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IN THIS ISSUE

ISSN 1359–7345 CODEN CHCOFS (23) 2577–2700 (2008)

Cover
See Peng Wang *et al.*, pp. 2635–2637.
A small dose of sensitizer with a conjugated spectator ligand harvests numerous photons for the conversion of light to electricity. Image reproduced by permission of Feifei Gao, Yuan Wang, Jing Zhang, Dong Shi, Mingkui Wang, Robin Humphry-Baker, Peng Wang, Shaik M. Zakeeruddin and Michael Grätzel from *Chem. Commun.*, 2008, 2635.

Inside cover
See Yongsheng Li *et al.*, pp. 2629–2631.
Hollow mesoporous silica nanospheres with tunable sphere diameter and shell thickness. Image reproduced by permission of Z. Feng, Y. Li, D. Niu, L. Li, W. Zhao, H. Chen, L. Li, J. Gao, M. Ruan and J. Shi from *Chem. Commun.*, 2008, 2629.
The authors thank Dr L. Xiong for assistance with the design of the cover artwork.

CHEMICAL SCIENCE

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

Chemical Science

June 2008/Volume 5/Issue 6

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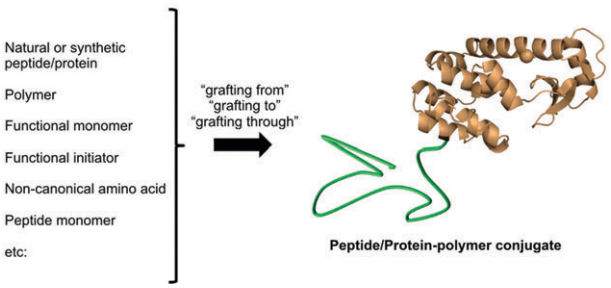
FEATURE ARTICLES

Peptide/protein–polymer conjugates: synthetic strategies and design concepts

Marc A. Gauthier and Harm-Anton Klok*

This feature article provides a compilation of tools available for the preparation of *polymer-reactive* peptides/proteins, *peptide/protein-reactive* polymers as well as strategies for assembling these modified building blocks into well-defined *peptide/protein–polymer conjugates*.



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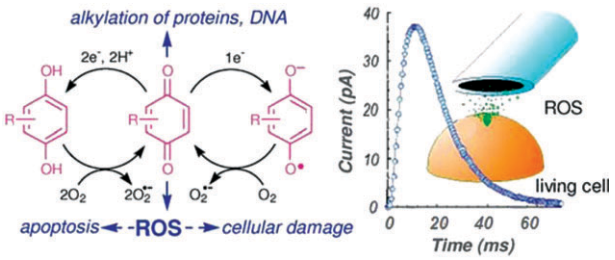
FEATURE ARTICLES



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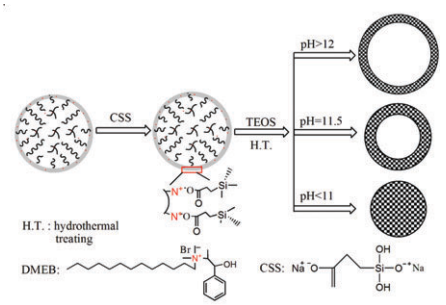

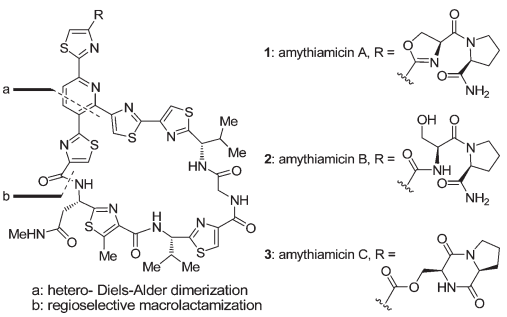

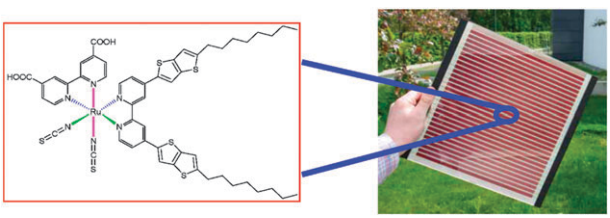

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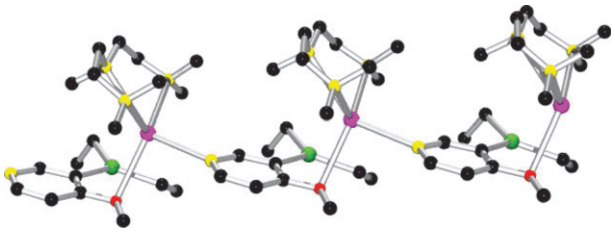

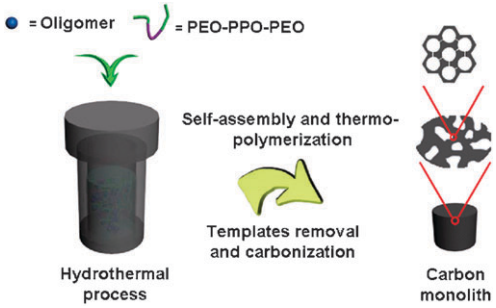

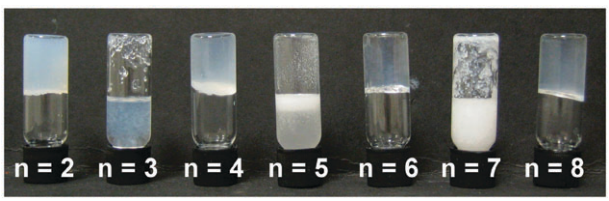

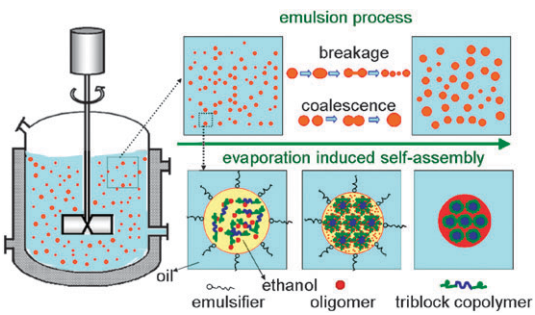

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Vincent Pecoraro, USA
Roger Sheldon, The Netherlands
J. Henrique Teles, BASF, Germany

Key Note Lecture
Alain Vandenbussche, SOLVAY Belgium

Invited Speakers
Paul Alsters, DSM, The Netherlands
Marco D'Ischia, Italy
Ronald Hage, Rahu Catalytics, UK
Jeremy Harvey, UK
Oxana A. Kholdeeva, Russia
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Ulrich Schwaneberg, Germany
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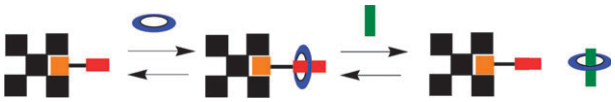
New catalysts, new oxidants, innovative methods for catalytic oxidation, ranging from bleaching to stereoselective oxyfunctionalization, new mechanistic insights into oxidative processes including biomimetic oxidation and enzymatic processes, are typical topics for ADHOC conferences.

