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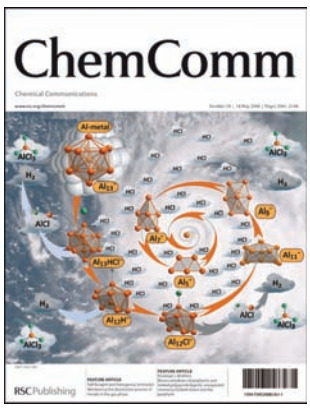

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See Ralf Burgert and Hansgeorg Schnöckel, pp. 2075–2089.
The degradation of an Al_{13}^- cluster as a model for the bulk, visualized in a hurricane of a HCl atmosphere.
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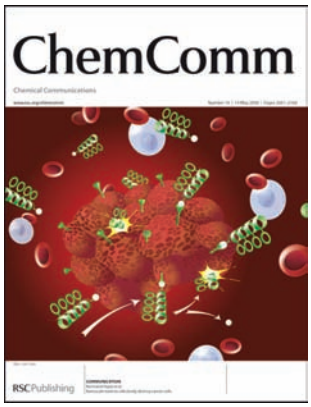

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Image reproduced by permission of Pierre-Luc Boudreault, Mathieu Arseneault, François Otis and Normand Voyer from *Chem. Commun.*, 2008, 2118.

CHEMICAL TECHNOLOGY

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Drawing together research highlights and news from all RSC publications, *Chemical Technology* provides a 'snapshot' of the latest applications and technological aspects of research across the chemical sciences, showcasing newsworthy articles and significant scientific advances.

Chemical Technology
May 2008/Volume 5/Issue 5
www.rsc.org/chemicaltechnology

FEATURE ARTICLES

2075

Monitoring the dissolution process of metals in the gas phase: reactions of nanoscale Al and Ga metal atom clusters and their relationship to similar metalloid clusters

Ralf Burgert and Hansgeorg Schnöckel*

Reactions of metalloid clusters such as the oxidation of Al_{13}^- clusters give an idea about the complex reaction cascades which occur during the dissolution and formation of metals.

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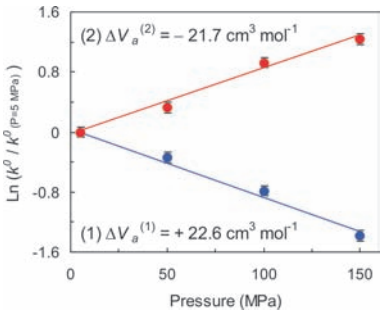
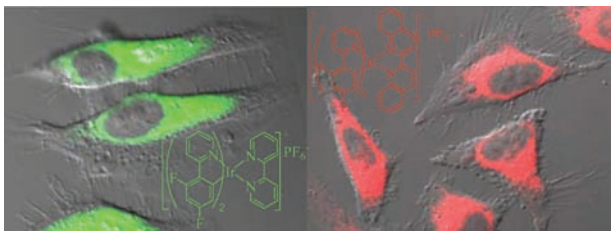
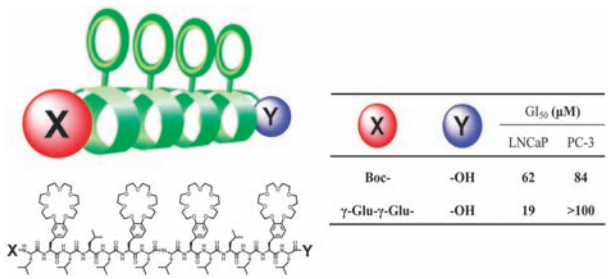
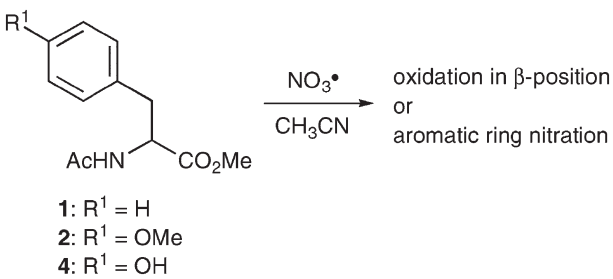


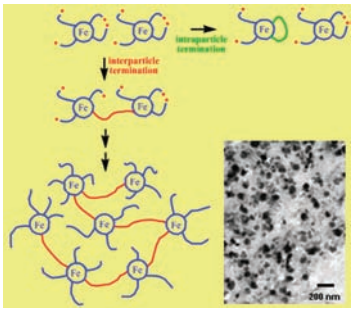






1: R^1 = H
2: R^1 = OMe
4: R^1 = OH

2124



A novel approach to magneto-responsive polymeric gels assisted by iron nanoparticles as nano cross-linkers

Miklós Czaun, László Hevesi,* Makoto Takafuji and Hirotaka Ihara*

Interparticle termination reactions in surface-initiated ATRP induce the formation of magneto-responsive polymeric gels providing the first example of a nano cross-linking strategy.

