February 2010 / Volume 7 / Issue 2 / ISSN 2041-5826 / HCTIB9 / www.rsc.org/highlightschemtechnol

Highlights in Chemical Technology

Investigating neurodegenerative diseases using a circular microfluidic platform

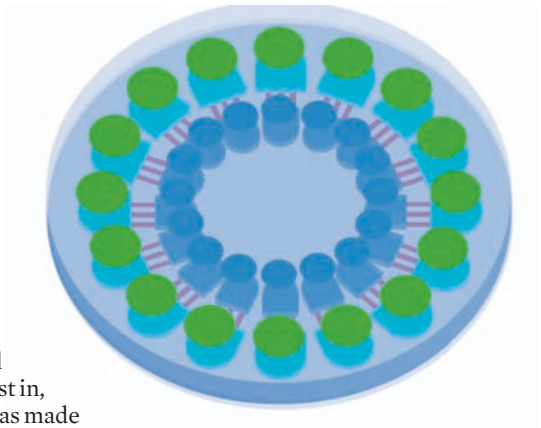
Circular chips study nerve cells

Scientists in the US have designed a circular microchannel pattern to study nerve cell interactions that are implicated in neuroinflammatory and neurodegenerative diseases, such as multiple sclerosis.

The central nervous system is made up of several highly specialised cell types, including neurons, axons and glial cells. Axons are nerve fibres which allow neurons to communicate with each other, while glials maintain and protect neurons from disease. Damaged axons and increased glial – axon interactions have been implicated in a large number of neurological disorders. But little is known about the mechanisms of these interactions or how axons respond to inflammation in the presence of disease, explains Arun Venkatesan at Johns Hopkins University, Baltimore.

Previous lab-on-a-chip devices have been unable to precisely control the different microenvironments that axons and glial cells exist in, which has made their study difficult. Now, Venkatesan and colleagues have designed a circular device that advances existing technologies and enables cells to be directly placed in their own environments. Venkatesan observed that glial cells accumulated more at injured axons rather than healthy ones.

The device is made up of several individual units, each with two compartments that house axons and glial cells in their own microenvironment connected by an array of microchannels. Manipulating the cells using techniques such as centrifugation, microstencilling and pipetting allows different interactions to be investigated.



The round device houses axons and glial cells in their own microenvironments

'The circular format of the device is ingenious,' says Albert Folch, an expert in microfluidics at the University of Washington, Seattle, US, 'because it allows for performing 16 assays at once, while at the same time centrifugation enriches the cell densities at the channel entrances.'

Venkatesan says the device can be used to focus on understanding the molecular mechanisms by which glial cells respond to damaged axons. 'Once we understand this, we hope to be able to redirect the response of these cells to protect and regenerate axons, with the aim of halting and reversing disability in disorders such as multiple sclerosis,' he adds. *Leanne Marle*

Reference
S Hosmane *et al*, *Lab Chip*, 2010, DOI: 10.1039/b918640a

In this issue

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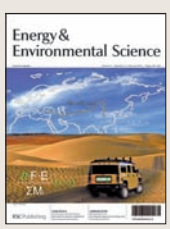
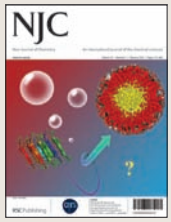




The latest applications and technological aspects of research across the chemical sciences

Application highlights

Rare-earth metals increase hydrogen production from methane oxidation

Enhancing catalytic activity

Decreasing the oxygen reactivity in catalysts can increase hydrogen production from methane oxidation, claim Chinese scientists.

The partial oxidation of methane produces syngas (CO/H_2 mixture) and is an attractive alternative to petroleum fuel. But, the process occurs simultaneously with total oxidation of methane, which does not produce H_2 directly and also releases heat that forms hot-spots on the catalyst that deactivate or destroy them, explains Guanzhong Lu at East China University of Science and Technology, Shanghai.

Lu and colleagues found that the reactivity of the oxygen atoms in the catalyst determines whether total oxidation or partial oxidation takes place. Adding europium ions into the catalyst structure makes stronger bonds that prevent the oxygen atoms reacting and more hydrogen is produced.

'We were amazed to find that hydrogen could be produced directly over the europium-doped oxide catalyst,' says Lu. 'This may lead to better utilisation of methane – decreasing the cost of natural gas, which could lessen our reliance on petroleum,' he adds.

Stronger metal–oxygen bonds result in direct production of hydrogen

Stuart Taylor, an expert in heterogeneous catalysts for selective oxidation at Cardiff University, UK, comments 'the direct formation of hydrogen from methane partial oxidation is desirable, but to achieve high yields, over-oxidation of thermodynamically less stable products must be controlled.'

Lu adds that the key factors that control the switch from partial to total oxidation are yet to be solved and the group plan to investigate the catalyst design further.