2650

Tuneable pseudorotaxane formation between a biotin–avidin bioconjugate and CBPQT^{4+}

Stuart T. Caldwell, Graeme Cooke,* Alan Cooper, Margaret Nutley, Gouher Rabani, Vincent Rotello, Brian O. Smith and Patrice Woisel

A biotinylated 1,5-dialkoxynaphthalene derivative has been shown to have the ability to bind strongly to avidin and thus act as an artificial binding site for cyclobis(paraquat-*p*-phenylene) thereby facilitating the formation of a tuneable pseudorotaxane-based bioconjugate.

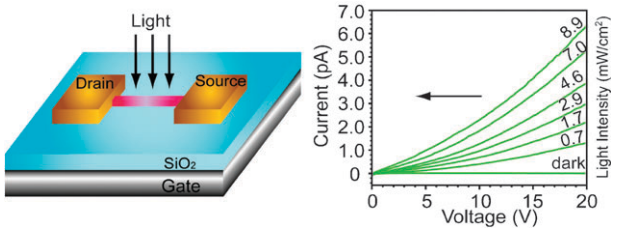


2653

ZnOEP based phototransistor: signal amplification and light-controlled switch

Heng-Xing Ji, Jin-Song Hu and Li-Jun Wan*

A phototransistor with a field-effect transistor configuration was fabricated using a single zinc octaethylporphyrin (ZnOEP) nanorod; the device showed ability in signal amplification and reversible light-controlled switching.

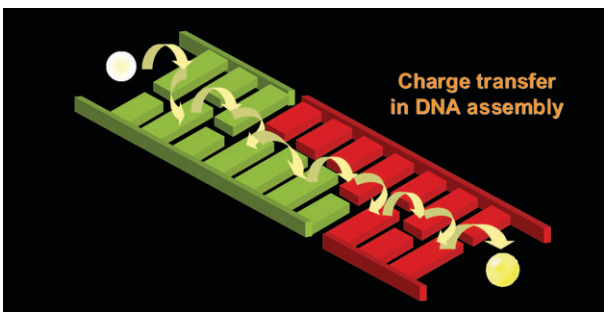


2656

Charge transfer in DNA assemblies: effects of sticky ends

Yasuko Osakada, Kiyohiko Kawai,* Mamoru Fujitsuka and Tetsuro Majima*

Transient absorption measurements of charge transfer demonstrated that in the DNA assembly constructed by simply mixing DNAs with sticky ends, charge transfer occurs over 200 Å selectively to the complementary sticky end sequences.

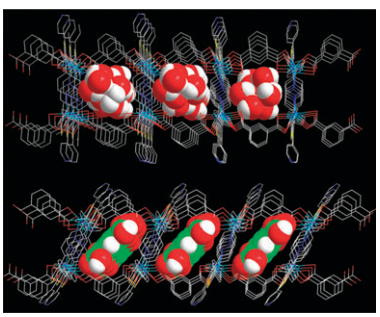


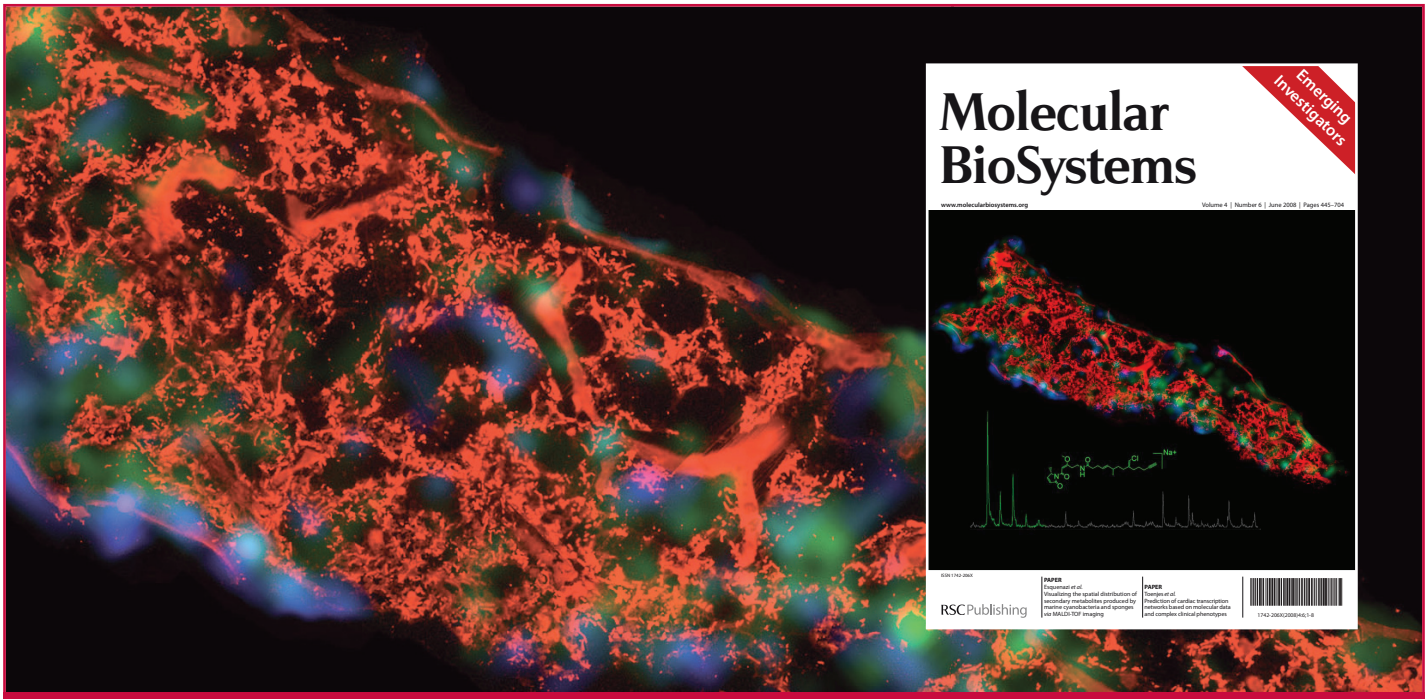
2659

Ligand-to-metal ratio controlled assembly of nanoporous metal–organic frameworks

Jian-Guo Lin, Yan-Yan Xu, Ling Qiu, Shuang-Quan Zang, Chang-Sheng Lu, Chun-Ying Duan, Yi-Zhi Li, Song Gao and Qing-Jin Meng*

Two bilayered metal–organic frameworks with nanoporous channels were synthesized at different ligand-to-metal ratios, which demonstrated an interesting crystal-to-crystal transformation property and a special fluorescent response to the different guest molecules included.





