon nanotubes (MWCNTs) are themselves effective water oxidation catalysts that can initiate oxygen evolution at overpotentials of only 0.3 V in alkaline media (Lu X., Yim W.-L., Suryanto B.H.R., Zhao C. *J. Am. Chem. Soc.* 2015, **137**, 2901–7). Oxygen-containing functional groups such as ketonic C=O on the outer walls of MWCNTs were found to play a crucial role in catalysing oxygen evolution by altering the electronic structure of adjacent carbon atoms and by facilitating adsorption of reaction intermediates. The well-preserved microscopic structure and highly conductive inner walls of MWCNTs enable efficient transport of electrons generated during oxygen evolution. These findings open the door to new applications of surface-oxidised carbon nanomaterials for catalysing important reactions for electrochemical energy storage and conversion.



Compiled by **David Huang** MRACI CChem (david.huang@adelaide.edu.au). This section showcases the very best research carried out primarily in Australia. RACI members whose recent work has been published in high impact journals (e.g. *Nature*, *J. Am. Chem. Soc.*, *Angew. Chem. Int. Ed.*) are encouraged to contribute general summaries, of no more than 200 words, and an image to David.

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## Aust J Chem

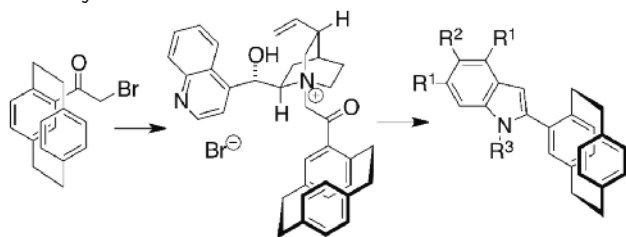
The April issue is dedicated to the memory of Sir John ‘Kappa’ Cornforth, who passed away in December 2013. He was raised in Sydney and Armidale and studied chemistry at the University of Sydney, working with Francis Lions and Gordon K. Hughes for his BSc(Hons) degree. Arthur Birch, later of Birch reduction fame, who was a year ahead of Cornforth at Sydney, has recounted in the *Historical records of Australian science* 2009 how Francis Lions used to make cocktails from distilled alcohol, and that ‘his student John Cornforth in about 1938 invented a “cocktail” that contained absolute ethanol flavoured with ethyl acetate and vanillin – which effectively smooths down the tissues – coloured by methylene blue [... which] produced chromatic urinary effects after imbibing, dismaying to the uninitiated’. Cornforth was known to make up limericks on the run, and he got his own back on Birch, as reported by Sir Harold Kroto in this issue:

That outpost of empire, Australia,  
Produces some curious mammalia,  
The kangaroo rat,  
The bloodsucking bat,  
and Arthur J. Birch inter alia.

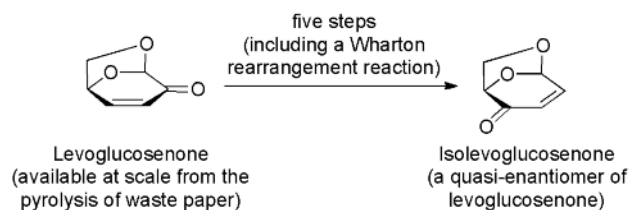
Cornforth subsequently spent all of his scientific life in the UK. *Aust. J. Chem.* has started a Cornforth Review series in his honour, and the first such review is published in this issue by L.R. Malins and Richard Payne (University of Sydney) on synthetic amino acids for applications in peptide ligation–desulfurisation chemistry.

Damon Ridley (formerly of the universities of Sydney and Sussex) contributes a foreword with narratives and comments on a number of Cornforth’s publications. Andrew Holmes (University of Melbourne) is the 2015 Cornforth Lecturer at the University of Sydney and reports with several co-workers a synthesis of highly water-soluble adamantyl phosphoinositide derivatives.

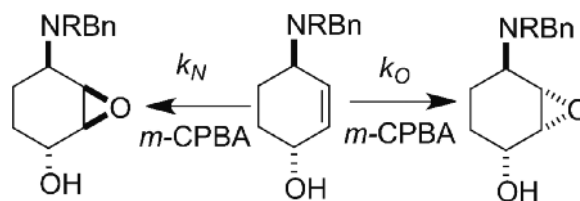
Gareth Rowlands of Massey University, New Zealand, and co-workers report an asymmetrical variant of the Bischler–Möhlau indole synthesis.



Martin Banwell and co-workers (ANU) report the rearrangement of levoglucosenone, a compound that will soon be available in tonne quantities through the pyrolysis of acid-treated biomass, to isolevoglucosenone.

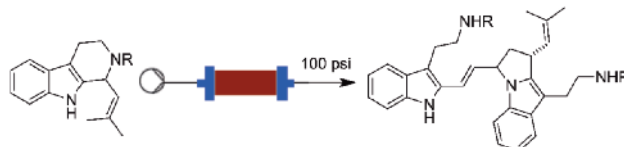


Steve Davies (Oxford) and co-workers describe epoxidation of *trans*-4-aminocyclohex-2-en-1-ol derivatives, which can take place by means of either hydroxyl-directing or ammonium ion-directing pathways. Thus, different ratios of stereoisomers are formed depending on the NRBn substituents as described by the two rate constants  $k_N$  and  $k_O$ .



Ray M. Carman, Paul V. Bernhardt and Tri T. Le (University of Queensland) report a highly unusual phenomenon, viz. the formation of a ‘pseudoracemate’; that is a ~70:30 mixture of diastereomers instead of the usually expected 1:1 racemate. The phenomenon is ascribed to a little-known interaction between remote chiral centres.

Steven Ley and Sonja Kamptmann (Cambridge University) describe flow chemistry methods resulting in the synthesis of an indole ‘dimer’, which can be converted to the borrerine-derived alkaloid flinderole A.



Several more papers complete this excellent issue.

Curt Wentrup FAA, FRACI CChem (wentrup@uq.edu.au),  
[http://uq.edu.au/uqresearchers/researcher/wentrupc.html?uv\\_category=pub](http://uq.edu.au/uqresearchers/researcher/wentrupc.html?uv_category=pub)





the manner in which their predictions were communicated. Ultimately, the convictions were based on the accused giving 'inexact, incomplete and contradictory information' about the dangers of the tremors prior to the quake.

In simple terms, on 5 April 2009 the six scientists met with a government official and two local representatives to discuss a recent series of small tremors and the alarms raised by a local lab technician who, reportedly on the basis of radon levels, predicted an imminent quake. They concluded that the risk of an earthquake within the next three days had risen from 1 in 200 000 to 1 in 1000 – in other words, unlikely but also significantly increased from 'usual'. The scientists left it to the local civil defence official to speak to a reporter, who inaccurately reported their findings as "The scientific community tells us there is no danger, because there is an ongoing discharge of energy. The situation looks favourable."

None of the scientists spoke up to correct this statement. In fact, Dr Bernado De Bernadinis, deputy chief of Italy's Civil Protection Department, added that local citizens should go and have a glass of wine. The next night, a big quake hit. And this is what the trial was about.

Contrast this case to a more recent, and fortunately non-lethal, example – New York's February 2015 'Nomageddon'. In this case, meteorological authorities issued a warning of a major snowfall that caused the closure of airports, rail lines and a range of other civic infrastructure, bringing the city to a standstill. Yet the threatened snow fell out to sea, and what had been initially forecast as

'Snowmageddon' was renamed ... to be followed by widespread public derision and grovelling apologies from the scientists involved.

Both cases come down to the same two fundamental principles: uncertainty and risk. Of these, uncertainty lies at the very core of science. It is accepted that true science is measurable, testable and repeatable. It is honed by detailed scrutiny and repeated challenge, and yet even so it remains open to change.

Even concepts as rigorously tested and thoroughly demonstrable as evolution are only raised to the level of 'theory' (a term that is widely misunderstood by non-scientists). Almost no theory ever reaches the lofty peak of becoming a 'law', and even then it is not unassailable. Newton's laws of motion may form the basis for a large chunk of modern science, yet accommodation is still made for the contradictory outcomes of quantum theory.

So, uncertainty is critical to the practice of science. Yet it sits uncomfortably with the principle of

risk, and this is ultimately what lies at the centre of many of the 'debates' listed earlier (except for AIDS denial, which is stupid and reported as such; and intelligent design, where scientific terminology is used without scientific process to disguise religious ideology).

Risk is complex. More than just an issue of perception, it embodies both the chance of an occurrence (positive or negative) and the effects of that event. Acceptable risk varies according to the group affected. The acceptable risk of chemical exposure to a factory worker is different from the acceptable risk for a nearby kindergarten.

Even the language of risk is a problem. How many of us truly understand what a 'one in 100 year' flood event risk actually means? As the Bureau of Meteorology explains, 'It is important to note that an ARI [average recurrence interval] of, say, 100 years does not mean that the event will only occur once every 100 years. In fact, for each and every year, there is a 1% chance (a 1 in 100 chance) that the



A government office damaged by the 2009 L'Aquila earthquake.

Wikimedia



## Between the 'scientific community' and 'the general public' ... lies a range of complicating stakeholders – media, governments and special interest groups. Collectively, these complicate the challenge of communicating science effectively to a nearly insurmountable extreme.

event ... will be equalled or exceeded (once or more than once).'  
([bit.ly/1DOvj7](http://bit.ly/1DOvj7))

The L'Aquila case ultimately came down to the perceptions of risk. Look at the inherent contradiction in the statement made before the trial by Dr Vincenzo Vittorini, who lost his wife and daughter in the quake: 'Nobody here wants to put science in the dock. We all know that the earthquake could not have been predicted, and that evacuation was not an option. All we wanted was clearer information on risks in order to make our own choices.' He knew that the scientists couldn't be certain. He knew that evacuation was not practical. So what 'clearer information' would have enabled him to make his own choices?

Between the 'scientific community' and 'the general public' (both loose terms encompassing quite diverse sets of skills and needs) lies a range of complicating stakeholders – media, governments and special interest groups. Collectively, these complicate the challenge of communicating science effectively to a nearly insurmountable extreme.

Of these, I want to particularly address the challenge of the media itself. Most critically, the media is a business, first and foremost. It thrives on circulation and sensationalism, and its dedication to the truth is peripheral at best.

Setting aside the ideological biases to reporting underlying particular major news networks, the issue of 'balanced reporting' itself distorts the communication of science. Far more knowledgeable people than me have

commented on the inherent problem in the perceived need in the media to present 'both sides' of a debate, regardless of the scientific merit (or utter lack thereof) of either claim. Call it the difference between the median and the mean. It gives massively disproportionate voice to the fringe, and to special interest groups motivated by anything other than science.

Consider climate change reporting. Without taking a position on the science myself, it would be fair to say that there is a majority consensus regarding the hypothesis of anthropogenic global climate effects. However, a widely reported paper by M.T. Boykoff and J.M. Boykoff ('Balance as bias: global warming and the US prestige press', *Global Environmental Change* 2004, vol. 14, pp. 125–36) found that a majority of 636 randomly sampled articles from US mainstream press gave 'roughly equal attention' to the two 'sides' of the discussion, while 35% emphasised the consensus view while still presenting the opposition in subordinate fashion, and only 6% focused on the consensus without bothering with the other 'side'.

Just as worryingly, there is an increasing trend in modern media towards the use of 'sound bites'. Over the years, science may have had some rare flashes of inspiration in this – think 'Eureka' (Archimedes), aided for posterity by a naked street run. But joking aside, science does not lend itself well to short summaries. It is very difficult to present findings in a measured fashion, with due attention to uncertainty, in just a few words.