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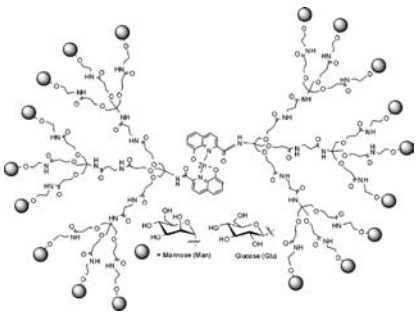
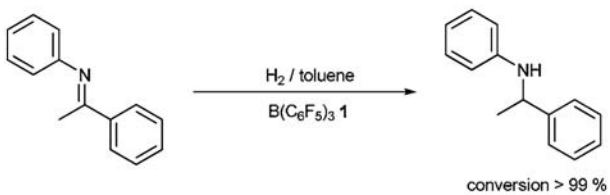


Supramolecular one-pot approach to fluorescent glycodendrimers

Raghavendra Kikkeri, Laila H. Hossain and Peter H. Seeberger*

Sugar-functionalized fluorescent metallic dendrimers that contain varying numbers and types of monosaccharides have been prepared using a self-assembly process and have shown to be highly efficient lectin sensors in turbidity assays.

2130

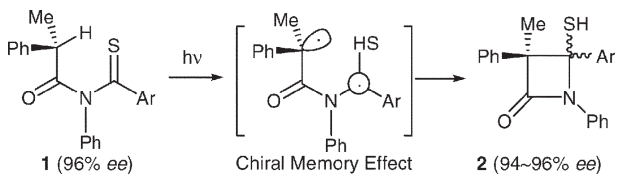


Metal-free catalytic hydrogenation of imines with tris(perfluorophenyl)borane

Dianjun Chen and Jürgen Klankermayer*

Metal-free homogeneous catalysed hydrogenation of imines was accomplished by the exclusive use of tris(perfluorophenyl)borane as catalyst.

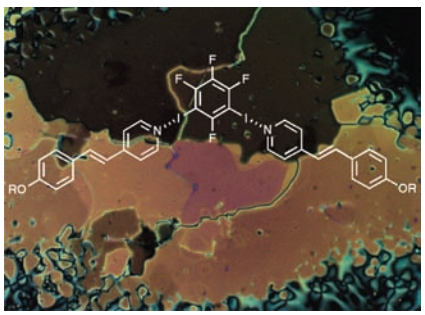
2132

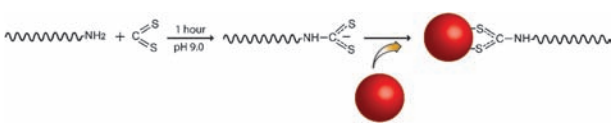


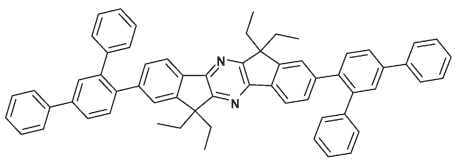
Asymmetric synthesis of β-lactams using chiral-memory effect on photochemical γ-hydrogen abstraction by thiocarbonyl group

Masami Sakamoto,* Hiroya Kawanishi, Takashi Mino and Tsutomu Fujita

Optically active β-lactams were synthesized *via* photochemical intramolecular γ-hydrogen abstraction reaction of thioimides involving a highly-controlled chiral-memory effect.







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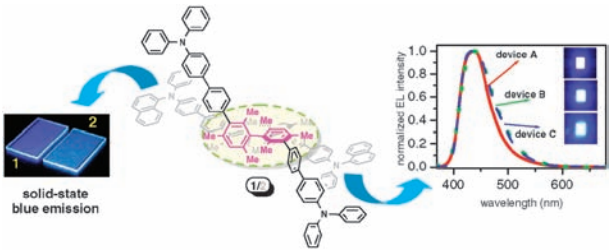
Blue light-emitting and hole-transporting amorphous molecular materials based on diarylaminobiphenyl-functionalized bimesitylenes

Jarugu Narasimha Moorthy,* Parthasarathy Venkatakrishnan, Duo-Fong Huang and Tahsin J. Chow*

The diarylaminobiphenyl-functionalized bimesityls **1** and **2** exhibit amorphous nature, high thermal stability and excellent blue emission in the solid state. They serve as both hole-transporting and emissive materials in OLEDs for blue emission with high external quantum efficiencies.

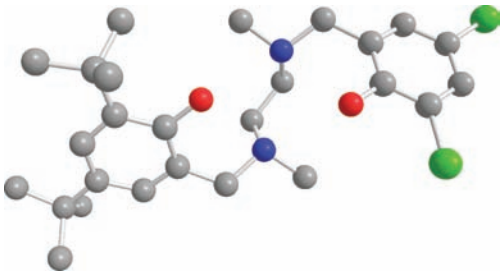


2149

Construction of C_1-symmetric zirconium complexes by the design of new Salan ligands. Coordination chemistry and preliminary polymerisation catalysis studies

Ad Cohen, Adi Yeori, Jacob Kopilov, Israel Goldberg and Moshe Kol*

Achiral and chiral [ONNO′]-type Salan ligands, featuring two different phenol arms, wrapped diastereoselectively around zirconium to give octahedral C_1-symmetric complexes whose activity reflected those of the parent symmetric compounds.