Emerging Investigators theme issue

Molecular BioSystems issue 6, 2008, devoted to outstanding young scientists at the chemical- and systems-biology interfaces, features novel methods to visualise and manipulate protein function in living cells, the development of chemical techniques to monitor specific protein post-translational modifications, new insights into metabolomics and much, much more!

050817

Papers include:

Visualization of phosphatase activity in living cells with a FRET-based calcineurin activity sensor
Robert H. Newman and Jin Zhang

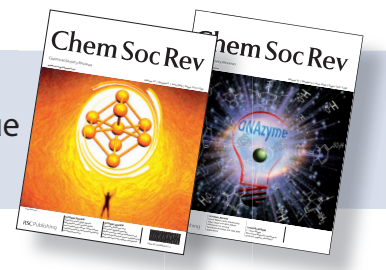
Conformation and the sodium ion condensation on DNA and RNA structures in the presence of a neutral cosolute as a mimic of the intracellular media
Shu-ichi Nakano, Lei Wu, Hirohito Oka, Hisae Tateishi Karimata, Toshimasa Kirihata, Yuichi Sato, Satoshi Fujii, Hiroshi Sakai, Masayuki Kuwahara, Hiroaki Sawai and Naoki Sugimoto

A quantitative study of the recruitment potential of all intracellular tyrosine residues on EGFR, FGFR1 and IGF1R
Alexis Kaushansky, Andrew Gordus, Bryan Chang, John Rush and Gavin MacBeath

Direct printing of trichlorosilanes on glass for selective protein adsorption and cell growth
Dawn M. Yanker and Joshua A. Maurer, Mol. BioSyst., 2008

A chemical approach for detecting sulfenic acid-modified proteins in living cells
Khalilah G. Reddie, Young Ho Seo, Wilson B. Muse III, Stephen E. Leonard and Kate S. Carroll

See also:
Chem Soc Rev issue 7, 2008 - Chemistry-Biology Interface theme issue
For more details contact chemsocrev@rsc.org



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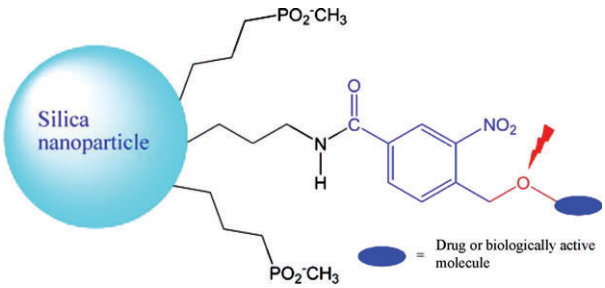

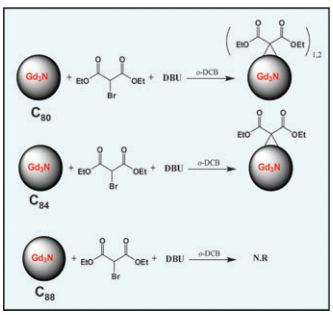

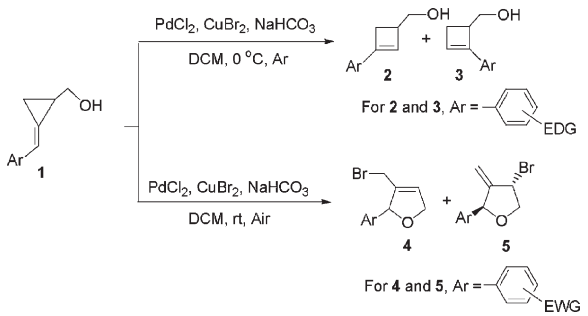

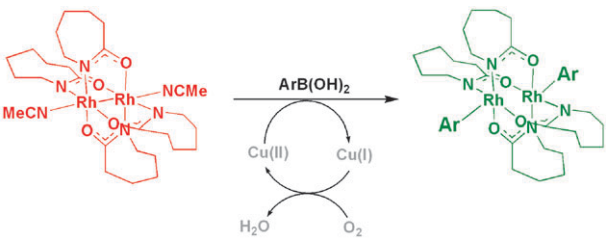

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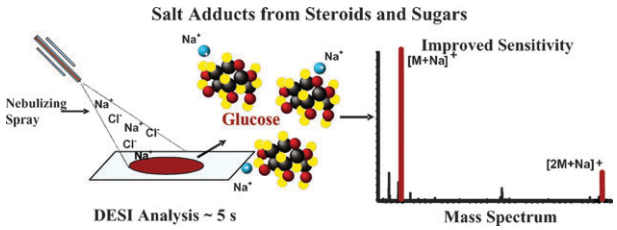
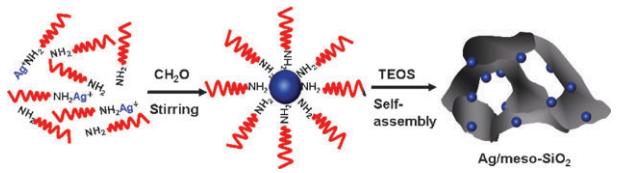


Carbohydrate and steroid analysis by desorption electrospray ionization mass spectrometry

Tiina J. Kauppila, Nari Talaty, Ayanna U. Jackson, Tapio Kotiaho, Risto Kostiainen* and R. Graham Cooks*

The detection limits of carbohydrates and steroids in DESI-MS are improved by the addition of salts to the spray solvent.

2677

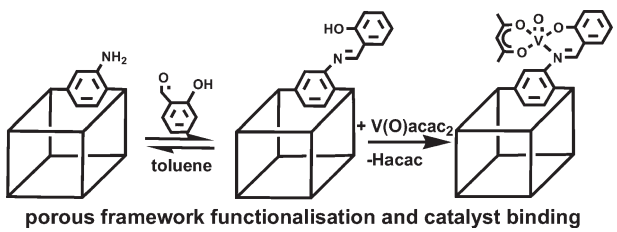


Highly active mesostructured silica hosted silver catalysts for CO oxidation using the one-pot synthesis approach

Hongyang Liu, Ding Ma,* Ross A. Blackley, Wuzong Zhou and Xinhe Bao*

A facile one-pot approach gave isolated silver nanoparticles anchored on a mesostructured silica matrix in a self-assembled way; these gave 100% CO conversion in CO oxidation reaction at room temperature.