Moreover, our words now have unprecedented longevity. Hardly a problem restricted to science alone, it is increasingly common to hear reasoning along the lines of 'but ten years ago you said this contradictory statement', the corollary being either that the interviewee was or is being untruthful, or that whether incorrect then or now, either way the person can be universally discounted. Obviously, this directly contradicts the very basis of good science.

In this context, the initial L'Aquila conviction is of concern – that the legal system is increasingly backing a public perception *requiring* scientists to not only do their jobs, but also take liability for the understanding of audiences outside the profession. This has the potential to gag scientists from the proper participation in public discussion of scientific issues.

As Stuart Clark noted in *The Guardian* after the 2012 conviction ([bit.ly/17Tf2j9](http://bit.ly/17Tf2j9)):

*In 1633, the punitive treatment of Galileo eviscerated the practice of astronomy in Italy for centuries ... although the conviction was for miscommunication, astronomy itself became toxic ...*

*Today, it is very hard to see how the conviction of these geologists will do anything to improve the sciences in Italy. Certainly, lessons in the communication of earthquake risk must be learned ... but who will dare to speak up now with this outcome as precedent?*

Ultimately, there is no simple answer to this problem. However, there is one emerging solution underway that I believe should help – the increasing inclusion of media and communications training in undergraduate science degrees, particularly at institutions in the UK. The better we understand the needs and approaches of the audiences with whom we are communicating, the better prepared we will be to do so.

---

**Dave Sammut** FRACI CChem is principal of DCS Technical, a boutique scientific consultancy, providing services to the Australian and international minerals, waste recycling and general scientific industries.



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# Heavy hydrogen

## Making the most of conductive molecules

The discovery of the conductive properties of organic materials has led to the expanding field of organic electronic devices and conductive polymers. Organic light-emitting diodes (OLEDs), photovoltaics and dye-sensitised solar cells are components of everyday items such as mobile phone and television displays and rooftop solar systems for electricity generation. Globally, the value of this market is predicted to grow from over \$16 billion in 2014 to more than \$75 billion by 2020 ([bit.ly/1Fvz8uG](http://bit.ly/1Fvz8uG)).

Development of new organic molecules with tailored electrochemical properties is attracting significant attention. One mechanism under investigation is the replacement of hydrogen ( $^1\text{H}$ ) with deuterium ( $^2\text{H}$ , or D) within the organic molecules in these devices. It is often assumed that this isotopic substitution

does not significantly change the chemical and optoelectronic properties of the parent compound, but the relatively large mass difference between hydrogen and deuterium can result in different behaviours of deuterated molecules from that of their protonated analogues.

This difference has been observed in optical fibres. They transmit light along a length of filament by multiple internal reflections of light. It is important that the light applied at one end of the filament is efficiently transmitted to the opposite end, so it is necessary to minimise light losses due to absorption and scattering. The transmitted light is often (unfavourably) attenuated by the C–H bond vibrations of the organic molecules used to construct the polymeric core of the fibre. Deuteration of these organic molecules eliminates the C–H bond vibration, reducing light losses along the transmission.

Deuteration of conducting polymers has been reported to alter the optoelectronic properties of the molecules and the resultant processes (such as charge transport) in photovoltaic devices (*Nature Mater.*, doi: 10.1038/nmat2633; *Nature Commun.*, doi: 10.1038/ncomms4180). Deuteration of organic molecules within the emissive layer of OLEDs has improved features such as light-emitting efficiency, high-voltage stability and device lifetime (*J. Phys. Chem. C*, doi: 10.1021/jp066116k).

Deuterated molecules can be synthesised in a variety of ways, based on either chemical or biological deuteration.

### Chemical deuteration

Several methods can be used to perform hydrogen/deuterium-exchange reactions at carbon centres, including pH-dependent exchange and exchange catalysed by either a



BY **ANWEN KRAUSE-HEUER**

## Molecular deuteration is making its mark in the expanding field of optoelectronics.

homogeneous catalyst (such as Pd or Pt salts, e.g.  $K_2PtCl_4$ ) or a heterogeneous catalyst (such as Pt/C or Pd/C). The source of deuterium for exchange is often  $D_2O$ , but these reactions can also be performed using  $D_2$  gas or deuterated protic solvents to provide labile deuterium atoms. High temperatures and pressures are also often necessary to achieve high levels of deuterium incorporation, requiring expensive specialised hydrothermal vessels (see photo p. 22).

Often, a desired molecule cannot be deuterated directly, because of factors such as insolubility, volatility, instability at high temperature and incompatibility of functional groups with the catalyst and/or reaction vessel. Instead, the synthesis of the desired deuterated molecule can require the deuteration of precursors and assembly via standard organic chemistry methodology.

### Biodeuteration

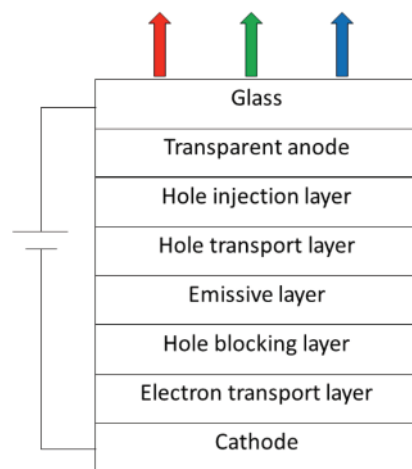
Another method for producing deuterated molecules is biodeuteration. Microbial cultures (such as *E. coli* or algae) are grown in  $D_2O$  and supplied with either deuterated or hydrogenated 'food', depending on the level of deuteration required. The desired deuterated molecule (such as proteins, lipids, nucleic acids or polysaccharides) is then extracted from the biomass and purified by standard biochemical techniques.

### Synthesis of deuterated OLED compounds

TCTA (tris(4-carbazoyl-9-ylphenyl)-amine) protein (utilised in hole transport layers) is one compound that has been deuterated for use in OLED devices. The synthesis of deuterated

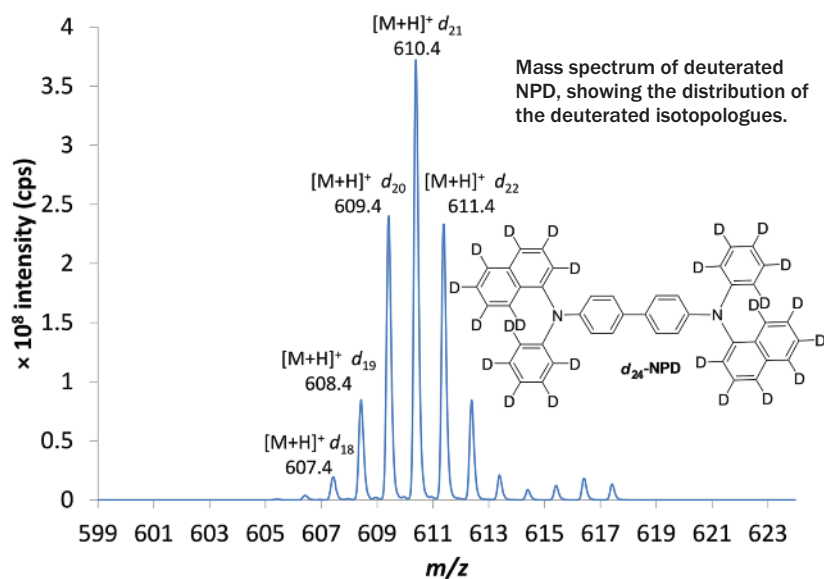
TCTA via H/D hydrothermal exchange in  $D_2O$  directly on protonated TCTA resulted in low yields and relatively low overall deuterium incorporation. This was despite the addition of THF as a co-solvent to improve the solubility of the compound in  $D_2O$  to facilitate the H/D exchange. Instead, the carbazole precursor was first deuterated under hydrothermal conditions in  $D_2O$  catalysed by Pt/C, and then reacted with protonated tris(4-bromophenyl)-amine via a modified Ullman condensation (see scheme p. 24) to synthesise deuterated TCTA (*Tetrahedron Lett.*, doi: 10.1016/j.tetlet.2011.12.032).

Organic chemists at the National Deuteration Facility (NDF) have recently developed a method that utilises mild reaction temperatures ( $80^\circ C$ ) and standard laboratory glassware for the large-scale (tens of grams) deuteration of primary and secondary arylamines, such as *N*-phenylnaphthylamine and *N*-phenyl-*o*-phenylenediamine. This method eliminates the requirement for

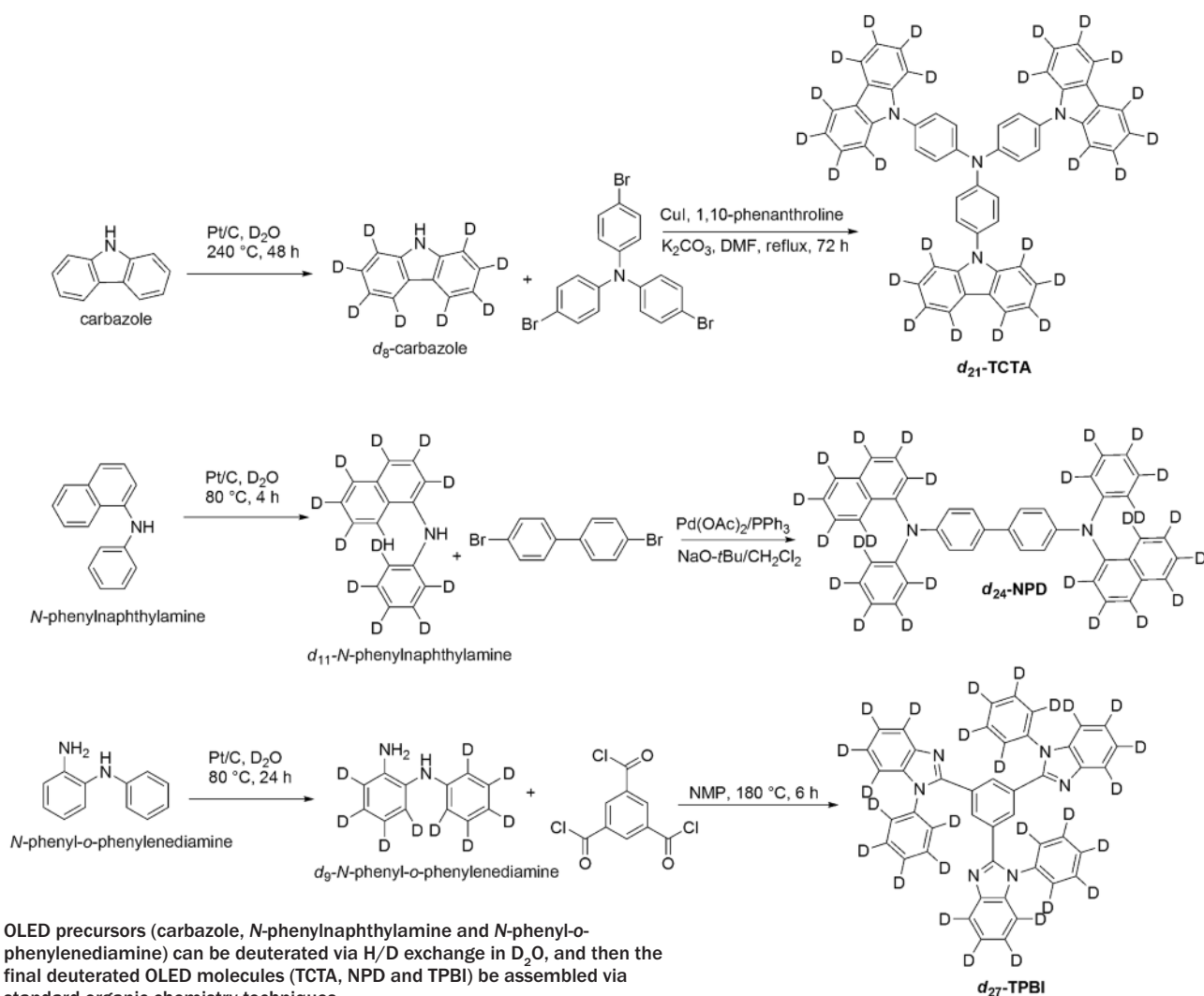


OLEDs are multiple organic layers sandwiched between two electrodes. Typically, an OLED electron transport layer contains electron deficient molecules, the hole transport layer contains electron-rich molecules, with the molecule(s) for the emissive layer selected on the basis of desired colour of the device and often blended with a host.

the expensive, specialised hydrothermal vessels for the bulk synthesis of these molecules. These deuterated precursors can then be used for the assembly of deuterated organic molecules (such as NPD and TPBI, see diagram on p. 24) for use in optoelectronic devices, as direct deuteration of these final compounds is also not favourable. The development of these mild conditions and the large-scale synthetic method can allow for synthesis of deuterated molecules with optoelectronic applications on a larger scale, which







may be of benefit for commercial applications.