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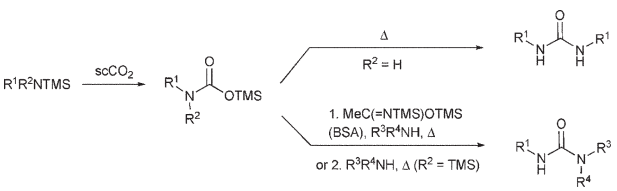
Clean and efficient synthesis of *O*-silylcarbamates and ureas in supercritical carbon dioxide

Matthew J. Fuchter, Catherine J. Smith, Melanie W. S. Tsang, Alistair Boyer, Simon Saubern, John H. Ryan and Andrew B. Holmes*

Carbon dioxide under supercritical conditions is inserted into trimethylsilyl amine derivatives to afford *O*-silylcarbamates that are effective precursors for the synthesis of a range of symmetrical (*e.g.* R^1 = Ph, 85% yield) and unsymmetrical ureas (*e.g.* R^1 = C_6H_{13}, R^3 = R^4 = ^{i}Pr, 73% yield).

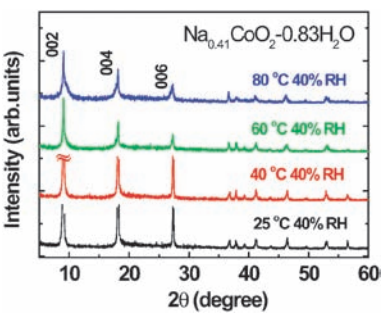


2155

Stabilization of cobalt oxyhydrate superconductor

Zhi Ren, Cao Wang, Xiang-fan Xu, Guang-han Cao,* Zhu-an Xu and Yu-heng Zhang

Post-treating the cobalt oxyhydrate superconductor in concentrated NaOH solution remarkably enhances its chemical stability. This finding is expected to promote future experimental research on the intriguing material.



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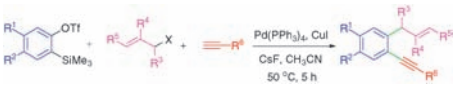
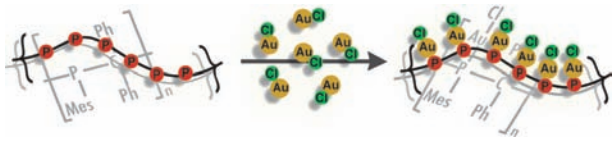


Palladium-catalyzed three-component coupling of arynes with allylic acetates or halides and terminal alkynes promoted by cuprous iodide

Sivakolundu Bhuvaneswari, Masilamani Jeganmohan, Ming-Che Yang and Chien-Hong Cheng*

Benzynes react with allylic acetates or halides and terminal alkynes in the presence of $Pd(PPh_3)_4$, CuI and CsF in CH_3CN at 50 °C for 5 h to give 1-allyl-2-alkynylbenzene derivatives in good to excellent yields.

2161



Macromolecular complexation of poly(methylenephosphine) to gold(I): a facile route to highly metallated polymers

Bronwyn H. Gillon, Brian O. Patrick and Derek P. Gates*

Well-defined gold(I)–phosphine containing polymers are synthesized through the chemical functionalization of the poly(methylenephosphine) $[MesP–CPh_2]_n$.

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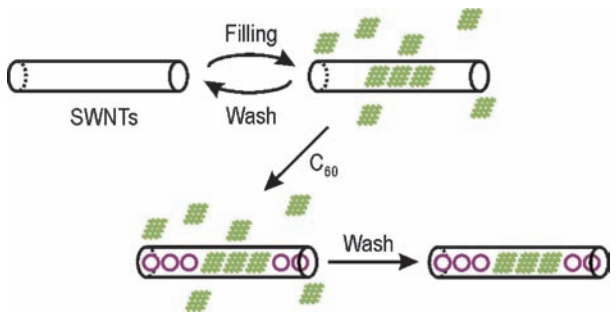

A simple method for the containment and purification of filled open-ended single wall carbon nanotubes using C_{60} molecules

Lidong Shao, Tsung-Wu Lin, Gerard Tobias* and Malcolm L. H. Green

Materials encapsulated inside opened SWNTs can be sealed using fullerenes as ''corks'', to block the ends and thereby provide a way to remove the excess of external soluble material present after the filling step.

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Chemical Technology

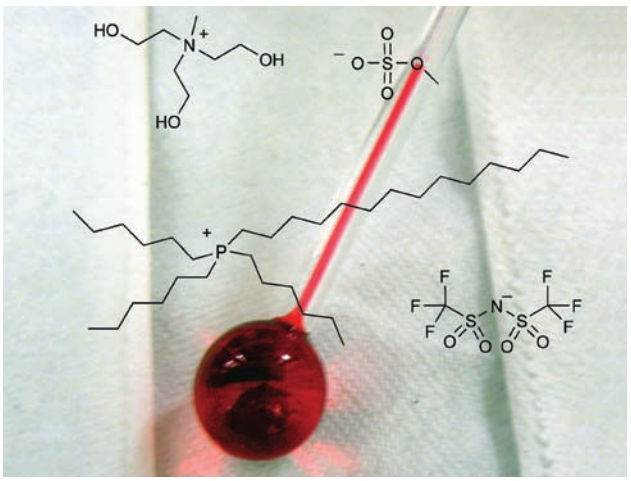
New role for ionic liquids could take temperature measurement to extremes

Designer thermometers rise to new levels

Scientists in Europe and the US have used ionic liquids in liquid-in-glass thermometers as alternatives to mercury and ethanol.