2680

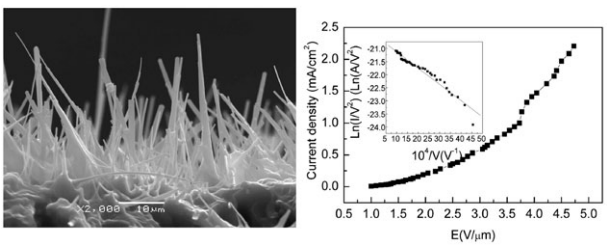


Framework functionalisation triggers metal complex binding

Michael J. Ingleson, Jorge Perez Barrio, Jean-Baptiste Guilbaud, Yaroslav Z. Khimyak and Matthew J. Rosseinsky*

Post-synthetic derivatisation of a porous material, monitored by solid state MAS-NMR spectroscopy, produces a functionalized material that binds the metal complex $V(O)acac_2$, in contrast to the precursor material which exhibits no proclivity for metal binding.

2683



Fabrication and field-emission performance of zirconium disulfide nanobelt arrays

Yu-Ling Zhang, Xing-Cai Wu,* You-Rong Tao, Chang-Jie Mao and Jun-Jie Zhu

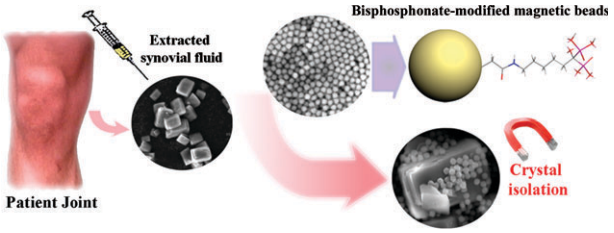
ZrS_2 nanobelt arrays were fabricated on Zr foils. Field-emission measurements show that the nanostructure is a decent field emitter with a turn-on field of $\sim$0.95 V μm^{-1} and a threshold field of 3.6 V μm^{-1}.

2686

Isolation of calcium phosphate crystals from complex biological fluids using bisphosphonate-modified superparamagnetic beads

Aaron Hernandez-Santana, Alexander Yavorskyy, Adedayo Olinyole, Geraldine M. McCarthy and Gillian P. McMahon*

This communication describes the use of bisphosphonate-modified superparamagnetic beads to selectively capture and extract calcium phosphate crystals from complex biological fluids such as synovial fluid.

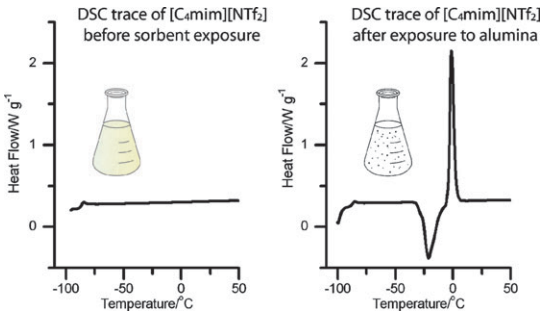


2689

Purification or contamination? The effect of sorbents on ionic liquids

Bronya R. Clare,* Paul M. Bayley, Adam S. Best, Maria Forsyth and Douglas R. MacFarlane

Purification of ionic liquids often involves the use of sorbents. These sorbents contaminate ionic liquids with nanoparticulates, which cannot be completely removed by 200 nm filtration and significantly impact the physicochemical properties of the ionic liquids.

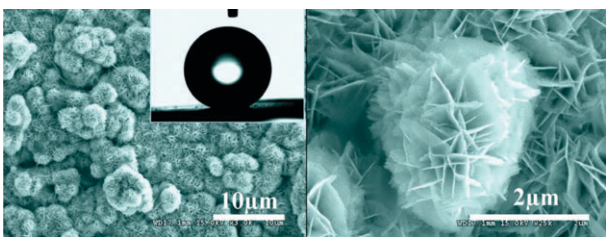


2692

Superhydrophobic pure silver surface with flower-like structures by a facile galvanic exchange reaction with $[Ag(NH_3)_2]OH$

Zongwei Cao, Debao Xiao, Longtian Kang, Zhongliang Wang, Shuxiao Zhang, Ying Ma, Hongbing Fu* and Jiannian Yao*

Superhydrophobic pure silver film on a copper plate without any modification was prepared, giving rise to a contact angle as high as 157°.

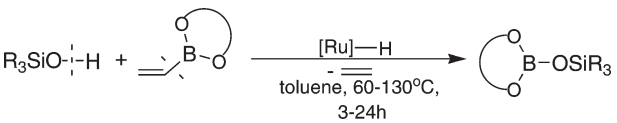


2695

New catalytic route to borasiloxanes

Bogdan Marciniec* and Jędrzej Walkowiak

A new, highly selective method for effective synthesis of boryl silyl ethers (borasiloxanes) *via O*-borylation of silanols with vinylboronates catalyzed by the Ru–H complexes $[RuHCl(CO)(PCy_3)_2]$ and $[RuHCl(CO)(PPh_3)_3]$ is described.



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Chemical Science

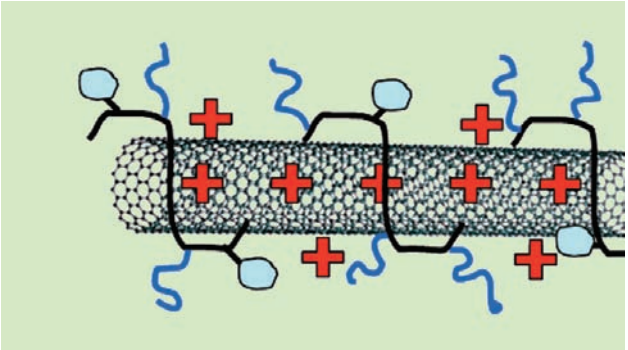
Polymer coating raises carbon nanotubes' potential for drug delivery

Carbon nanotubes wear coats to deliver drugs

Polymer coated carbon nanotubes could find a new use in drug delivery, claim Korean scientists.

Sangyong Jon, at Gwangju Institute of Science and Technology, and co-workers designed an amphiphilic polymer coating – that contains both hydrophilic and hydrophobic parts – for carbon nanotubes (CNTs). They found that in vitro the coating made the CNTs dissolve better in water and plasma, and allowed them to conjugate to biomolecules. Both are vital properties for drug delivery applications.

It is known that CNTs assist in killing cancer cells when irradiated because of their near IR absorption property, explains Jon. CNTs have also been shown in vitro to be able to deliver anticancer drugs to specific cells. However several complications arise when this concept is moved into the body, he continues. CNTs that remain dispersed in plasma for a reasonable amount of time, without aggregating or blocking capillary vessels, are needed. They also must not adsorb unwanted proteins onto their surface. And finally they need functional groups that can carry biomolecules and drugs.