### Characterisation of deuterated molecules

It is important to be able to calculate the overall efficiency of deuteration in the final organic molecule; for neutron studies, this allows the scattering length density of the material to be estimated. The overall levels of deuterium incorporation are determined by mass spectrometry (MS), as each additional deuterium atom incorporated into the molecule increases the mass of the molecule by one mass unit. The percentage deuteration can be calculated by analysing the area under each corresponding isotopologue, taking

into account the percentage contribution of the  $^{13}\text{C}$  isotopic distribution. The example mass spectrum of deuterated NPD (p. 23) shows the distribution of the isotopologues.

Nuclear magnetic resonance (NMR) spectroscopy can be used as a complementary technique to MS to calculate the percentage of deuteration. The deuterium nucleus has a spin quantum number of 1, making it NMR silent in  $^1\text{H}$  NMR spectroscopy. By adding an internal standard with a known number of moles of protons, and comparing the integration of the resonance of the internal standard to the resonances of the residual protons (as the deuterated sites are NMR silent), it is possible to

**The replacement of hydrogen with deuterium can alter and improve the optoelectronic properties of the molecule, and allow the functional devices to be studied via neutron scattering techniques.**

## National Deuteration Facility

The NDF was established in 2007 and is jointly funded by the National Collaborative Research Infrastructure Strategy (NCRIS) and the Australian Nuclear Science and Technology Organisation (ANSTO). The NDF primarily provides deuterated molecules to be used for experiments within the Bragg Institute that use neutrons generated by ANSTO's nuclear reactor, OPAL.

Access to the OPAL Neutron Beam Facility and the NDF for non-proprietary research is via a peer-reviewed merit based proposal system, with more information available at [www.ansto.gov.au/ResearchHub/Bragg/Facilities/NationalDeuterationFacility](http://www.ansto.gov.au/ResearchHub/Bragg/Facilities/NationalDeuterationFacility).

A view of the neutron guide hall at the Bragg Institute, ANSTO.



calculate the number of moles of residual protons in the sample. Integration of individual resonances can also indicate the amount of deuteration incorporation at specific sites.

In addition to aromatic molecules for optoelectronic devices, the NDF is able to synthesise a wide variety of deuterated molecules, for a variety of applications, including deuterated fatty acids, lipids, phospholipids, sugars and surfactants. Many of these molecules are particularly useful for investigations of biological systems that can be studied by neutron reflectometry and small-angle neutron scattering (SANS).

### Deuteration for neutron studies

As well as potentially improving performance of OLED devices, deuteration allows devices to be studied by neutron beam instruments, such as those at ANSTO's Bragg Institute.

Researchers from the University of Queensland have utilised the Platypus neutron reflectometer at the Bragg Institute to investigate the buried interfaces within functioning OLED devices.

During a neutron experiment, the neutrons directed at a sample interact with and are scattered by the nuclei

they encounter. The various nuclei interact differently with neutrons; the measurement of this interaction is known as the scattering length.  $^1\text{H}$  ( $0.3742 \times 10^{-12}$  cm) and  $^2\text{H}$  ( $0.6671 \times 10^{-12}$  cm) have very different scattering lengths; this difference can be exploited during a neutron beam experiment to highlight and study particular components of a system. The NDF synthesised deuterated molecules for incorporation into functioning OLED devices, as selected combinations of protonated and deuterated components provide scattering contrast between the layers, allowing analysis and measurements of the individual layers.

These experiments revealed information about the thermal stresses experienced by the layers and materials found in typical photoluminescent OLED devices. At increased temperatures ( $90\text{--}100^\circ\text{C}$ ), two of the individual layers began to diffuse into one another. This was made apparent by the use of alternating protonated/deuterated layers, which showed changes in the scattering length density across the device thickness as the protonated and deuterated materials began to diffuse into one another at the interface (*Adv. Mater.*, doi: 10.1002/adma.201104029; *Adv. Funct. Mater.*, doi: 10.1002/

adfm.201002365). This diffusion resulted in changes to the charge transport behaviour of the device and a subsequent degradation in performance.

### Further applications and understanding

Organic electronic devices already feature prominently in many aspects of our lives, and this will likely only continue to increase. In order to continue to improve the performance and push the boundaries in the applications of these devices, new molecules may be required, along with a greater understanding of how these devices work. The deuteration of organic molecules for optoelectronic applications can assist in achieving both of these outcomes. The replacement of hydrogen with deuterium can alter and improve the optoelectronic properties of the molecule, and allow the functional devices to be studied via neutron scattering techniques. The beneficial features imparted by deuteration may also be applied to many other fields of chemistry, physics and biology.

**Dr Anwen Krause-Heuer** MRACI is an organic synthetic chemist at the Bragg Institute, Australian Nuclear Science and Technology Organisation.

# Bomb-proofing buildings

BY  
**CHENGQING WU**

**A new form of reinforced concrete that can absorb the blast of an explosion is being developed for use in buildings that can withstand terrorist attacks.**

**T**he increasing number of terrorist attacks has generated considerable concern throughout the world. Not only do explosive devices used in terrorist attacks result in multiple deaths and casualties, they can also cause the collapse of buildings, bridges and other important infrastructure.

When a bomb is detonated outside a building, it releases a huge amount of energy instantaneously. The resulting shock wave in the surrounding air expands rapidly to the front of the building, blowing its exterior walls and columns. The blast pressure inside the building moves floors upwards while the blast pressure on the outside of the building forces the side walls, roof and rear walls inwards.

The direct air-blast effects cause local failure of parts of the building. Flying debris generated from the direct blast causes further damage to the building and injury to its

occupants. Local failure may progress to global failure and the collapse of the building.

To enhance the resistance of structures to both local and global failure due to an explosion, there has been a significant increase in both theoretical and experimental research into the behaviour of structural components subjected to blast loading. The major objective is to increase the energy dissipation capabilities of the structural components, with most of the focus on developing new materials to absorb blast energy.

In order to improve the capacity of building materials to absorb the high-energy impacts of bomb blasts, we are developing an 'ultra-high performance concrete' (UHPC) that substantially improves the mechanical properties and plasticity of hardened concrete. We are currently developing and testing new materials that incorporate nanoscale materials into steel fibre-reinforced self-compacting concrete.





Damage to the US Embassy, Beirut, caused by a terrorist bomb attack in 1983.

US Army/Wikimedia

The steel fibres not only increase the concrete's plasticity and tensile strength – the ability to withstand stretching or pulling – they also create a homogeneous mix that binds cracks and retards their propagation, thus preventing sudden compressive failure.

### What is ultra-high performance concrete?

Ultra-high performance concrete is a mix of self-compacting concrete with 1–3% steel or synthetic fibres by volume. With low water to binder content and much smaller particle size, the self-compacting concrete is known for its high 'flowability' and good cohesiveness.

Combining self-compacting concrete with end-hooked, waved and spiral steel fibres can enhance anchorage properties within the surrounding structure and significantly

improve its performance. The further addition of nanoparticles of  $\text{CaCO}_3$ ,  $\text{SiO}_2$  and  $\text{Al}_2\text{O}_3$  facilitate chemical reactions that can be used to improve the performance of UHPC.

Immediately after the mixing procedure, slumps of the fresh concrete are measured to ensure that the consistency and flowability of the UHPC is suitable for construction purposes.

### Improved blast resistance

Tests with our Chinese collaborators at Tianjin Chengjian University have found that structural components made from UHPC have a greater ability to withstand the effects of blasts. The material is at least five times stronger than conventional concrete, with five times the ability to withstand compression, 10 times the tensile strength and improved plasticity. Furthermore, the energy dissipation

**The steel fibres not only increase the concrete's plasticity and tensile strength – the ability to withstand stretching or pulling – they also create a homogeneous mix that binds cracks and retards their propagation, thus preventing sudden compressive failure.**

## Formula calculates thickness of bombproof concrete

A new type of steel-reinforced concrete protects buildings better from bomb attacks. Researchers have developed a formula to quickly calculate the concrete's required thickness. The material is being used in the One World Trade Center at Ground Zero.

Earthquakes and explosions produce tremendous forces. Pressures in the immediate vicinity of a car bomb are in the range of several thousand megapascals, and even further away from the detonation itself, pressures are still in the order of several hundred kilopascals. Pressure in a bicycle tyre – at about three bar – corresponds to about 300 kilopascals. 'So people at a good distance from the detonation point are not so much endangered by a pressure wave – our bodies can usually cope pretty well with them – it's flying debris that poses the real danger,' explained Dr Alexander Stolz from the Safety Technology and Protective Structures department at



The One World Trade Center at Ground Zero rests on a 20-storey, bombproof foundation that reaches 60 metres underground. Overall, at points within the building where safety is especially critical, several thousand square metres of safety concrete have been used to shore up the construction.

the Fraunhofer Institute for High Speed Dynamics, Ernst Mach-Institut, EMI in Efringen-Kirchener, just north of Basel in Germany. This is exactly what happens to conventional reinforced concrete when it is hit by an explosion's pressure wave: it is so brittle that individual and often large pieces are torn off and fly through the air uncontrolled.

Dr Stephan Hauser, managing director of DUCON Europe GmbH & CoKG, has developed a concrete that merely deforms when subjected to such pressures – and doesn't break. Behind the development is a special mixture made from very hard high-performance concrete, combined with finely meshed reinforced steel. The EMI has been supporting Hauser for many years in the optimisation of his patented innovation. In particular, the researchers take responsibility for dynamic qualification testing of the material under extreme loads. This also involves characterising the material and calculating characteristic curve profiles. The researchers have developed a mathematical formula that simply and quickly computes the required thickness of the new concrete for each specific application.

'Calculations used to be based on comparable and historical values,' said Stolz. 'Now we can use a universal algorithm.'

The formula was developed during a test series with the new shock tube in Efringen-Kirchen.

'We can simulate detonations of different blasting forces – from 100 to 2500 kilograms TNT at distances from 35 to 50 metres from buildings. And that's without even having to use explosives,' said Stolz.

The principle behind it is this: the shock tube consists of a (high-pressure) driver section and a (low-pressure) driven section, which are separated by a steel diaphragm. Air can be compressed in the driver section to a pressure of up to 30 bar, i.e. to approximately 30 times atmospheric pressure at sea level. The steel diaphragm is ruptured when the desired level of pressure is reached: the air is forced through the driven section as a uniform shock front that hits the concrete sample being tested, attached to the end of the shock tube.