Ionic liquids (ILs) are salts in liquid form and already have a wide range of applications, from use in drug delivery to fuel cells and batteries. Robin Rogers of The Queen's University of Belfast, UK, and his colleagues have now found another role for them. 'We have known the basic properties of ILs and have thought for some time that they should make a great thermometer fluid,' says Rogers. 'We simply had to prove it!'

ILs offer several advantages for thermometers: they have a faster temperature response time compared to mercury and operate over a wider range of temperatures compared to many molecular liquids, including ethanol. Non-toxic ILs can be used and their low volatility reduces their ability to escape into the environment, giving an additional environmental advantage over mercury, which needs to be carefully disposed of if a thermometer is broken.



Ionic liquid thermometers can be adapted for a particular temperature range by changing the liquid's make-up

To make its thermometers the US team used normally clear ionic liquids coloured red with an IL-dye. This made the liquid level easily visible without affecting the linear relationship between liquid volume and temperature. The thermometers could be adapted for a particular temperature range by changing the make-up of the liquid. Rogers and colleagues chose an ammonium-based liquid for general applications, as it is economical and non-toxic. They also used an alkylphosphonium-based liquid for a more specialised thermometer with a wider temperature range.

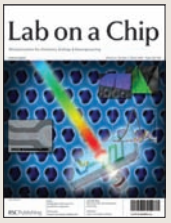
Rogers suggests that the thermometers could have uses both in industry and research and development. 'Specialty thermometers with a suitable liquid range could be interesting for operation under extreme environment conditions,' he says, 'for example, Antarctica and deep sea vents.'

Gary Baker, who also works with ILs, at Oak Ridge National Laboratory, US, says that 'using an IL as a filling fluid toward a new class of liquid-in-glass thermometer nicely illustrates the broad potential of ILs as potentially green replacements for conventional solvents.' He adds that 'the work opens up yet another avenue in engineering science, as ILs continue to find relevance in increasingly diverse areas.'

Sylvia Pegg

Reference
H Rodríguez *et al*, *Green Chem.*, 2008, DOI: 10.1039/b800366a

In this issue



The latest applications and technological aspects of research across the chemical sciences

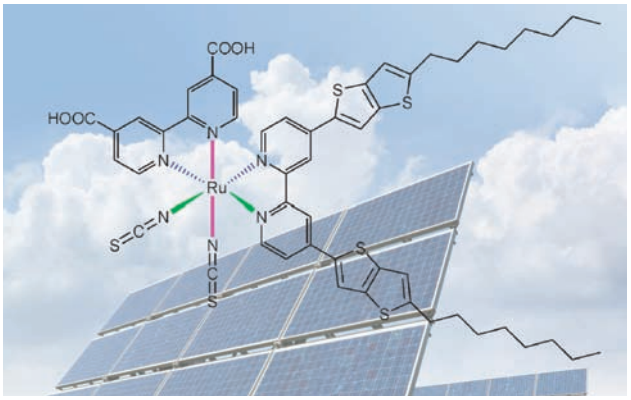
Application highlights

Dye-sensitised solar cells look to improve their share of the retail market

A bright future for solar cells

A new efficient light harvesting molecule could lead to cheaper solar cells, claim international scientists.

Developed in the early 1990s, dye-sensitised solar cells are a class of low-cost solar cells which have a layer of titanium dioxide coated with a light-harvesting sensitiser (dye). Peng Wang from Changchun Institute of Applied Chemistry, China, and Shaik Zakeeruddin and Michael Grätzel from Swiss Federal Institute of Technology, Lausanne, Switzerland, and colleagues have made a new sensitiser with a high extinction coefficient – meaning it is excellent at absorbing light. The new sensitiser is a ruthenium complex with highly conjugated ligands containing thiophene rings. Preliminary tests using this sensitiser in a solar cell obtained a power conversion efficiency of 10.53 per cent, which is comparable with the 11.1 per cent achieved by the most efficient dye-sensitised solar cells reported to date. Grätzel says that this 'looks very promising'. This conversion may be lower than for commercially available silicon-based solar cells (at 20–25 per cent efficiency) but dye-sensitised solar cells are still desirable as they are hydrophobic and so more stable and robust than silicon-based solar cells, which suffer from water sensitivity.



Conjugated ligands increase the amount of light absorbed by the ruthenium complex

Reference
F Gao *et al*, *Chem. Commun.*, DOI:10.1039/b802909a

The addition of the thiophene rings to the ligands in the ruthenium complex increases the conjugation, and improves the sensitiser's overall light absorbing capabilities. 'Less dye is required to extract the same amount of energy from the available light, which translates into immediate cost savings,' says Kevin Tabor, director of science and research at G24 innovations, Cardiff, UK, a large scale manufacturer of solar cells using Grätzel's technology. Additionally, the thiophene ring has shifted the absorption band of the sensitiser into the red region. 'This means further energy uptake over other sensitisers and from an aesthetics perspective, a deeper coloured, almost black solar cell,' explains Tabor.