Coating increases carbon nanotubes' stability in vitro

Jon's polymers consist of three parts: a hydrophobic section that can anchor to the CNT's surface, a hydrophilic poly(ethylene glycol) part which blocks adsorption of unwanted proteins, and a carboxylic acid that can immobilise drugs for transport in the body. 'Compared to the amphiphilic polymers and polymer surfactants that were used to coat CNTs previously, CNTs coated with our polymers show much better dispersibility as well as stability in vitro,' says Jon. The group also tested their coated CNTs for effective loading and delivery of an anticancer drug, doxorubicin, in vitro. 'Our results indicate that these coated CNTs may hold promise as potential drug delivery vehicles,' says Jon.

Ali Khademhosseini, who researches biomaterials at Harvard-Massachusetts Institute of Technology, Cambridge, US, highlights the potential of this work, 'researchers are extremely interested in using CNTs for drug delivery; this work takes a step in making this a reality'.

Jon says that the toxicity associated with CNTs is another major challenge for their future medical applications, but this coating should reduce this problem by making the CNTs more biocompatible. 'We hope the coated CNTs could be used to treat diseases such as cancer,' he says.

Fay Riordan

Reference
S Park, *Chem. Commun.*, 2008, DOI: 10.1039/b802057d

In this issue

A snapshot of the latest developments from across the chemical sciences

Research highlights

Drying laundry inside is found not to be a major cause of household mould

How mouldy is your house?

Concerns about mould growing in houses are on the increase, claim mycologists in France.

Sandrine Roussel at the University Hospital of Besancon and colleagues studied mould present on surfaces and in the air in French houses, with some surprising results.

Mould has been linked to a number of respiratory illnesses, such as asthma and indoor allergies. And is often blamed on poor hygiene and unsuitable usage of housing, for example drying laundry inside. However, Roussel's study of 500 rooms in 128 houses found that the most important factors were actually the floor the room was located on, lack of effective ventilation systems, types of heating systems used and past water damage.

You may also think the bathroom, where mould is often most visible, would be the worst offender. But mould concentrations in bathroom air were found to be no higher than in bedrooms, kitchens or living rooms. 'Moulds present on walls are not systematically present in the air,' explains Roussel. 'Particular conditions of temperatures, humidity, of circulation of the air are needed so that the spores fall down surfaces and are transported in the air.'

SHERI ARMSTRONG, 123RF

Particular conditions are needed to transfer mould on walls into the air

They also found that 18% of rooms with no visible moulds or smell were highly contaminated. Roussel explains sources of moulds can be hidden behind walls or under carpets.

The researchers collected data from both questionnaires and air sampling. Roussel believes subjective methods like questionnaires are necessary, but air sampling is also needed to quantify the number and type of spores present. There are a large variety of mould species which have different effects on health, explains Roussel.

The debate about the necessity to quantify the number and type of spores present in the indoor air is common to numerous countries. Establishing an indoor mould standard is important for health reasons, and would also allow tenants to take proceedings against their landlords. 'Nowadays, no one would agree to live in housing which presents any risks towards lead or carbon monoxide. Tomorrow moulds and other chemical substances will probably follow,' Roussel says.

Sarah Corcoran

Reference
S Roussel *et al*, *J. Environ. Monit.*, 2008, DOI: 10.1039/b718909e

Mechanism of the gas-phase hydrolysis of organophosphonates explored

Surprise reaction degrades chemical weapons

Australian scientists improve our understanding of how peroxides destroy chemical warfare agents.

Peroxides are efficient and effective chemicals for chemical warfare agent decontamination, both in solution or as a vapour. Although these chemicals are widely used, the way that they work – their reaction mechanisms – are not well understood. Now Andrew McAnoy, at the Defence Science and Technology Organisation, Melbourne, and Stephen Blanksby and colleagues at the University of Wollongong have identified the reaction pathway for the perhydrolysis degradation reaction.

The chemical reaction between the chemical warfare agent stimulant, dimethyl methylphosphonate, and the hydroperoxide (HOO^-) anion was carried out in the gas phase with surprising results. 'What we observed was a chemical reaction, the α-effect, which for the last twenty years has been widely accepted as impossible to observe in the gas phase,' says McAnoy.

DSTL

Vaporous hydrogen peroxide has been used to clean up anthrax

The α-effect refers to the enhanced reactivity of an atom which occurs because an adjacent atom has lone pair electrons. 'It is this enhanced reactivity which is believed to be responsible for the efficient, and sometimes selective, degradation of chemical warfare agents,' says McAnoy.

McAnoy describes the research as an important link between theoretical and experimental chemistry. However he recognises there are challenges to be overcome. 'These gas phase reactions have still to be linked to degradation processes taking place on the lab bench and ultimately in the field,' he says. 'If this can be done then existing technologies can be improved and new, better technologies developed.'

'Vaporous peroxide-based decontaminants have the potential to clean up buildings, vehicles and even small electronic equipment following chemical or biological contamination,' McAnoy says. 'Indeed, vaporous hydrogen peroxide was used in some of the remediation work that followed the 2001 anthrax attacks in the US.'

Janet Crombie

Reference
A M McAnoy, M R L. Paine and S J Blanksby, *Org. Biomol. Chem.*, 2008, DOI:10.1039/b803734e

Carbon nanotubes help assess capsaicinoid concentrations in chilli sauces

Electrochemistry takes the heat

Eating chilli sauces and the burning sensation on your tongue are permanently interlinked; you can't have one without the other. But there's a fine line between nicely spicy, and unpleasantly painful. UK electrochemists are now offering help to the food industry and chilli lovers, using carbon nanotubes in a more accurate technique for measuring the strength of hot sauces.

Richard Compton and his team at the University of Oxford picked the electroanalytical technique adsorptive stripping voltammetry (AdsVS), and used multi-walled carbon nanotube based electrodes to adsorb capsaicinoids – the compounds that make chillies hot. By monitoring the capsaicinoids' electrochemical response, the team measured concentrations of the compounds in five commercially available sauces, ranging from the mild Tabasco Green Pepper sauce to the stupendously hot Mad Dog's Revenge.

The traditional Scoville method for quantifying the heat of foods is considered rather subjective, but remains the dominant one used by industry. It involves repeatedly diluting a food sample to the point at which a panel of five expert tasters cannot detect any heat. Samples are given a Scoville rating equal to the number of dilutions required.

'AdsVS is a fantastic detection technique for capsaicinoids because it's so simple,' says Compton. 'It integrates over all of the heat-creating constituents because all the capsaicinoids have essentially the same electrochemical response. Multi-walled carbon nanotubes provide a huge surface area for adsorption of capsaicin and are [structurally] perfect – akin to the basal plane of graphite,' he explains. The adsorption leads to an enhanced electrochemical response. Capsaicinoid concentrations obtained by AdsVS can also be converted into Scoville units.