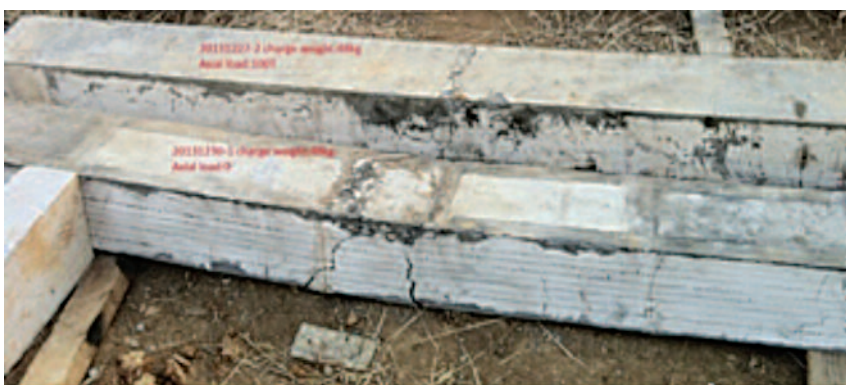
'With conventional concrete, the impact pressure ripped out parts of the sample concrete wall, which failed almost instantly, while the ductile and more flexible security version of the concrete merely deformed. There was no debris, and the material remained intact,' said Stolz.

Thanks to its ductile qualities, the security concrete is considerably less bulky and yet more stable than conventional steel-reinforced concrete. Thinner building components are possible.

'As a rule of thumb, you get the same stability with half the thickness,' said Stolz.

FRAUNHOFER





**Top: This reinforced concrete column failed under a 10 kg explosive load.**

**Bottom: The UHPC columns maintained their structural integrity after a 50 kg explosive load.**



**The horizontal spread of UHPC concrete reinforced with steel fibres (left) is comparable with conventional concrete (right). Keeping the horizontal spread consistent is necessary to endure the quality and workability of UHPC.**

capabilities of the UHPC structural components can be several orders of magnitude higher than normal concrete materials.

Full-scale blast tests have also been conducted to investigate the resistance of UHPC columns to nearby explosions. In order to resist this blast loading and minimise structural damage, the concrete column must be

able to absorb or dissipate the energy.

Our blast tests revealed that while a conventional reinforced concrete column failed to withstand a 10 kg explosive, the new UHPC column could survive a 50 kg explosive. This indicates that columns made of the new UHPC materials are strong enough to prevent the collapse of buildings after terrorist attacks made

with devices such as contact suitcase bombs and nearby car bombs.

UHPC therefore has tremendous potential for use in high-rise buildings, bridges and other infrastructure under threat of seismic, impact and blast loads.

## Ongoing research

All military and buildings that may be a target should be designed for reduced vulnerability against terrorist attack. The superior strength and plasticity of UHPC make it an ideal material for these engineering challenges. The new UHPC we have developed has great potential for use in the design of future blast-resistant structures and ultimately to the development of blast-mitigating technologies.

Our research team has already carried out an extensive investigation, and both finite element analysis and blast-testing techniques have been used to study the characteristics of UHPC under different loading conditions. The results will help us devise guidelines for using the new material in building designs.

The price of the new concrete is about five times that of conventional concrete, which is currently prohibitive for widescale use. However, we are working to improve the cost-effectiveness of the formula.

If costs can be reduced to enable its widespread use, there is no doubt that the new UHPC can help strengthen Australia's defence and national infrastructure engineering capabilities and help safeguard against terrorist attacks.

**Chengqing Wu** is a senior lecturer in the University of Adelaide's School of Civil, Environmental and Mining Engineering. He is also the Director of the TCU-UA Joint Research Centre on Disaster Prevention and Mitigation, and chairs the Australian Chapter of the International Association of Protective Structures.

First published in *Australasian Science* ([www.australasianscience.com.au](http://www.australasianscience.com.au)).



## Honorary doctorate for David Wood



David Wood, past-president of the RACI, has been awarded an honorary doctorate by the University of Melbourne, of which he is Emeritus Professor and Professorial Fellow. The doctorate was presented on David's birthday in December 2014 at the Royal Exhibition Building in Melbourne.

David joined the Department of Chemical Engineering in the 1960s as a lecturer, progressing to Head of Chemical Engineering and then to Dean of the Engineering Faculty. Also, in addition to his academic work, he has been very involved in outside activities. In his view, 'lucky people like me should give back to society what they have gained in terms of good opportunities and education'.

In the late 1970s, David initiated a proposal to completely overhaul the superannuation scheme for Australian university staff. He was active in the staff union and one day he put his hand up and 'the rest is history'. The end result was UniSuper.

Over many years, David has played significant roles, including Vice-President, Worldwide, of the Institution of Chemical Engineers. He has edited some of its journals, chaired many of its committees and worked hard to establish the Australian presence. He has received a number of awards from the IChemE, including the CHEMECA Medal in 2001. This followed the outstanding Sixth World Congress of Chemical Engineering, which he chaired. He was determined to show that Australia could showcase chemical engineering in this country to the rest of the world. He founded and eventually chaired the World Council of Chemical Engineering, which aims to improve the outreach of chemical engineering throughout the world.

David has been an active member of the RACI, including as President, as one of the organisers of the International Year of Chemistry activities and as chair of the *Chemistry in Australia* management committee.

David described his past 10 years working (in an unpaid capacity) in China for nine universities as 'the most satisfying', including his appointment as an Honorary Professor at Tianjin University.

In his citation, David is described as 'a committed and passionate chemical engineering professional, a leader and educator who has made significant contributions to both this university and the profession of chemical engineering as a whole'. David said his work at the University of Melbourne has been most enjoyable and he is very honoured to have been given the opportunity to work there. 'By world standards it is really a great university and I have had the chance to teach brilliant students and to undertake enjoyable research.'

As David was presented with the award in the presence of many new graduates, faculty members and his family and friends he reflected on 'the great fortune that I have had to have been given the opportunity to participate in a great university, a great profession (chemistry and chemical engineering) and to have some wonderful friends and associates'.



## Graeme Hanson

### Electron paramagnetic resonance innovator

Graeme Richard Hanson was born in Melbourne on 16 July 1955. He attended local state schools and gained entry to La Trobe University to study science, completing a BSc with Honours in 1978. His Honours research and thesis showed the hallmarks of tenacity and application that were to typify his scientific life. The work was

continued at La Trobe into his PhD, and it was during these formative years that Graeme was introduced to the technique, the research area and the people who influenced his research and led to the establishment of his scientific reputation. That technique was electron paramagnetic resonance (EPR) spectroscopy, the research area was bioinorganic chemistry and the people were Tony Wedd, John Pilbrow and Keith Murray.

After leaving La Trobe, Graeme moved to the Harvard Medical School with Professor Bert Vallee, where he was involved with EPR characterisation of the inhibitor complexes of cobalt carboxypeptidase A. From there he moved to Monash University, joining John Pilbrow and Keith Murray, and then to the Chemistry Department at the University of Queensland, where his interest in the marine cyclic peptides began. He then moved to the then Centre for Magnetic Resonance to establish the EPR facility, under the directorship of David Doddrell. Graeme established, promoted and developed the facility with all the tenacity and perseverance that typified everything he did. Graeme's reputation in the field of EPR grew, both nationally and internationally.

At the time of his passing, Graeme was a professorial research fellow (promoted in 2002) and the Head of the EPR Group at the Centre for Advanced Imaging at the University of Queensland. He was an honorary professor in the School of Life and Environmental Sciences at Deakin University in Victoria, a Fellow of the RACI and Treasurer of the Society of Biological Inorganic Chemistry.

One of the many important scientific contributions Graeme made was to establish EPR spectroscopy as an essential tool for electronic structure analysis of paramagnetic compounds and for the correlation of electronic structure with geometry. His deep understanding of the physics of metal complexes and electron spin and the mathematics to describe these phenomena led to the development of the Sophe suite of programs to simulate EPR spectra, a program package unique in its power and versatility. For Graeme, careful planning and thorough

discussions with collaborators and the optimisation of the experiment to get the highest possible quality of data were important, coupled with an insistence on a consistent interpretation of the data. He could see things in a spectrum and interpret what he saw with an uncanny skill, and no paper was complete until those interpretations and simulations were done.

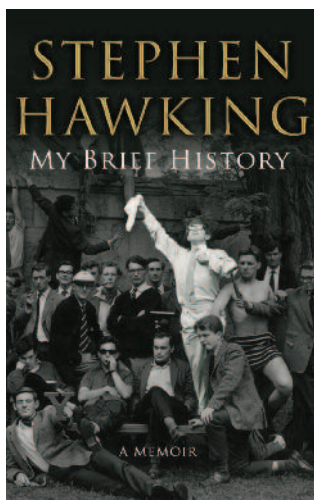
Graeme contributed to the development of the Biological Inorganic Chemistry community. He served as the Treasurer for the Society of Biological Inorganic Chemistry (SBIC) for two consecutive terms. He served as Treasurer of ANZMAG, the Australian and New Zealand Society for Magnetic Resonance. In 2003, Graeme was co-chair (with Tony Wedd and Trevor Hambley) of the 11th International Biological Inorganic Chemistry Conference held in Cairns. As late as December last year Graeme was instrumental in the success of the Asian Biological Inorganic Chemistry Conference (AsBIC7) held on the Gold Coast, which he co-chaired with Sue Berners-Price.

A common theme in the messages from the international community and former students is the description of Graeme as a kind-hearted person. He was committed to supporting the next generation of scientists and worked hard to secure travel bursaries for students attending AsBIC7 and established the AsBIC Early Career Awards.

Graeme took a keen interest in soccer and his sons played the game at various clubs around Brisbane and he was usually involved in some capacity. He was President of the Moggill Football Club in outer Brisbane for a number of years. He was either coach or manager of various teams over the last 11 years or so and coached his team to victory several times at the Regional Futsal Championships held in Brisbane each Easter.

Graeme had an enormous influence on the people around him, especially students. From him we all learnt the value of perseverance, thoroughness and pursuit of the answer. Just as his family, his wife Lyn, children Jeff, Harry, Joanne and Adrian, will miss him, so will the scientific community. To quote from a colleague: 'Graeme was a great man, a wonderful personality, very special, modest, gentle, supportive and patient, and a great scientist, very thoughtful, thorough, sincere, and restless in his search for answers. He lived in his own world, in the middle of a wonderful family, the international EPR society and the bioinorganic community. Graeme had a special humour, his way to enjoy life, he was a happy man.'

**Lawrence Gahan** FRACI CChem (with **Sue Berners-Price** FRACI CChem, **Peter Comba** MRACI CChem and **Tony Wedd** FRACI CChem)



## My brief history: a memoir

Hawking S., Bantam Press, 2013, hardback, 127 pp., ISBN 9780593072523, \$25 approx.

Stephen Hawking must surely be one of the most widely recognised people on Earth. His frail wheelchair-bound body, which entraps one of the most brilliant minds of our age, evokes pity, wonder and awe that somebody whom life has dealt such a poor hand should have become one of the world's greatest theoretical physicists and cosmologists.

Hawking's most famous book is *A brief history of time*. It's probably true to say that a lot more people have started it than finished it. Complex stuff! By contrast *My brief history* is brief by title and content, I suspect both for marketing reasons (playing on the word 'brief') and because, for Stephen Hawking, the actual writing task is horrendously difficult. His memoir is easy reading (I polished it off over a couple of nights in bed) and recommended for a general readership.