Developing a more efficient sensitiser will help towards increasing the market share of this type of solar panel, says Grätzel. *Emma Shiells*

A natural energy source for fluid mixing on the small scale

Cellular power plants fuel molecular motors

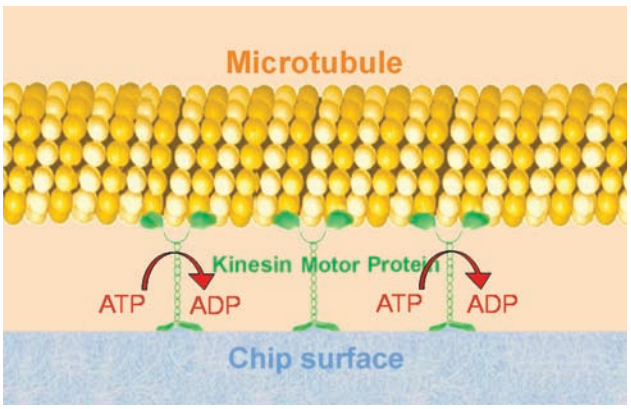
Mitochondria have been used to power miniature motors for microfluidics.

Specialised subunits found within many living cells, mitochondria are essentially the cells' power plants. The structures use glucose to generate adenosine triphosphate (ATP), a multifunctional compound that transports chemical energy within cells. Now Jed Harrison from the University of Alberta, Edmonton, Canada, and colleagues have used mitochondria to synthesise ATP as fuel for molecular motors in microfluidic systems.

Roughly the size of a credit card, microfluidic devices are used to examine fluid flow in structures and channels less than a millimetre across, often being used in disease diagnostics. Using motors allows efficient fluid mixing and transport inside the devices.

ATP has already been used to power microfluidic motors based on kinesin – a protein that moves as it hydrolyses ATP. Currently, ATP is produced in microfluidics with the enzyme pyruvate kinase, but this is a low energy density fuel, and an improved ATP source is the goal.

Using mitochondria to produce ATP instead, the Canadian team found that these miniature machines could power a kinesin motor inside a two-chamber device. 'Using mitochondria directly avoids the significant challenges associated with creating a synthetic enzyme cascade to duplicate the mitochondrial role,' explains Harrison. 'We take advantage of the biomolecular machinery nature has already assembled.'



On-chip: kinesin moves along microtubules as ATP is hydrolysed

Reference
J R Wasylycia *et al*, *Lab Chip*, 2008, DOI: 10.1039/b801033a

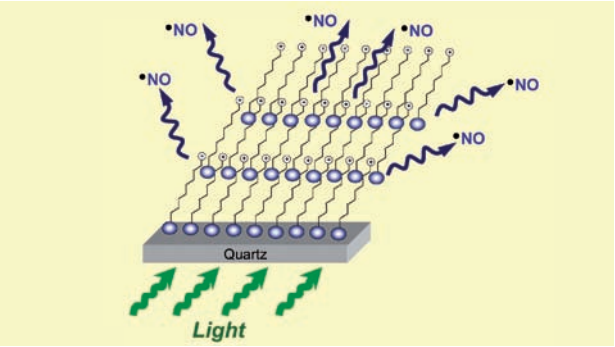
Harrison adds that, although there are many future challenges for molecular motors, he believes this is the first step towards a system that has a high energy density fuel source and can recycle products back into ATP. 'And the simplicity of the device is a key point which should ensure its success in labs which are not specialists in microfabrication,' says Matthieu Piel, who heads a systems cell biology research group at the Curie Institute, Paris, France. *Rebecca Brodie*

NO releasing film provides 'significant step' towards molecule-based machines

Layered film offers NO control

A film that releases one of the body's signalling molecules could find uses from biochemical studies to new materials, say scientists in Italy. Ludovico Valli and co-workers at the Universities of Salento and Catania, have developed a multilayer film that releases nitric oxide (NO) under light stimuli.

NO is more than just an environmental pollutant, it also plays a vital role in a range of biological processes, including blood vessel dilation, neurotransmission and hormone secretion. Therefore, compounds that deliver NO are of great interest for biochemical research. 'But only a limited number of NO photodonors have been integrated in appropriate materials,' says team member Salvatore Sortino, explaining the group's motivation.



Shining light on multilayer films releases NO on demand

The researchers incorporated a light-sensitive NO donor molecule into multilayer films. They found that the films were stable in the dark, but when illuminated emitted a nanomolar amount of NO. The NO reservoir size can be varied by changing the number of layers. Also, increasing the films' light exposure times increases the levels of NO delivered. 'This offers the possibility of accurately controlling NO dosage exclusively by light,' says Sortino, 'making the films ideal for potential studies in biochemical research where precise control of NO release is required.'