'You could use high-performance liquid chromatography (HPLC) but that would involve separation of all the capsaicinoid components,' says Compton. HPLC is also expensive and requires bulky equipment.

No need to taste when you've got nanotubes

The AdsVS method has a high potential for use as a quality control tool in the food industry. According to Compton, AdsVS 'is suitable for use with handheld electronics, providing an instantaneous measurement of the Scoville unit. We have put in a patent on the technology, and ISIS [University of Oxford's technology transfer subsidiary] is actively seeking backers to commercialise it.'

Kenneth Ozoemena, an expert in electrochemical nanotechnology from the University of Pretoria, South Africa, praises the research. 'I strongly feel this work will go down in history as one of the excellent advantages of electroanalytical techniques over other known probes for applied analytical chemistry,' he says. *James Hodge*

Reference
R T Kachoosangi, G G Wildgoose and R G Compton, *The Analyst*, 2008, DOI: 10.1039/b803588a

Changing natural product output of fungi unveils mystery compounds

Fungi wake up to new natural products

Re-awakening 'silent' metabolic pathways in fungi has revealed a new range of natural products to US scientists.

Fungi produce a wide variety of natural products, including toxins – for example, the amanitins, primarily responsible for the toxicity of the death cap fungus – and life-saving drugs such as penicillin. As a result, the genetics of fungi have generated much interest in recent years. Now, Robert Cichewicz and colleagues at the University of Oklahoma, Norman, have shown that metabolic pathways that are normally 'silent' can be re-activated to make new compounds.

Many fungi have a wealth of genes encoding for far more natural products than they actually produce, says Cichewicz. The explanation is thought to be that when fungi do not need certain compounds, they inhibit the transcription of the DNA that codes for the proteins that make them, preventing their biosynthesis. Knowing what these mystery compounds are, says Cichewicz, could be very important for the development of new medicines, as well as for helping us to understand the ecological roles that fungi play.

'Silent' DNA in tidal pool fungi has been activated

Reference
R B Williams *et al*, *Org. Biomol. Chem.*, 2008, **6**, 1895 (DOI: 10.1039/b804701d)

The DNA involved is known to be inhibited by being scrunched up in a globular form called heterochromatin. To activate this DNA and turn on these 'silent' natural product pathways, Cichewicz had the idea of treating fungal cultures with small molecules known to interfere with the formation of the heterochromatin, thus allowing the DNA to unwind and be transcribed.

To show their idea in action, the researchers took a culture of *Cladosporium cladosporioides*, a tidal pool fungus, and treated it separately with 5-azacytidine and suberoylanilide hydroxamic acid. Both treatments, says Cichewicz, dramatically changed the natural product output of the fungus, with two completely new natural products being isolated.

The new approach impresses Jon Clardy at the Harvard Medical School, Boston, US, who says that it could 'greatly expand the suite of biologically active small molecules obtained from fungi' and that it 'capitalises on recent developments in drug discovery to increase the odds of discovering new drugs'.

The results also have important implications for research into how fungi and other microorganisms communicate, explains Cichewicz. *David Barden*

News in brief

Locking up radiotoxicity
International scientists are using computer simulations to give insights into the long-term safety of nuclear waste in deep geological repositories

See **www.rsc.org/chemicalscience** *for the full version of this article*

This month in *Chemical Technology*

10 minute diagnosis on the microscale
US scientists have developed a new device that uses surface plasmon resonance to speed up disease detection

The worm doesn't turn
Scientists in the US have developed an on-chip suction that stops worms wriggling during medical research

Keeping track of particles-in-a-chip
New simple method monitors reaction rates in microfluidic devices using fluorescent tags

Hydrogel helps the medicine go down
An easy-to-swallow microdevice could provide better treatment for cancer patients

See **www.rsc.org/chemicaltechnology** *for full versions of these articles*

This month in *Chemical Biology*

Plastic coats wrap up gene delivery
UK chemists have used smart polymers to deliver DNA into cells. Based on pH-sensitive poly(ethylene glycol) lipids, the polymers can be used as a removable protective coat for gene delivery systems

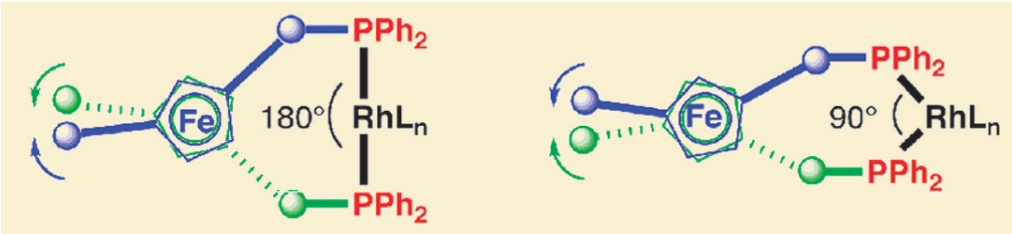
Radical proposal for atmospheric link to asthma
Australian researchers have discovered that nitrate radicals irreversibly damage amino acids

How does a virus bore a hole in a cell?
Chemists in the US studying how viruses enter cells say their results could help in the search for new antiviral medicines

See **www.rsc.org/chembiology** *for full versions of these articles*

Manipulative molecular machines

Miniature devices make the cut



Molecular scissors work by switching the geometry of rhodium

Chemically-powered molecular scissors and tweezer-like triangles offer new ways to manipulate structures on the nanoscale, claim Japanese and German researchers.

A Japanese team from the University of Tokyo has made a scissor-like nanomachine. Kenichi Tanaka and Kazushi Kinbara say their machine runs continually in the presence of molecular fuels.[1] Meanwhile, a separate study into self-assembling molecular triangles could be adapted to make adjustable molecular tweezers, say Michael Schmittel and Kingsuk Mahata at Siegen University in Germany.[2]

The engine in Kinbara's molecular machine is a rhodium complex, which is attached to two molecular arms by a ferrocene pivot. Two 'fuel' molecules trigger the rhodium to continually switch its geometry, which opens and closes the molecule's arms like the blades of a pair of scissors.

The first fuel, diphenylphosphoryl azide, plucks a carbonyl ligand from the rhodium complex, converting it from a tetrahedral to a square planar geometry, opening the arms. An aldehyde – the second fuel – replaces the carbonyl on the rhodium and switches the structure back to tetrahedral, which re-closes the arms. As long as both fuels are present in solution, molecular motion continues.