The book is dedicated to Hawking's three children and is, accordingly, a personal family memoir. It's astonishing to learn, for example, that the Lucasian Professor of Mathematics at Cambridge University, a Chair once held by Isaac Newton, concluded his formal study of mathematics when he finished school in St Albans. The rest of what he needed he just picked up subsequently, along the way. Hawking's father, a researcher in tropical medicine, counselled there was no future in mathematics (he could only become a teacher!) and rather he should direct his efforts towards chemistry. The young Hawking, somewhat surprised to be accepted as a student by Oxford, entered enthusiastically into the prevailing Oxford ethos of his set that study and hard work were all just a tad boring. Consequently he did so little work (he calculated he did less than one hour per day over the course of his degree!) that his academic fate required fronting a board to see whether he deserved a First or a Second – should he go on to a research career or be damned to a life in the civil service. Fortunately, the cards fell the right way and he went on to Cambridge to do research.

Hawking wanted to work for his doctorate with Fred Hoyle, the arch-proponent of the theory of a steady-state universe. Given Hawking's pivotal role in the Big Bang theory, it was fortuitous that Hoyle was too busy to take him on as a student and Hawking worked instead with the much more accessible Dennis Sciama. At about this time, the early 1960s, the young Hawking (born 1942) married and became aware of his

diagnosis with motor neurone disease. Given his gloomy prognosis, Hawking could well have given up and accepted his seemingly imminent demise. As subsequent events confirm, he did not. The story of his life is inspirational, of magnificent courage against his major health problems, driven by an amazing will to not let his handicaps hold him back, but to do what he can and not get too worried about what he can't.

The last chapter of the book, 'No Boundaries', is most inspirational. Without boasting, Hawking notes some of the achievements accomplished since he acquired motor neurone disease aged 21. To quote him, 'I have had a full and satisfying life. I believe that disabled people should concentrate on things that their handicap doesn't prevent them from doing and not regret those they can't do. In my case, I have managed to do most things I wanted.' He has travelled the world, visiting every continent except Australia (but including Antarctica); he has lectured in the Great Hall of the People in Beijing and in the White House; he has been down in a submarine and up in a hot air balloon; he has been up in the 'vomit comet' and experienced zero gravity; and he anchored the Paralympic Games in 2012. He has been feted by presidents and potentates. He's twice been married and has three children, one of whom (Lucy) he co-authors children's books with. Not too many folk, able bodied or no, can claim such lofty achievements. In passing, Hawking mentions that he's not yet won a Nobel Prize (though he has won the more valuable Fundamental Physics Prize). Well, I guess he's in good company there, at least with the first bit!

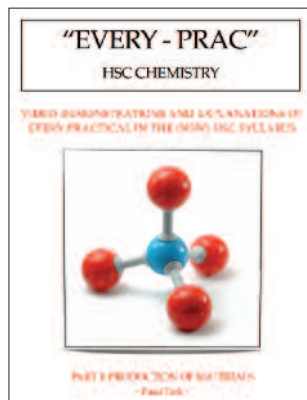
I thoroughly enjoyed this book; indeed I found it quite inspirational. It gives interesting insights into Stephen Hawking the fellow human being as distinct from Stephen Hawking the utterly dependant genius in a wheelchair. It made me realise how lucky I am, but also just how wonderful the human brain really is when it isn't cluttered with the everyday trivia of daily life. Take away all the dross of daily existence and, like Stephen Hawking, you can truly *think*. Who knows what we might all be capable of? But of course, I don't envy his situation.

R. John Casey FRACI CChem

	<p><b>Rowe Scientific</b> PTY LTD www.rowe.com.au</p>	<p><b>ADELAIDE</b> 08 8186 0523 rowesa@rowe.com.au</p>
	<p><b>Pledge to Chemists</b> If chemists in Australia are experiencing difficulty in obtaining supply, please send me an email on reg.rowe@rowe.com.au and I promise to help you. This is not a "subtle" attempt to obtain more business, but is a sincere pledge to help fellow scientists source the items they need to do their work, and thereby help Australia grow. This is the raison d'être for Rowe Scientific Pty. Ltd. R.J. Rowe (FRACI)</p>	<p><b>BRISBANE</b> 07 3376 9411 roweqld@rowe.com.au</p> <p><b>HOBART</b> 03 6272 0661 rowelas@rowe.com.au</p> <p><b>MELBOURNE</b> 03 9701 7077 rowevic@rowe.com.au</p> <p><b>PERTH</b> 08 9302 1911 rowewa@rowe.com.au</p> <p><b>SYDNEY</b> 02 9603 1205 rowensw@rowe.com.au</p>



## 'Every-Prac' HSC Chemistry: video demonstrations and explanations of every practical in the (NSW) HSC syllabus



Ticli P., Eucalyptus Media Ltd, 2014

Part 1: Production of materials, ISBN 9780992400613, \$4.99

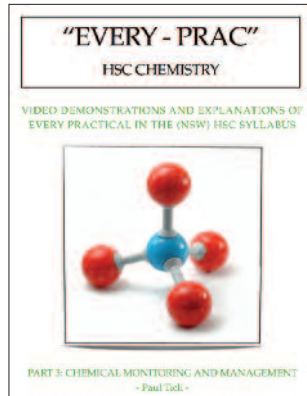
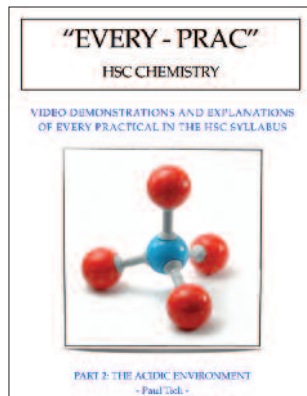
Part 2: The acidic environment, ISBN 9780992400620, \$4.99

Part 3: Chemical monitoring and management, ISBN 9780992400637, \$4.99

As the title 'Every-Prac' HSC Chemistry suggests, this interactive series of three e-books demonstrates experiments of the New South Wales high school chemistry course core content and is a useful resource for review by students in years 11 and 12. It could also serve as a useful laboratory manual as a student progresses through their course. Some experiments may be useful as a teacher resource where access to chemicals and/or equipment is limited, for example the preparation of bromine (Part 1) to show its different reactivity in addition and substitution reactions.

Ticli's books are named according to the modules of the textbook *Conquering chemistry HSC course* (Roland Smith, McGraw Hill, 4th edn, 2006). This NSW syllabus-based textbook is commonly used throughout high schools. The modules become the names of the 'Every-Prac' series, for example Module 1 'The Production of Materials' pairs with Part 1 of Ticli's e-book titled 'Production of Materials'. Even though the material is NSW-centric, the content is universal to chemistry

study and would have utility for teachers and students in other parts of Australia.



All experiments are filmed in the teaching laboratory, which adds authenticity and familiarity for students. The presentation style is relaxed and simple terminology is incorporated in the discussions. The video clips are on average about six minutes each; the shortest is three minutes while the longest is more like 15 minutes. Overall there are 39 videos, either a movie of the experiment being performed or a screencast explanation.

In total, the series comprises 62 pages. The book's organisation is 'practical'; each topic starts off by identifying key points, which are then matched to syllabus dot points. A summary of results and calculations (if required) follows each video, and a review section consisting of multiple-choice questions is included at the end of each part of the series.

These e-books represent a review of experiments previously covered in class. While the syllabus requires students to plan experiments, select appropriate equipment and relay MSDS information, there's no opportunity to demonstrate these qualities throughout this series. The addition of extension work/experiments at the end of a topic or in the review section would address this aspect. Repetitive utterances (e.g. 'aaah') during some video dialogue detracts from what is otherwise good work. The series would also have benefitted from tighter editing to remove more typing and grammatical errors and correct a few minor technical faults (e.g. NTP occurs at 20°C rather than 24°C).

Overall 'Every-Prac' HSC Chemistry closely complements the NSW high school chemistry syllabus, would serve as a useful teaching aid in the laboratory and achieves its intended purpose – namely a medium for the review of all experiments by students as they prepare for final exams.

According to Facebook posts, Ticli appears to be well liked by his students. This author has also produced and written three religious-based Kindle books – *Moral-i-Tales: The cove* and *The magic puppet*, and *Yosemite – a spiritual journey*. He studied physiotherapy at the University of Sydney and 13 years later completed his Diploma of Education. He also holds a Masters degree in theology.

Alison McKenzie

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## Mass spec behind the scenes

It started as a comment over coffee at RMIT University's city campus. While discussing possible joint projects with Agilent for the coming year, I'd mentioned that I was shortly heading to a metabolomics conference in Singapore. Tom Hennessy from Agilent suddenly spoke up: 'We make all our LC-MS instruments in Singapore; I can arrange a visit to the factory for you if you like'.

For an analytical chemist like me, being offered a chance such as this is somewhat akin to being offered a private tour of Willy Wonka's chocolate factory, so naturally I accepted.

Two months later I found myself in a taxi, heading away from the glitz and shiny towers of the southern part of Singapore island towards the more industrialised north.

The Agilent facility sits within the Yishun industrial estate ([bit.ly/1F7cRmK](http://bit.ly/1F7cRmK)), only a stone's throw away from the Strait of Johor, which separates Singapore from Malaysia. From the outside, the only real clue to the building's identity is the Agilent logo high up on one of the walls. Just like Wonka's factory, however, the real magic happens on the inside.

Once inside, I was met by Saw Wan-Koon (LC-MS Facility Manager), Caleb Ng (South East Asia Life Science Country Manager) and Low Sui-Ching from Agilent corporate relations, after which some of us commenced a surprisingly long walk to the life sciences manufacturing facility. Joined by the incredibly knowledgeable Ching Soon-Tee (LC-MS engineering manager) at the facility, we donned dust gowns and overshoes, then had to pass a static electricity discharge test before proceeding to the factory floor.

Agilent has more than 40 years of history in Singapore, dating from the time the company was part of Hewlett Packard. Agilent opened what it calls the automation solutions facility in the country in 2009 to produce high-precision liquid-handling and laboratory robotic instruments. They followed up with the life sciences manufacturing facility in 2010.

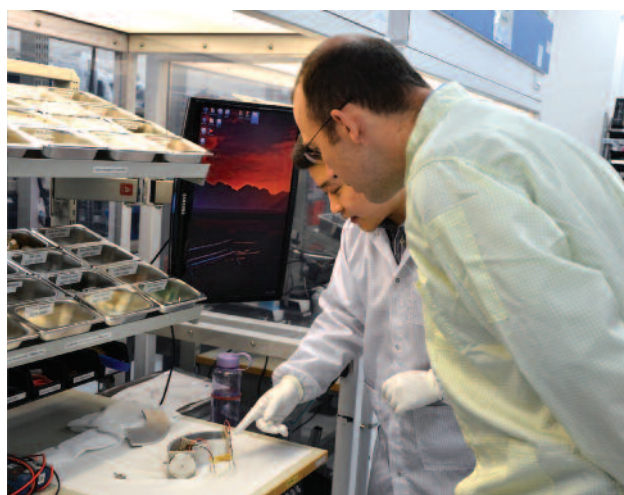
The entire portfolio of Agilent's LC-MS (as well as microarray) instrumentation is manufactured in the Singapore facility. This includes the 6100 series single-quadrupole LC-MS, the 6200 series accurate-mass time-of-flight LC-MS, the 6400 series triple-quadrupole LC-MS and the 6500 series accurate-mass quadrupole time-of-flight LC-MS as well as the beast that is the 6560 new ion mobility Q-TOF (quadrupole-time of flight) instrument.

According to Sui-Ching, the growing amount of public and private sector research and development in the country, coupled with the availability of well-trained local workers and an excellent supplier network (and possibly the favourable tax system), offers a pretty good environment for research instrumentation and scientific tools companies to develop and build high-end analytical instrumentation for the global market. Several other instrument manufacturers also have bases in Singapore.