Alberto Credi, of the University of Bologna, Italy, whose research interests include photoactive devices and machines, agrees. 'Several molecules will release nitric oxide under light irradiation in homogeneous solution,' says Credi. 'But integrating them into these films represents a significant step towards molecule-based materials and devices for NO delivery with spatial and temporal control.' *Vikki Chapman*

Reference
L Valli, G Giancane and S Sortino, *J. Mater. Chem.*, 2008, DOI: 10.1039/b802126k

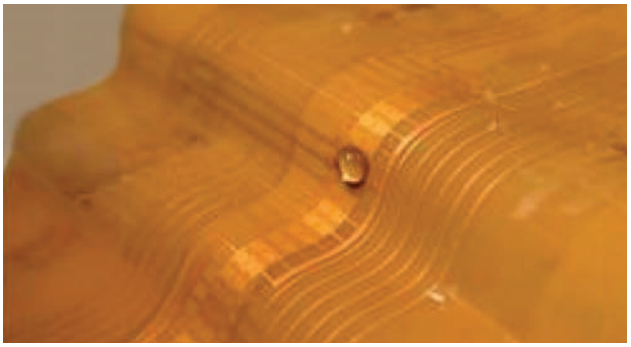
Fluid movement cycles temperature for DNA studies

Driving water droplets uphill

Lab-on-a-chip technology could soon simplify a host of applications, thanks to a new way to move droplets up vertical surfaces on flexible chips.

Canadian chemists have developed an all-terrain droplet actuation (ATDA) method to move droplets across chips at a wide range of angles. Aaron Wheeler and colleagues at the University of Toronto say digital microfluidic devices using ATDA could be used to move fluids rapidly between different environments, for example to cycle between heating and cooling.

Wheeler developed ATDA on flexible, water-repellent polyimide surfaces, clad with copper, which can be bent into a variety of shapes including steps, twists and overhangs. The fluid beads are moved by sequentially activating a series of electrode pairs, which is thought to pull the droplet forward by reducing water repellence in front of the droplet. This process gives the team full control of the droplet, including up and down vertical surfaces.



A reduction in water repellence pulls the drop up a stepped surface

Wheeler suggests several potential uses for the technique, including PCR (the polymerase chain reaction), which is used in DNA analysis. PCR depends on rapid temperature cycling – and Wheeler showed the method can be used to move fluids between a cooling structure and a hot plate. The team also showed ATDA devices can be used to extract DNA from a complex organic mixture. By half-immersing the device in the mixture, and driving the water droplet in and out of it, the process could automate a tedious technique molecular biologists use to purify DNA, says Wheeler.

Richard Fair, who studies lab-on-a-chip devices at Duke University, Durham, US, says it is too soon to tell whether all-terrain devices will be useful. 'Demonstrating these applications is kind of cool, but whether ATDA is the best way to do them is another issue,' he says.

Wheeler agrees that the ultimate uses of ATDA are still to be established. 'We're not totally sure what this will be good for but it's been fun to do something new,' he says. 'This certainly isn't the only way to cycle temperature on a lab on a chip device but it's really easy.'

James Mitchell Crow

Reference
M Abdelgawad *et al*, *Lab Chip*, 2008, DOI: 10.1039/b801516c

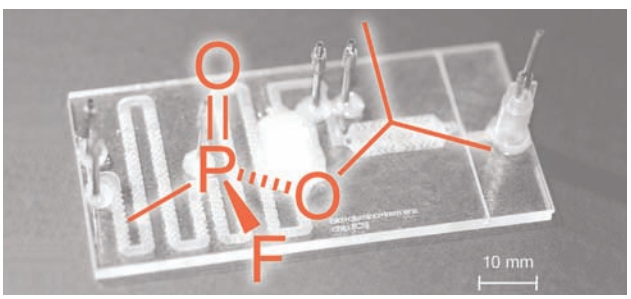
Device performs multistep sequence to detect neurotoxins in droplet of blood

Nerve agent detector on a chip

A microfluidic device that can identify exposure to sarin could help identify individuals needing treatment at sites of terrorist attack.

A lab on a chip that can detect traces of sarin and related neurotoxins in a small drop of blood has been made by Nam-Trung Nguyen at Nanyang Technological University in Singapore and colleagues. Nguyen says that the device would allow the first responders to a terrorist strike, such as the 1995 Tokyo subway sarin attack, to quickly distinguish the 'worried well' from genuinely exposed individuals requiring treatment.

'Our device integrates an entire protocol for the detection of trace amounts of nerve gas agents in blood,' says Nguyen. 'One of the challenges is using whole blood as the sample – the device needs to handle several tasks, from blood sample preparation to final optical detection.'



Trace amounts of sarin inhibit an enzymatic reaction on the chip

The blood flows through the chip in a sequence of steps. Initially, the blood cells are burst open and the sarin released, before the blood proteins and other particulates are filtered out. The purified mixture is then mixed with a substrate and a chromophore, and passed over an immobilised enzyme. If the sample contains no sarin, the enzyme reacts with the substrate, which then attacks the chromophore, which is detected by an external UV-visible spectrometer. But if sarin is present it inhibits the enzyme, so the chromophore passes to the detector unchanged.

'The device can also be used to detect organophosphorus insecticides,' adds Nguyen. 'A simple, low-cost device for evaluating the degree of insecticide contamination could be important for rice-producing countries. Together with other future water technologies, our technology could be crucial for securing and providing clean water sources for the population.'

Jonas Berquist studies chip-based blood analysis at Uppsala University, Sweden, and says he is impressed with the number of steps integrated into the device. He points out that the next step would be to remove the need for an external detector. 'For a first screen device, it would be nice to have something easily detected [by eye], like a colour change,' he says.