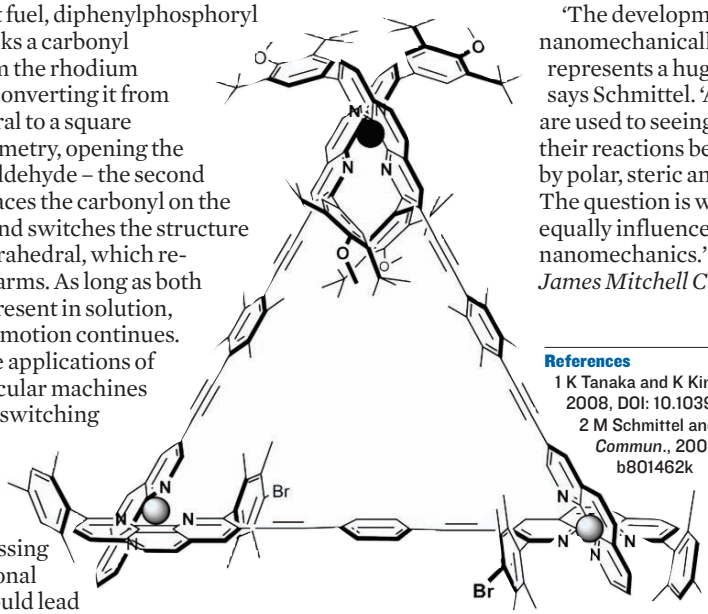
'Possible applications of such molecular machines go beyond switching devices,' says Kinbara, who adds that harnessing unidirectional motion would lead to molecular transportation systems or molecular pumps. 'The next step is to develop a system where the mechanical motion of the ligand can be extracted as mechanical force. We would also like to develop much larger systems including transition metal catalysts as a power-generating unit.'

In another study, Schmittel made self-assembling molecular triangles, overcoming the tendency of such systems to form less-constrained squares. Each side of the structure is made from a rod-like molecule with a metal ion binding site at each end. Schmittel pre-formed two sides of the triangle by attaching two arms to a copper ion 'corner' – and then attached the third side using silver ions to form the remaining two corners. By shortening the third side and attaching it part way down the two arms, Schmittel suggests the structure could form adjustable molecular tweezers.

'The development of nanomechanically operated devices represents a huge challenge,' says Schmittel. 'As chemists we are used to seeing molecules and their reactions being influenced by polar, steric and solvent effects. The question is whether we can equally influence them through nanomechanics.'

James Mitchell Crow

Self-assembling triangle could potentially become a molecular tweezer



References
1 K Tanaka and K Kinbara, *Mol. BioSyst.*, 2008, DOI: 10.1039/b801621f
2 M Schmittel and K Mahata, *Chem. Commun.*, 2008, DOI: 10.1039/b801462k

Instant insight

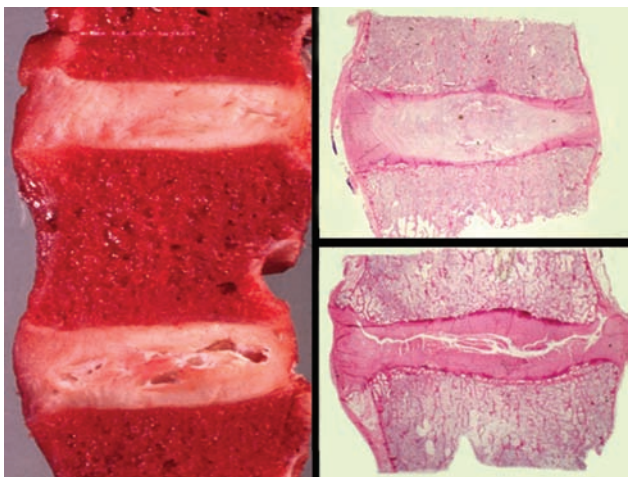
Swellable gels fix bad backs

Brian Saunders and Tony Freemont at the University of Manchester, UK, discuss a new approach for treating back pain using injectable microgel implants

Keeping our backs, and especially the intervertebral discs, healthy is essential for our well-being. With at least 40% of lower back pain being caused by intervertebral disc degeneration, the annual costs of this condition to health care and lost productivity to economies are enormous. Costs to the US alone were estimated at over US$40 billion in 2004.

The intervertebral disc must be flexible and capable of absorbing and distributing loads that far exceed those of the body's weight. The load-absorbing part of the intervertebral disc is the nucleus pulposus, which consists of a natural hydrogel with a high water content. Unfortunately the water content of the nucleus pulposus decreases with age and when affected by some diseases, reducing its ability to distribute load. Degeneration also results in the formation of interconnected voids in the disc, which causes a decrease in height. This adversely alters the biomechanics in the spine, and the altered biomechanical load distribution accelerates void formation.

Current therapies for treating the degeneration of intervertebral discs include spinal fusion or disc replacement. Both approaches involve complex operations taking considerable surgical time, and resulting in the patient being in hospital for days and off work for months. They also treat the symptoms and not the cause. A minimally invasive method for restoring disc height and biomechanical load distributions is urgently needed. One such approach being developed involves injecting dispersions of pH-responsive microgel particles into the spine. These particles are like nanometre-sized polymer sponges which swell when the pH approaches values present in the nucleus pulposus. This changes the dispersion from a fluid into a stiff, load-bearing gel. The pH triggered fluid-to-gel transition is essential for developing a minimally-invasive approach to delivering load-bearing implants. Injectable fluids have the added advantage of filling irregularly shaped voids. Additionally the particles are pre-prepared outside the body, meaning the need to perform chemical reactions in the body is avoided. The gels also have mechanical properties that can be tuned.



The top two images are of healthy intervertebral discs and the lower of degenerated discs

To assess the potential of this approach, models of degenerated intervertebral discs containing the gels have been studied. The treated discs were placed within a compression testing rig to test their mechanical properties, and exposed to loads similar to those experienced by human intervertebral discs during exercise. These tests showed it is possible to restore the mechanical properties of degenerated intervertebral discs to normal values using the responsive microgel. Another hopeful sign for this technique are preliminary experiments that have shown good biocompatibility of the microgel with intervertebral discs cells.

A future aim for this responsive microgel approach is to mix the dispersions with biological species that encourages the creation of a biomechanical environment suitable for the regeneration of disc tissue within the nucleus pulposus.

There are some important challenges that researchers need to overcome in order to develop this technology into a new treatment, including establishing an interparticle bonding approach capable of preventing migration of the particles within the nucleus pulposus under load. Also, the particles may need to be engineered to biodegrade at controllable rates.

This new approach for treating back pain has considerable potential for providing an injectable implant targeted at degeneration of the intervertebral discs. Importantly, the approach does not exclude other approaches, such as spinal fusion, should revision be necessary. The versatility in particle design of microgels will assist this process greatly and could enable the future application of this technique to other soft tissue types within the body.