For commercial reasons, I am not allowed to report too much of what I saw. Agilent also weren't too keen to tell me details

of the construction and specifications of individual components such as the detectors or electron guns, or even how long it took to put a machine together and what the annual factory output is. I can tell you that the start of the process is to clean every part thoroughly (and I mean very thoroughly) – just a microscopic speck of dust or dirt in the wrong place can cause a lot of problems. Cleaning is done with a selection of solvents and ovens.

Individual workers assemble each sub-unit according to very strict and detailed work plans and these sub-units are put together later into the final instruments. These are tested extensively before being shipped out to the customer (see photo).



Low Sui-Ching and Agilent Technologies

Agilent's LC-MS Engineering Manager Ching Soon-Tee describes the technology of Agilent 6495 Curve Collision Cell and how each unit is assembled. The details on the part bins to the left of the picture give some insight into the process of putting together the individual units.

The Agilent visit was a real highlight of my trip to Singapore. I got to see a side of modern analytical chemistry that not many scientists experience and to learn a lot about instrument manufacture and engineering. I was also quite interested to see that the Agilent factory uses fridges from Thermo Fisher.

In June last year, Agilent launched the latest addition to its portfolio of LC/MS instruments – the 6495 LC/MS triple-quadrupole (QQQ) system (which I am doing my best to find the funding for in my lab) – as well as their entry-level 6020 LC/MS single-quadrupole system, so the Singapore team should be manufacturing instruments for a good while to come.

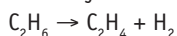
**Dr Oliver Jones** MRACI CChem is a senior lecturer in analytical chemistry at the Australian Centre for Research on Separation Science (ACROSS) at RMIT University in Melbourne who is always happy to see behind the scenes. Oliver would also like to thank the many people at Agilent who made this visit possible, including, but not limited to, Tom Hennessy, Nicole Pendini, Sunil-Chidambar Kulkarni, Davina Law-Stewart, Caleb Ng, Robin Philp, Ching Soon-Tee, Saw Wan-Koon and Low Sui-Ching.



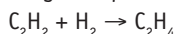
## Steam cracking: how do we stack up?

Ethane cracking is practised all over the world at scales from 50 kt/year to over 2 Mt/year. How do the Australian economics compare to those in the Middle East, South-East Asia and the US?

In Australia, steam cracking to produce olefins is used for the production of high-value plastics products (such as gas and water piping). The stoichiometry is:



The reaction is favoured by high temperatures (>800°C) and low partial pressures, which are obtained by adding steam to the system. The hot gases are rapidly quenched and then compressed to help separate the products. A selective hydrogenation process is used to remove small quantities of acetylene also formed at high temperatures:



The purified ethylene is separated and then polymerised by a variety of processes to produce polyethylene. This product is then extruded to form the required commodity (e.g. pipes).

The Australian industry comprises two operations: one at Botany (300 kt/year), which uses ethane from the central Australian gas fields, and one at Altona (200 kt/year), which uses ethane from Bass Strait, supplemented with LPG from local refineries. These facilities are small compared with many operations in Asia, which unlike those in Australia have grown rapidly with the growth of China (see table below); for instance the Singapore cracking capacity is more than five times that of Australia.

### 2013 Far East ethylene capacity and 10-year growth rate

	Ethylene capacity (t/year)	Ethylene 10-year growth (%)
Australia	502 000	-1.0
China	13 778 000	67.4
China Taiwan	4 006 000	41.0
India	3 315 000	27.6
Indonesia	600 000	8.3
Japan	6 935 000	1.3
Malaysia	1 723 000	3.7
Singapore	2 780 000	29.9
South Korea	5 630 000	12.6
Thailand	3 172 000	56.3
<b>Total</b>	<b>42 441 000</b>	

A typical ethane cracking operation has inputs and outputs as shown in the next table.

The complex free radical nature of the pyrolysis leads to products higher in molecular weight than the ethane feedstock. For small-scale operations, these are usually used as furnace fuel. For large-scale operations, integrated into a petrochemical complex, these materials are separated and result in by-product credits.

### Typical inputs and outputs for ethane cracking (wt/wt)

INPUTS	(wt/wt)
Ethane	1.302
Ethane operating allowance (5.5%)	0.072
Furnace fuel	0.660
Fuel operating allowance (3%)	0.020
<b>Total inputs</b>	<b>2.053</b>
OUTPUTS	(wt/wt)
Ethylene	1.000
Propylene	0.034
Butadiene and other C4 olefins	0.034
Pyrolysis gasoline	0.022
Hydrogen	0.132
Methane	0.080
<b>Total outputs</b>	<b>1.302</b>

The impact of ethane price on the cost of ethylene production is illustrated in the lower line of the graph for an ethane cracker of 500 000 t/year ethylene capacity with a capital cost typical for a US Gulf construction of \$850 million.

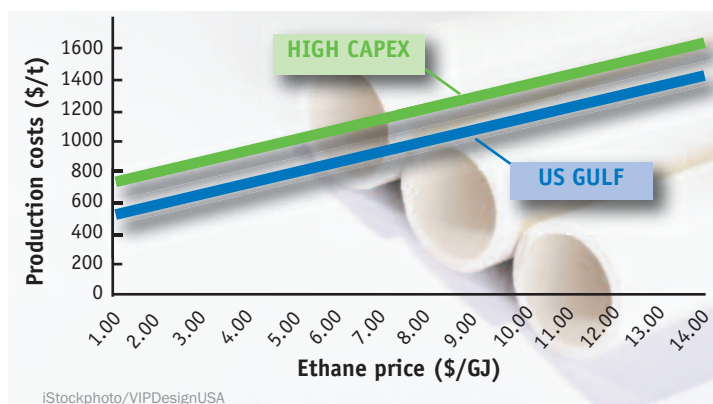
In many parts of the world (including parts of Australia), gas production cost is less than \$2/GJ. Recovering the ethane costs an additional \$1/GJ; so facilities that have access to such gas produce ethylene for about \$600/t. By comparison, traded ethylene prices are about \$1300/t. This is the case in the Middle East, which has attracted large-scale investments in petrochemical plants to build on this feedstock cost advantage and, as a consequence of shale gas developments in the US, is now driving a major resurgence of investment in the US chemical industry.

For Australia, ethane is traditionally priced on a scale relative to the price of crude oil (typically \$6–8/GJ). This is obviously a major cost disadvantage relative to cracking operations in the Middle East and US. Furthermore, because ethane can be incorporated into LNG, the cost of ethane could rise to match the export LNG value, potentially more than \$12/GJ.

For Australia, there is a further issue – the cost of construction relative to other parts of the world. A common view is that construction costs here are 50% higher than in the US. This situation is reflected in the 'HIGH CAPEX' line in the graph. This data shows that in order to produce ethylene in a new ethane cracker, the cost of ethane feedstock has to be well below \$9/GJ.

Australia is unique in the Pacific Rim of having imposed a carbon tax on emissions. For cracking operations, this results principally from emissions from the cracking furnace. With an emissions charge of \$25/t of carbon dioxide, this adds about \$55/t to the production cost. Applying such a tax without commensurate application by regional players would further inhibit investment in Australia.

As far as the present operations are concerned, where plants are older and have a significant portion of the capital written



For Australia, ethane is traditionally priced on a scale relative to the price of crude oil ... a major cost disadvantage relative to cracking operations in the Middle East and US.

#### Sensitivity of ethylene production cost to ethane price.

off, the production cost would give a positive production margin, but there is little likelihood of significant plant expansions.

As this analysis shows, the main issue is the price of feedstock. Given the uncertainty in the eastern seaboard gas market with the potential for methane and ethane being priced for the expensive north-east Asia LNG trade, the obvious alternative is coal, the export price of which is in the region of \$3–4/GJ and lower than \$2/GJ for domestic use. Coal-based routes to olefins are now proven (in China 20 Mt/year of coal-based olefins facilities are planned) and offered by several major technology suppliers. Since methanol is an intermediate in this route, it can also be applied to stranded gas reserves in the remote regions of the country. However, such projects would always be at the mercy of a pipeline to the nearest LNG facility.

Technology under development concerns the production of ethylene by catalytic cracking. Propylene is already produced in this way by deep fluid-catalytic cracking (FCC), which is a

variant on a refinery FCC unit. The interest is to change the catalyst composition to incorporate more ZSM-5 zeolite and use naphtha as feedstock (rather than heavy fuel oil) to generate an olefin equilibrium in which ethylene is a significant component. There is also interest in the direct catalytic cracking of heavy oils, including crude oil to ethylene. However, losses to coke are a significant problem.

Despite a long history, there are no commercially proven direct routes for the conversion of methane to ethylene. Oxidative coupling (OXCO process) is still the subject of much research, the major issue being the selectivity of the process to ethylene over the deep oxidation products carbon dioxide and water. Recently, new proposals have revived interest in pyrolysis routes to acetylene but coke lay-down is the major issue to be overcome.

Unfortunately, all of these alternatives (other than coal-based routes) require gas prices close to well-head production costs for viability.



**Duncan Seddon** FRACI CChem is a consultant to coal, oil, gas and chemicals industries specialising in adding value to natural resources.

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## Teaching awards acknowledge great teachers

Teaching is a vocation. Like parents, great teachers delight in the success of their children and students. The creative process brings much satisfaction and joy to the creator, whether it is the creation of a meal or the creation of an artistic masterpiece. Even though we might complain about the tedium of household chores such as ironing, there is also satisfaction in the creation of a well-ironed garment from a mess of wrinkled fabric. Teachers help their students create themselves (see October 2012 issue, p. 37). Brian Schiller, the recipient of the 2014 Prime Minister's Prize for Excellence in Science Teaching in Primary Schools, said: '... my greatest reward has always been in working with the children themselves, witnessing them interacting in wonder with the world around them and fuelling their high level of creativity and imagination'.

The best-known national awards are the Prime Minister's Prizes for primary, secondary and tertiary education, the Australian Awards for Teaching Excellence, the BHP Billiton Science and Engineering Teacher Awards, and the Australian Citations for Outstanding Contributions to Student Learning.

The RACI also has its state and national awards for contributions to education. The RACI Centenary of Federation – Primary & Secondary Teaching Award is awarded by each state Branch to recognise and reward outstanding excellence in the teaching of senior-secondary chemistry or the primary or junior-secondary science. For the purposes of these awards, the ACT is considered to be part of New South Wales and the Northern Territory to be part of South Australia. One national Primary and one national Secondary Teaching National Award can also be presented to the most outstanding candidates from the Branches. Nominees and nominators for the RACI Centenary of Federation

Awards do not need to be RACI members.

The Pearson RACI Chemistry Educator of the Year Award is for junior Australian university academics teaching in the chemistry discipline.

The RACI Fensham Medal is the most senior award for education in the RACI, and recognises outstanding contributions to the teaching of chemistry and science in general over an extended period. Nominees must have demonstrated outstanding achievement in chemistry and chemistry-related teaching and learning excellence over a period of at least 10 years at the primary, secondary or tertiary levels of chemical education, or through public or industry-based appointments.

The RACI Division of Chemical Education also has its own awards. Up to three divisional citations can be awarded each year in recognition of a significant contribution to chemical education. The divisional medal is awarded on the basis of the overall contribution to chemical education in Australia in the previous 10-year period, by way of research, teaching and/or promotion of chemistry.

Sir Thomas More: Why not be a teacher? You'd be a fine teacher. Perhaps a great one.

Richard Rich: If I was, who would know it? You?

Sir Thomas More: Your pupils, your friends, God. Not a bad public, that ... And a quiet life.