James Mitchell Crow

Reference
H Y Tan *et al*, *Lab Chip*, 2008, DOI: 10.1039/b800438b

Interview

Having a gas

Gary Hieftje tells Nina Notman about the fun side of science

Gary Hieftje

Gary Hieftje is a distinguished professor at Indiana University and holds the Robert and Marjorie Mann Chair in chemistry. His research interests include fundamental and applied investigations into atomic and molecular absorption, emission, and mass spectrometry and metallomics. Gary is chairman of the *Journal of Analytical Atomic Spectrometry* editorial board.

What motivated you to become a scientist?
As a child I always loved building things like model planes. I also enjoyed making things explode. As with many chemists, these things came together – I would build a model plane and also build something to make it explode mid-flight.

When I was about 8 years old, I used to play with a chemistry set. But the set had a limitation – a small alcohol lamp that didn't get very hot. It was possible using the lamp to bend soft glass but not to do the real glass blowing I wanted to get involved in. So I talked to my uncle who was a plumber and learnt a lot about plumbing. I then used this knowledge to put in a gas line for a Bunsen burner. I was 10 years old when I did it and it was all unknown to my father. When I showed him this bit of glass that I had blown, he asked me where I had done it. I showed him the gas line in the basement and he just about went crazy!

Do you remember your first experiment?
Making gunpowder was my first real chemical experiment. At first, this was very conventional – a mixture of powdered charcoal, potassium nitrate and sulfur. But my mother complained about the sulfur stink, so I substituted cinnamon for sulfur just out of curiosity. It worked but not quite as well. So I looked in a chemistry book and learnt that potassium perchlorate was a much stronger oxidising agent than potassium nitrate. Potassium perchlorate, charcoal and cinnamon made a wonderful explosion and also smelled pretty good!

What is hot in atomic spectrometry at the moment?
A lot of things are hot, which is a nice term for people who use plasmas and flames. One area is speciation and a subset of speciation that we are calling metallomics – the study of metals in living things ranging from single cells to whole organisms.

Another hot topic is melding atomic and molecular techniques. People are now using mass spectrometric methods that involve inductively coupled plasma to give elemental and atomic information, and other sources such as electrospray ionisation to yield molecular information.

How do you see the future of atomic spectrometry?
I see the future in a very positive light. Some people view atomic spectrometry as a stagnant field because we already have such powerful tools. There are good tools, such as inductively coupled plasma mass spectrometry (ICP-MS), but there are still a lot of unknowns and areas where vast improvements are possible. For example, it can be shown on paper that detection using ICP-MS could be improved down to the single atom or ion level. These advances are going to be increasingly important for the areas of nano- and bioscience.

Another important future area for atomic spectrometry is the imaging process. Currently, we take bulk solutions or samples and determine their elemental composition but soon we will also need to determine their atomic placement.

What is the most exciting project your group is working on at the moment?
The thing I'm most enthusiastic about right now is a new source we have for ambient MS. This technique involves determining samples as they are, everything from a napkin to something on my hand that I have touched. The sample is placed in front of a specialised source, which desorbs the species from the sample surface and ionises them so they can be analysed by MS.

As a significant role model to young aspiring analytical scientists, what advice can you give on a successful research career?
It's really very easy; work hard and have fun. There is an awful lot of fun in science. I've worked in areas ranging from synthetic organic chemistry to the far reaches of analytical instrument building. I have yet to find an area that isn't exciting once I've learnt enough about it.

What research would you most like to be remembered for?
It isn't the research that I want to be remembered for; it is for the students that leave my group. To me research is just a very nice, convenient by-product of the educational process.

What do you like doing away from work?
I enjoy gin martinis tremendously! I also like skiing, water skiing, swimming and running.

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Instant insight

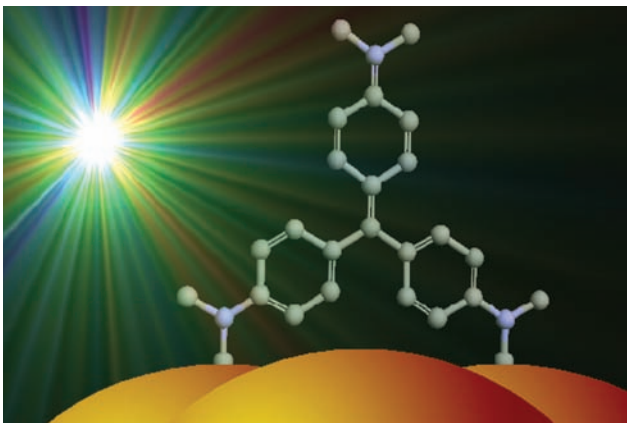
Detection on the nanoscale

Nicholas Pieczonka and Ricardo Aroca of the University of Windsor, Canada, use Raman scattering to look at one molecule in a million

Single molecule spectroscopy (SMS) uncovers the information and behaviour that is lost when measuring an ensemble of molecules. To be able to detect the spectroscopic signal from a solitary molecule, it must have extraordinary absorption or emission properties. And so, the majority of SMS work has been accomplished by measuring the fluorescence of molecules with exceptional luminescence abilities. But the molecular information and the class of molecules that can be probed through fluorescence are limited.