Reference
A J Freemont, and B R Saunders, *Soft Matter*, 2008, **4**, 919 (DOI: 10.1039/b718441g)

Read Tony Freemont and Brian Saunders' feature article 'pH-Responsive microgel dispersions for repairing damaged load-bearing soft tissue' in issue 5, 2008 of Soft Matter

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The secret life of molecules

Christer Aakeröy talks to Freya Mearns about the language of molecules and molecular dating

Christer Aakeröy

Christer Aakeröy is a professor of chemistry at Kansas State University, Manhattan, US. His research interests focus on crystal engineering, both the fundamentals and its application in the pharmaceutical industry. He is the *CrystEngComm* regional associate editor for the Americas.

Why did you decide to specialise in crystal engineering?
It was a topic that was just developing when I was working on my PhD and it seemed like an area where I could actually make a little bit of difference. I really wanted to gain a better appreciation of what goes on *between* molecules – I wanted to be able to listen in on the conversation between molecules and, ideally, understand how they exchange information. Obviously they communicate but we do not have a dictionary for translating their language into reliable and versatile tools for predicting how they will recognise, bind and assemble into larger architectures.

What projects are you working on at the moment?
From my perspective, crystal engineering and supramolecular chemistry are still at a very fundamental level. Intermolecular interactions are very complex and subtle and we have only just begun to understand why certain molecules like each other and why others do not. More importantly, we need to learn more about how we can engineer properties based upon the structure of molecular aggregates.

The applications we are looking at right now relate primarily to the pharmaceutical industry. We try to change physical properties such as solubility, dissolution rate, thermal stability and hygroscopicity of bulk materials. We have also worked on porous materials that we then use for the selective capture of various toxic guests.

However, I unashamedly like the fundamental aspects of our research. How do molecules really find suitable partners and how do they get together? I guess it is a little bit like observing and understanding molecular dating. We then try to develop synthetic protocols for assembling discrete molecules into larger aggregates with precise arrangements and stoichiometries.

You're involved with the Terry C Johnson Center for Basic Cancer Research at Kansas State University as part of your research. Could you tell me about this collaboration?
Pharmaceutical companies make a large number of molecules on a daily basis. However, only a tiny fraction of those compounds actually make it out onto the market because many of them lack the necessary physical properties such as desired solubility or thermal stability, or they're difficult to process.

We are looking at improving the solubility of some potentially potent anticancer compounds. Their solubility is so poor that currently we cannot use them for anything because their bioavailability is just too low.

We also try to make molecular hosts – molecular-sized capsules that will allow us to encapsulate drugs. These capsules would be, in a sense, remote-controlled allowing us to open them up when they get to the target. We hope to manipulate the capsule from the outside using light or pH, and to functionalise the outside of the capsule so that it recognises a particular organ or cell. That would be the ultimate delivery vehicle but we are a long way from that goal.

The financial support that we received from the Center has allowed us to generate some very useful preliminary data that is now helping to move some of our research program from fundamental to applied scientific problems.

You work both in academia and with industry and you have been fortunate enough to work in many different places around the world. Is this flexibility a real bonus to working in science?
It is one of the most appealing aspects of being a scientist because it's both an interdisciplinary and a very international community. The fact that you can move around easily from country to country or from industry to academia is a precious commodity. I'd hate to feel trapped in one particular place. The mere thought that you can actually go somewhere else makes up, to some extent, for the rather poor salaries that many academics receive. There is a degree of freedom in science that I think is priceless.

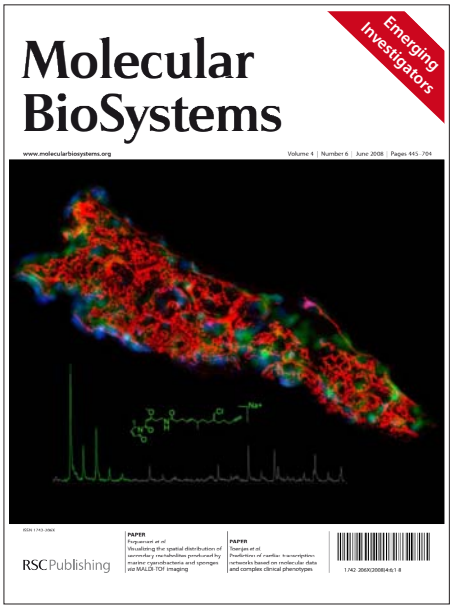
What is the secret to being a successful scientist?
You have to be curious and completely open-minded. Natural curiosity about how things work, and why events take place in certain ways, is the starting point for any scientific venture. Much of the rest is hypothesis-driven experiments and careful methodology. In addition, there is really no substitute for hard work.

What scientific discovery would you like to have been responsible for?
Realising that our sun is actually not the centre of the universe. We are just a small part of the big picture!

Essential elements

Emerging Investigators

Highlighting the brightest new researchers in the field, issue 6 of *Molecular BioSystems* (*MBS*) is not to be missed. The 20 full research papers, seven communications and two reviews are written by outstanding young scientists at the chemical- and systems-biology interfaces. The issue features novel methods to visualise and manipulate protein function in living cells, the development of chemical techniques to monitor specific protein post-translational modifications, new insights into metabolomics and much, much more.



All the contributors were personally recommended by *MBS* editorial or advisory board members as young scientists whose work has the potential to influence the future directions of these fields. All submissions were subjected to full peer review and the result is an issue showcasing work in some of the most fascinating and important areas of biology.

We intend to run future issues of this kind so watch this space. Finally, *MBS* extends a big thank-you to all the Emerging Investigators themselves for making this such an excellent collection of papers. We wish them every success in their future careers and – in the words of Tom Kodadek, the *MBS* editorial board chair – 'Clearly the future of this exciting area of biology is in good hands!'

Find out more at www.molecularbiosystems.org

And watch out for a related theme issue from *ChemSocRev* (*www.rsc.org/chemsocrev*) in July; issue 7 will be a thematic issue examining the interface of chemistry with biology.

Pioneers in Miniaturisation Prize

Leading the way in miniaturisation, *Lab on a Chip* has teamed up with Corning Incorporated to again host the Pioneers in Miniaturisation Prize. Spanning a variety of disciplines, this prize recognises outstanding achievements and significant contributions by a younger scientist to the understanding and advancement of micro- and nanoscale science.

As a leading-edge science and technology organisation, Corning Incorporated is keen to reward, recognise and encourage the development of miniaturisation in the chemical and biological sciences and promotes interdisciplinary research required for the most significant innovations in this area.

The recipient of the award will receive a US$5000 bursary to support their continued contribution to the field. A deadline for applications has been set for 31st August 2008. Following the final decision, which will be made by committee, a winner will be announced at the μTAS 2008 conference, in San Diego, CA, US.

For more information visit www.rsc.org/loc

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