Robert Bolt, *A man for all seasons*, 1960

While the acknowledgement of personal achievements by a small circle of family, friends and community was sufficient for Robert Bolt's character, Sir Thomas More, most people need occasional recognition of a job well done. This is important for morale. And especially so for teachers, who are often undervalued by the wider Australian society. Geoff McNamara, the recipient of the 2014 Prime Minister's Prize for Excellence in Science Teaching in Secondary Schools, said: 'It's a recognition that what we are doing here in public education is important and is valued'. Furthermore, awards often give persuasive authority to recipients and empower them to continue to implement new ideas. Even more importantly, awards indicate to other teachers that it is OK for them to follow and thus spread good teaching and learning practices.

If you know outstanding chemistry or science educators, please encourage them to apply for an award. In particular, nomination for the RACI Centenary of Federation Awards only requires a few pages. The deadline for all state and national awards is 30 June 2015 ([www.raci.org.au/events-awards/education](http://www.raci.org.au/events-awards/education)). Please contact the National Office, [awards@raci.org.au](mailto:awards@raci.org.au), for further information.



**Kieran F. Lim (林百君)** FRACI CChem ([kieran.lim@deakin.edu.au](mailto:kieran.lim@deakin.edu.au)) is an associate professor in the School of Life and Environmental Sciences at Deakin University.





## From where does the H<sub>2</sub>S come?

This is the fourth article in the quartet on volatile sulfur compounds (VSCs). I doubt if this quartet will stand the test of time as do the string quartets of Joseph Hayden. This is the music I listen to when writing, hoping that some of Hayden's creative genius may stimulate the brain cells. And four articles on VSCs in wine may seem a little too much, but it does reflect my association with these compounds since my PhD days. For reasons that I no longer remember, I was given the challenge of making thiol complexes of rhodium. What I do remember, without any fondness, is the particular odour that seemed to follow me after a day in the lab.

In my March column (p. 39), I mentioned that the lack of readily available nitrogen in grape juice was one factor contributing to the production of H<sub>2</sub>S. Supplementation of nitrogen by the addition of diammonium phosphate (DAP) is common practice, although it does come at a cost. A variety of other yeast supplements are now available, which assist the yeast in its task of completing the fermentation. On the other hand, if the amount of nitrogen in the grape can be enhanced through vineyard practices, the need for nitrogen supplementation may possibly be eliminated.

The total nitrogen content of the grape berry consists of approximately 60–65% proteins, 20% free amino acids and 15–18% peptides as well as a range of other nitrogenous compounds. The main forms used by the yeast, the so-called yeast-assimilable nitrogen, are free amino acids and the ammonium ion, the latter being the basis for DAP supplementation. Yeasts are rather fussy in regard to amino acids. One yeast favourite is arginine and this is considered by some oenologists as one of the most significant, if not the most significant, contributor to yeast nutrition. Proline is often the amino acid of highest concentration in grapes, but is not utilised under typical anaerobic fermentation conditions.

Some years ago, Jessica Wade in her PhD project at Charles Sturt University examined the effect of irrigation and the timing of nitrogen fertilisation on Shiraz grapes grown in the Riverina region. Jessica found that it was possible to vary the amino acid composition and especially the arginine to proline ratio, providing useful insights into how to use vineyard practice to manage fruit composition. Geoff Johnston from Pirramimma in McLaren Vale has worked extensively on vineyard soil management and has achieved his target of essentially eliminating the formation of H<sub>2</sub>S during fermentation. Geoff tells me that he can see the difference between his fruit and that from his growers in terms of the propensity for H<sub>2</sub>S production. This is a good example of working grapes at their source, the vineyard, to get the desired outcome in composition.

In red wine production, a small amount of oxygen never goes astray and this is one way to remove any H<sub>2</sub>S. One winemaker

once told me that he connects a garden hose to the base of the red wine fermenter and pumps air through it to minimise H<sub>2</sub>S production. When pumping wine from a fermenter to an empty tank, a 'spray ball' can be used. This is like a showerhead through which the wine passes, collecting a small amount of oxygen on the way. One winery where I worked used a wooden single-piston pump to move wine around and this had the added benefit of aerating the wine. Perhaps this is an early example of the relatively modern technique of micro-oxygenation.

There are times when the above strategies do not work and the H<sub>2</sub>S aroma remains. Copper fining (see March issue, p. 39) with copper(II) sulfate or citrate can be used to remove the off-odour. Older winemaking practice may have used silver and even cadmium salts! For reasons not yet known, the amount of copper(II) required is in considerable molar excess of the H<sub>2</sub>S concentration and the excess copper can lead to other quality defects such as the onset of oxidation and enhanced colouration. A similar issue also exists with beer. Mark Smith of the Australian Wine Research Institute (AWRI) has drawn my attention to an electrochemical answer proposed by Thorne et al. (*J. Inst. Brew.* 1971, vol. 77, pp. 148–53). These authors demonstrated that placing copper electrodes in beer would allow copper(II) ions to be released *in statu nascendi* to react with the volatile sulfur compounds and thereby minimise the amount of copper(II) required. The approach was shown to be effective on an industrial scale for beer production, but I cannot find any examples of its application in wine chemistry.

Increasingly, there are reports in the oenology literature that the H<sub>2</sub>S aroma returns over time in wines that have been previously treated with copper(II). While I have often suggested that this may be due to the lower access to oxygen under screw-cap seals, there would seem to be more to the chemistry than simply oxygen availability. There has long been speculation, particularly in the older French wine literature, that copper(I) is capable of reducing SO<sub>2</sub> to H<sub>2</sub>S. This six-electron reduction of sulfur is something about which I have always had considerable reservations. However, at the Crush 2014 symposium in Adelaide, Marlize Viviers from the AWRI showed that the combination of copper(II) and SO<sub>2</sub> resulted in elevated concentrations of H<sub>2</sub>S, up to 40 times higher than the odour threshold in comparison to the control. The mechanism of the process still needs to be determined, and there must be some exciting chemistry occurring that hopefully might be revealed soon. So, perhaps this may not be the final article on VSCs. Maybe it is more of an unfinished symphony!



**Geoffrey R. Scollary** FRACI CChem (scollary@unimelb.edu.au) was the foundation professor of oenology at Charles Sturt University and foundation director of the National Wine and Grape Industry Centre. He continues his wine research at the University of Melbourne and Charles Sturt University.

## Chemical communication among plants

Can we communicate with plants? Plant-growers from all over the world think we can, if their ancient (deeply rooted?) stories are true.

Reportedly, in China, the footsteps method of cultivation is where the gardener softly walks by his or her plants each day, encouraging them to be productive. From the other side of the world, an elderly French gardener jokes that he bares his backside to the tomatoes, to show them what they should look like when they are ripe. Across the Channel, we hear that some are convinced that talking to their plants encourages growth. Here in Australia, an expert on a radio gardening program was asked: 'Do the weeds know when you are on holiday? It seems they grow more when you are away!'

Perhaps, by observing the plants each day, these various gardeners see potential problems early enough to fix them. Or perhaps there is really a way to communicate with plants.

Scientific research into chemical communication in plants has a long history. Charles Darwin and his son were the first to show that a chemical substance in the tips of plants was affected by light and 'communicated' this information to the growing seedling, causing it to grow towards the sun. This compound was later called 'auxin' and is part of the gibberellin group of plant hormones.

Makers of the US TV program *MythBusters*, knowing that 'data' is not the plural of 'anecdote', devised a more rigorous test to determine whether sound could encourage plants to grow. They played recordings of speech and different types of music to equivalent plants in equivalent glasshouses, ensuring that they included a negative control. They avoided placing humans with the plants, in case the carbon dioxide from the breath of a speaker affected the results. They concluded that sound had a 'plausible' positive effect on plant growth ([bit.ly/1C8LfAI](http://bit.ly/1C8LfAI)).

Plants are indeed known to respond to mechanical stresses such as touch and gravity. Vibrations or mechanical pressure can cause changes in the shape of proteins embedded in plant membranes, thus opening or closing various ion channels. This

can initiate electrical impulses, which in turn can start biochemical cascades that change the metabolism of the plant in a way that turns genes on or off, causing the plant to respond appropriately. Examples of plants responding to touch are vines, trigger plants and shorter grass under the clothesline. Perhaps some plants are sensitive enough to the change in pressure caused by sound waves, and respond similarly ([bit.ly/1MuHxD3](http://bit.ly/1MuHxD3)).

But real communication is a two-way interaction, so do plants talk to us?

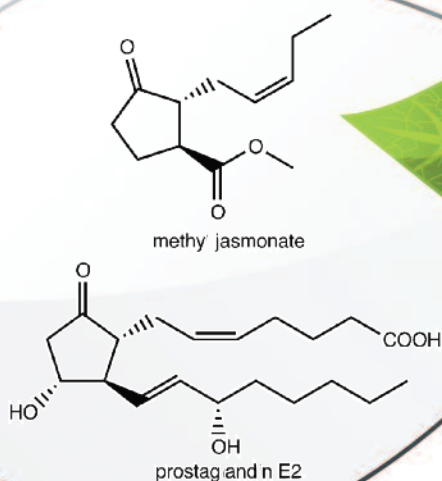
They certainly try. Using smell and colour, they attract animals and insects to a food or shelter source – to benefit the plant, it must be admitted. They also use a chemical armoury to repel organisms that may eat them, or to attract beneficial organisms to feed on these pests. When we detect an odour on crushing or watering our plants, that is the plant telling us that it is in danger. Very recent research has demonstrated that plants can respond differently to attack by different insects ([bit.ly/1xetatl](http://bit.ly/1xetatl)).

Some compounds produced by a damaged plant actually communicate with nearby plants, causing them to start producing defensive chemicals of their own in a type of induced immune response. The jasmonates or their derivatives (e.g. methyl jasmonate) are commonly involved in these interactions. They have structural similarities to the prostaglandins (e.g. PG E2) which cause the inflammation that is one of our own primary defences against invading organisms.

Another group of compounds important in plant defences are the salicylates, which appear to 'cross-talk' to the jasmonates and often have an antagonistic relationship with them. It is interesting to note that one of the effects of aspirin in our bodies is to reduce inflammation by opposing the production of prostaglandins.

Many other plant communication systems are slowly being elucidated. Some plants initiate induced responses to attack using compounds that are transported between their roots, using the hyphae of fungi as their transport mechanism. And I recently heard a PhD student on the radio, wishing she could ask her seeds (chemically!) what signals they used between them, so that they knew when to germinate. She is persevering with these attempts, hoping that her success will help make some agricultural practices more efficient ([ab.co/1Ag0yQg](http://ab.co/1Ag0yQg)).

So it seems that even respectable scientists doing rigorous research think that we can communicate with plants – if only we try hard enough – and use some chemistry.



**Dr Deidre Tronson** FRACI CChem used to be a mad scientist, but is now the Good Little Banksia Lady who, in retirement, is an enthusiastic member of Scientists and Mathematicians in Schools at a local primary school. She has proudly raised three science graduates. She has had separate careers in research and teaching, culminating in a position as part-time senior lecturer at the University of Western Sydney, Hawkesbury campus.

## Skipping Girl

Driving along Victoria Street, Melbourne, for the umpteenth time, I looked up at the Skipping Girl sign with its glowing 'neon' tubes and for the first time began to wonder about the industrial chemistry behind the vinegar behind the Skipping Girl.

The sign was commissioned by Nycander & Co as an advertisement for their Skipping Girl vinegar, and built by Neon Electric Signs in 1936. The emergence of girls skipping in the sun signalled the end of winter in Sweden, from whence the Nycanders came, and a keen observer would see some semblance of Swedish national dress in 'Little Audrey's' clothes. Nycanders went out of business in the mid-1960s, and when the building was demolished in 1968 the sign was removed and after passing through several hands, appears to have been lost. A new one was constructed and installed on the roof of an electroplater's building a few doors from its original home, where fundraising by Friends of Audrey and free electricity from AGL have enabled it to continue to grace the Abbotsford skyline.