Raman scattering (RS), the inelastic scattering of light from molecules, is an alternative optical spectroscopy that provides a vibrational spectrum, a true characterisation of any stable electronic state. It is rich in information and can be applied to virtually any type of chemical species. It is not always an efficient process; however its cousin, resonance RS, can be orders of magnitude more intense.

Just over 30 years ago, scientists discovered that a molecule's Raman signal could be greatly enhanced by putting it close to metallic nanoparticles. They found that the source of the enhancement was the intense fields provided by the localised surface plasmon resonances (LSPR), or waves of electrons, that occur when the nanoparticles are excited by light. The new physical phenomenon delivered several new analytical techniques, including surface-enhanced Raman scattering (SERS) and surface-enhanced resonance Raman scattering (SERRS). Several groups expanded the potential for SER(R)S even further by demonstrating that certain nanostructures provide intense field enhancements, known as hot spots, that are large enough for single molecule detection.



Molecules close to metallic nanoparticles show enhanced Raman scattering

Today, there is a vast body of work that illustrates both the promise and the inherent challenges in SM-SER(R)S. Only two metals (silver and gold) and a handful of nanostructures (aggregated colloids, metal island films and scanning tunnelling microscopy (STM) tips) have demonstrated SM sensitivity. Also, investigations have revealed a very strong dependence between the scattering ability of the molecule and the type of nanostructures that can be used. Molecules that are relatively weak scatterers require nanostructures that can support hot spots, whereas for strong scatterers, single plasmon supporting structures, such as STM tips, will do.

A daunting challenge to SM-SER(R)S is that, in many instances, SM detection depends critically on the structure of the molecule for selective adsorption, particularly onto hot spots. And although ensemble SERS has been observed for all types of molecular systems, SM-SER(R)S has been observed only for a very limited selection of chemical structures, in particular molecules containing electron-rich moieties.

Scientists are developing a greater understanding of the underlying features of the Raman signal measured for a single molecule. At present, the most common signature that supports the claim that the recorded spectrum comes from a single molecule is fluctuations of the signal. This includes variations in the frequency, bandwidth, relative intensity and, sometimes, an on-and-off behaviour of the spectrum. These dynamics hold a wealth of information that is waiting to be untapped.

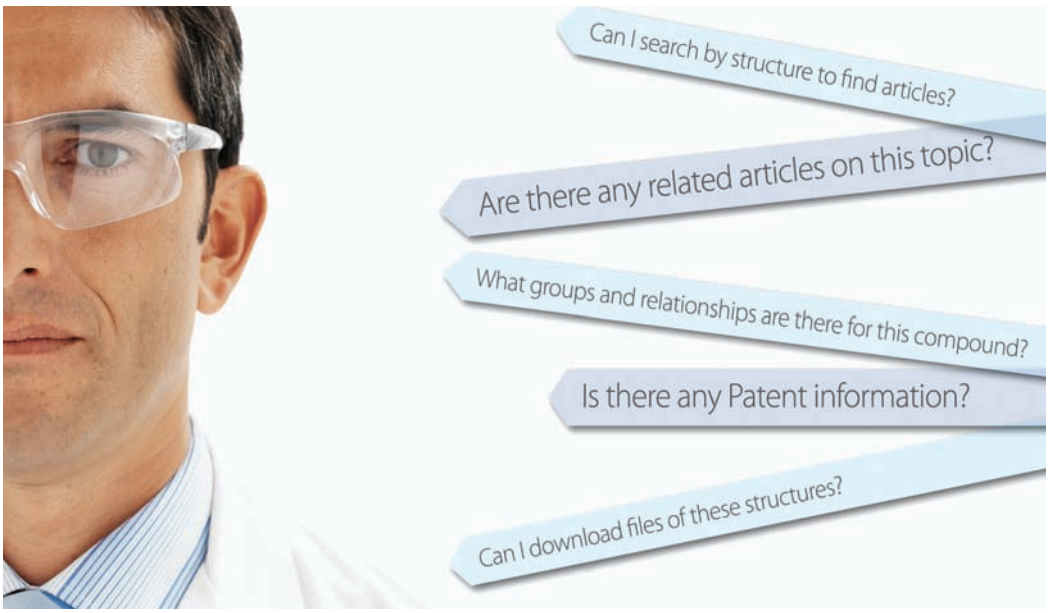
The use of plasmon supporting nanostructures for SM-SER(R)S is still at an early stage of development and holds enormous promise for potential applications. The future of SM-SER(R)S will demand a great deal of effort from experimentalists and theorists but this will be justified by the application of SMS in areas of nanoscience and ultrasensitive chemical analysis. The most important implications and fascinating applications may come from the advancement of our understanding of plasmonics. The interaction of molecular systems with confined electromagnetic waves in metallic nanostructures is clearly an exciting subject of study and will no doubt be the source of new knowledge in SM-SER(R)S.

Read Pieczonka and Aroca's tutorial review 'Single molecule analysis by surfaced-enhanced Raman scattering' in issue 5, a SERS thematic issue of Chemical Society Reviews.

Reference
N P W Pieczonka and R F Aroca, *Chem. Soc. Rev.*, 2008, **37**, 946 (DOI: 10.1039/b709739p)

Essential elements

Faced with questions?



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