Oskar Emil Nycander, born in about 1860, arrived in Melbourne from England in 1909. His company took over the old Shamrock Brewery in 1910 and began the manufacture of yeast that was compressed into blocks and sold to bakers. Nycander was a bacteriologist who had studied in Copenhagen under Emil Christian Hansen and worked in Denmark, Germany and Derby (UK). He held a number of Danish, British and German patents concerning alcoholic fermentation and yeast production. The Melbourne *Argus* reported in August 1910 that a tour of the factory had been conducted for bakers, who were being encouraged to take up the new product in place of their own individual yeast plants or supplies they got from breweries where yeast was a by-product. Vinegar production commenced a few years later.

In April 1938, the *Argus* sponsored a Modern World Exhibition in the Earl's Court ballroom just across the river from downtown Melbourne. Nycanders displayed their Skipping Girl vinegar and provided descriptions of the manufacturing process, which started with malted barley in which diastase converted starch into sugars, and continued with fermentation by yeast to produce an alcoholic solution much like beer. That liquid was sterilised and sprayed down a packed tower while air was blown up through the liquid as it trickled over the packing of beech twigs and shavings into which a special bacterium had been inoculated. The alcohol was thus converted to acetic acid but the final product also contained aromatic esters and higher alcohols that derive from the original malt and give the vinegar its specific flavour.

With a touch of advertising genius, the company organised a skipping contest for girls and held it on a stage adjacent to



their display stand. Heats for girls 11 years and under and 14 years and under were skipped each afternoon, and the winners competed in a final on Saturday 30th. The junior final was won by Lorna Rees and the senior final by Sylvia Conroy of South Melbourne, who set a new endurance record by skipping continuously for 32 minutes 60 (sic) seconds.

When I was young, skipping was not just for girls because it was part of the fitness regime for boxers. I recall seeing aspiring pugilists working the rope at a gym just up the street from where I lived. Skipping was also a competitive sport, in which groups like the Amateur Skipping Association of Victoria

held annual championships, and some prominent people competed. One such was J.J. Brown, Victorian state secretary of the Australian Railway Union, who in 1948 established a new world marathon skipping record – 21 138 turns in 110 minutes (192 turns a minute). The British skipping champion, Jim Allen, was amazed that someone could sustain three turns of the rope a second for nearly two hours, and wrote to the *Argus* asking them to arrange a contest. As far as I can ascertain, nothing came of it. Brown, described in the *Australian Dictionary of Biography* as 'a robust six-footer [183 cm], non-smoker, teetotaler and fitness fanatic' skipped at the gymnasium of the Victorian Railways Institute, where in 1950 he improved on his record by making 30 111 turns in 155 minutes (194 turns a minute or 3.2 a second).

Nycander died in 1927 (his wife in 1936), but the company survived them for many years. You can find on the internet an interesting item by Neville A. Michie about his father, A.I. Michie, who worked for Nycanders from about 1928 to 1954, starting as an assistant industrial chemist and eventually became factory manager. When the company was purchased by Mauri Brothers, he moved to Sydney and took charge of all their vinegar and yeast factories in Australia. Accompanying the text is a photograph of Michie at work in the Nycander laboratory.

Mauri Brothers & Thompson were direct competitors of Nycanders. Originally an engineering firm that produced machinery for the food industry, they had been manufacturing yeast in Melbourne since 1911 but in a decade of vertical integration they took over some of their customers and in the 1920s and 1930s they also began production of vinegar (Champions Vinegar). It was another wave of acquisitions in the 1950s that resulted in the absorption of Nycanders, and the conglomerate was itself taken over by Burns, Philp in 1982.



**Ian D. Rae** FRACI CChem (idrae@unimelb.edu.au) is a veteran columnist, having begun his Letters in 1984. When he is not compiling columns, he writes on the history of chemistry and provides advice on chemical hazards and pollution.



**ALTA 2015: Nickel-Cobalt-Copper, Uranium-REE and Gold-Precious Metals Conference & Exhibition**  
23–30 May 2015, Perth, WA  
[www.altamet.com.au/conferences/alta-2015](http://www.altamet.com.au/conferences/alta-2015)

**18th International Conference on Organometallic Chemistry Directed Towards Organic Synthesis (OMCOS-18)**  
28 June – 2 July 2015, Barcelona, Spain  
[www.omcos2015.com](http://www.omcos2015.com)

**11th International Symposium on Ionic Polymerization**  
5–10 July 2015, Bordeaux, France  
<http://ip15.sciencesconf.org>

**35th Australasian Polymer Symposium**  
13–15 July 2015, Gold Coast, Qld  
[www.35aps.org.au](http://www.35aps.org.au)

**12th International Conference on Materials Chemistry (MC12)**  
20–23 July 2015, York, UK  
[www.rsc.org/events/international](http://www.rsc.org/events/international)

**24th International Symposium: Synthesis in Organic Chemistry**  
20–23 July 2015, Cambridge, UK  
[www.rsc.org/events/international](http://www.rsc.org/events/international)

**IUPAC 2015**  
48th General Assembly 6–13 August 2015,  
45th World Chemistry Congress 9–14 August 2015,  
Busan, Korea  
[www.iupac2015.org](http://www.iupac2015.org)

**13th Conference on Laser Ablation (COLA-2015)**  
31 August – 4 September 2015, Cairns, Qld  
<http://cola2015.org>

**13th Annual UNESCO/IUPAC Workshop and Conference on Macromolecules and Materials**  
7–10 September 2015, Port Elizabeth, South Africa  
<http://academic.sun.ac.za/unesco>

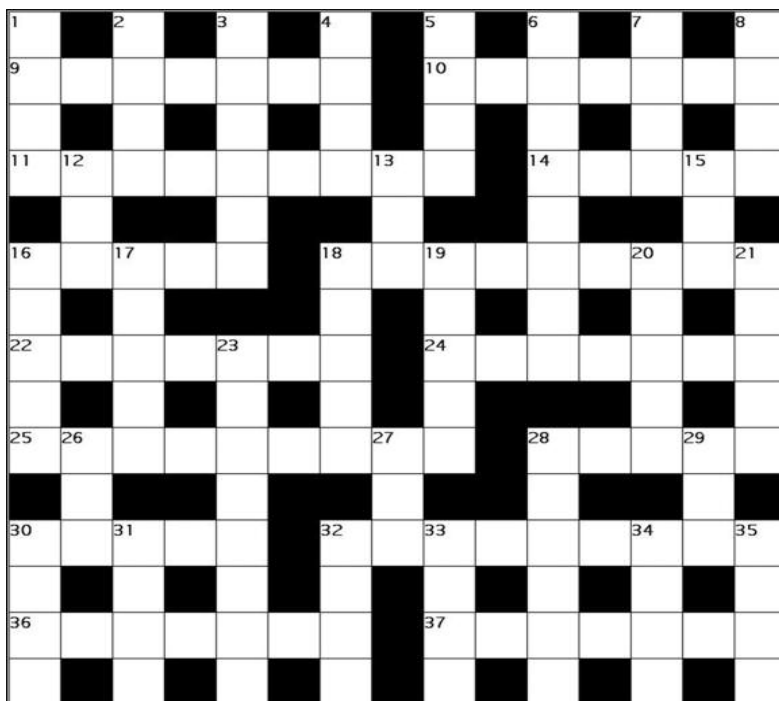
**22nd International Clean Air and Environment Conference**  
20–23 September 2015, Melbourne, Vic.  
<http://casanz2015.com>

**4th Federation of Asian Polymer Societies – International Polymer Congress**  
5–8 October 2015, Kuala Lumpur, Malaysia  
[www.4faps-ipc.org.my](http://www.4faps-ipc.org.my)

**2015 Sustainable Industrial Processing Summit and Exhibition**  
9 October 2015, Turkey  
[www.flogen.org/sips2015](http://www.flogen.org/sips2015)

**Pacificchem 2015**  
15–20 December 2015, Honolulu, Hawaii  
[www.pacificchem.org](http://www.pacificchem.org)

RACI events are shown in blue



Across

- 9 Fuel sat around? Double negative. (7)  
10 Maintain and develop standard. (7)  
11 Deter cost explosion of electronic equipment. (9)  
14 Let it change name. (5)  
16 Three element font. (5)  
18 Tie spiced curry to a plant protection product. (9)  
22 Puncture parting. (7)  
24 Glycidol is one erythropoietin ex ID mixup! (7)  
25 Reduced by use of iron? (9)  
28 Water second side. (5)  
30 Put away 1673161. (5)  
32 A mixture of zirconium, beryllium, lithium, neon and uranium makes mist. (9)  
36 Ranges from canvas. (7)  
37 Earnings coming back. (7)

Down

- 1 Consumed and recycled. (4)  
2 Sulfur ignited opening. (4)  
3 Friend holds a science unit. (6)  
4 Acetone's functional group will not take too much confinement. (4)  
5 Lift sound beams. (4)  
6 Sensed novel nitro group carries no charge. (8)  
7 A 9 Across, perhaps, comes up in Ultrafast Laser Spectroscopy. (4)

- 8 A very important stretch of DNA held up in culpable negligence suit. (4)  
12 Hesitation about a lug. (3)  
13 Grain sounds ironic. (3)  
15 See 27 Down.  
16 A chromium document is strong and sharp. (5)  
17 It represents chemists form four elements. (1.1.1.1.1.)  
18 Iron media. (5)  
19 Sulfur produced water rush. (5)  
20 I dig up a compound containing a carbon–nitrogen double bond. (5)  
21 A pulsed electron paramagnetic resonance technique contained in procedure seems appropriate. (5)  
23 Hear tune about ethyl carbamate. (8)  
26 Electron at feed. (3)  
27 & 15 Down Holds the lashes for batting. (6)  
28 9 Across reacts losing a fluorine and accepting oxygen to make a substance that dissolves. (6)  
29 Electron, get on silver; get on. (3)  
30 Instrument venture. (4)  
31 To follow at  $10^{-18}$ . (4)  
32 House in fine structure. (4)  
33 Drill first – be on receiving end. (4)  
34 Scratch bottom. (4)  
35 Radical 32 Down lost nitrogen balance. (4)

Graham Mulroney FRACI CChem is Emeritus Professor of Industry Education at RMIT University. Solution available online at Other resources.

## New Benefit

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January 1 Abstr  
February 2 of  
April 3 Abstract  
June 25 - Oct. 15  
October 16 Stai  
November  
December

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## Coming up

- X-ray spectroscopy and the chemistry of interfaces
- The remarkable lives of bees
- Can sharing your personal data protect your freedom?
- Haber's rule and the influence of exposure time on toxicity

# 2015 NATIONAL AWARDS

The RACI is a professional membership organisation and one of the most important duties of the organisation is the recognition and promotion of the contributions and achievements of our members.

There are a range of prestigious awards covering a broad range of areas from school education to applied research that are aimed at the full range of members from Post Graduate Students to Distinguished Fellows.

These awards are open to all members of the RACI who meet the specific award requirements. Some can be applied for while others require nomination by third parties.

The awards are listed on the website at [www.raci.org.au/awards](http://www.raci.org.au/awards) together with the criteria requirements and proposed methods. Any other information can be requested from [awards@raci.org.au](mailto:awards@raci.org.au) or by contacting the RACI National Office directly on (03) 9328 2033.

Presentation of the awards will be at a special dinner held in November 2015.

**SUBMISSIONS CLOSE AT 5 p.m. (EST)  
ON 30 JUNE OR 31 MAY FOR  
POST GRADUATE STUDENTS.**