Carl Saxton

Reference

C Wen *et al*, *Chem. Commun.*, 2010, **46**, 880 (DOI:10.1039/b920725b)

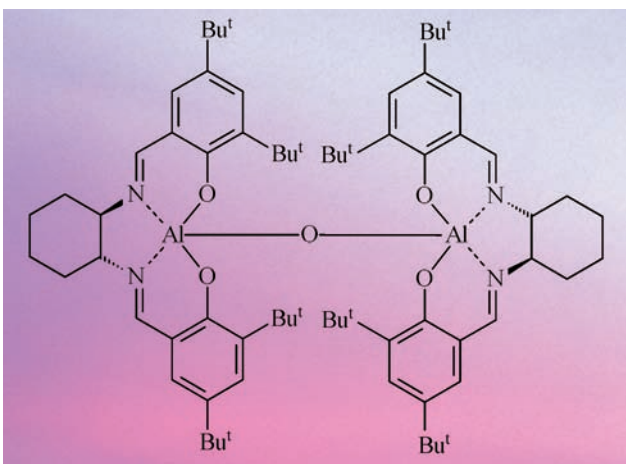
Energy and cyclic carbonates produced from methane combustion

Minimising carbon dioxide emissions

An integrated process to generate energy from methane combustion without producing waste carbon dioxide has been proposed by UK scientists.

With climate change an ever-present threat, reducing CO_2 emissions is critical. But increasing energy demands mean the solution isn't as simple as cutting fossil fuel combustion. Michael North and his team at the University of Newcastle have devised a system that could be used to maintain the energy production while immediately converting the waste CO_2 into useful chemicals, avoiding the costs associated with carbon capture and storage.

North's system uses a membrane to separate and feed pure oxygen to the fuel allowing clean combustion, eliminating any NOx production. The waste CO_2 is then fed into a reaction mixture with an epoxide and a catalyst producing cyclic carbonates.



The tetrabutylammonium catalyst allows coversion of CO_2 under mild conditions

Cyclic carbonates have many applications including degreasing agents, electrolytes and solvents.

Although reusing waste CO_2 to make cyclic carbonates is not a new idea, previous proposals involve using a catalyst that needs temperatures above 150°C and high pressures, which require more energy to be put in. In North's system an aluminium complex with a tetrabutylammonium bromide cocatalyst catalyses the reaction at temperatures in the range of 20–100°C, compatible with waste heat from the power plant.

'The beauty of this system is that you're not making a new C–H or C–C bond, so the reaction is exothermic,' says North.

Nilay Shah, a chemical engineering expert at Imperial College London, UK, is impressed by the system. 'It's about the creativity of looking for the best molecules to make from CO_2, so that you can start to make really high volume molecules,' he says.

North demonstrated the process on a laboratory scale but says he is confident it could be made into a continuous flow process for a commercial system. He also plans to further investigate the catalyst's tolerance towards water and other impurities. *Yuandi Li*

Reference

I S Metcalfe *et al*, *Energy Environ. Sci.*, 2010, DOI: 10.1039/B918417a

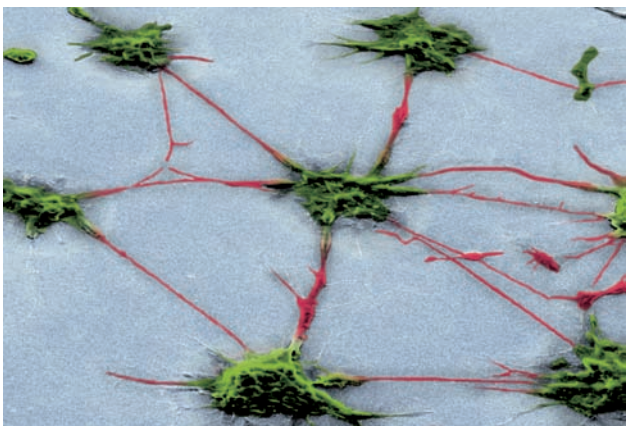
Rapid neurotoxicological screening of chemicals using a neural network platform

Neuron array advances toxicity testing

Scientists in Germany have developed an alternative to animal testing for rapid screening and identification of chemicals that pose a health risk to the human nervous system.

Neurotoxicity laboratories worldwide face the daunting challenge of screening a growing catalogue of chemicals to identify those that could pose a risk to human health, following the introduction of Reach legislation. Toxicity testing is often carried out using animals but with spiraling costs in terms of cash and number of animals, a reliable in vitro assay is needed. Lack of comparable read-outs between in vivo and in vitro systems can present problems, explains Jonathan West at the University of Dortmund, Germany, but he claims to have overcome this problem using a neural network.

West and colleagues designed a new testing platform, called a network formation assay (NFA) that montiors connections (or outgrowths) between specifically placed neurons and their neighbours. Formation of these connections is a basic principle of memory and learning, and its disturbance is often a clinical sign of neurotoxicity, says West. 'Because NFA examines neuron connections it represents an in vitro model that is comparable to the in vivo state', he adds.



Connections forming between the neurons are used to measure toxicity

The device contains human neurons placed in a hexagonal array using cell patterning. Exposing the array to acrylamide, a neurotoxic reference compound, significantly inhibits the network formation. Without the need to locate the neurons or measure the lengths of the connections means that a typical assay takes only three hours compared with up to 200 hours for manual testing.

'This simple and smart application of microengineered systems can significantly improve standard biological protocols', says Marco Cecchini at the National Enterprise for nanoScience and nanoTechnology, Pisa, Italy.

'NFA may also be applied within the context of reproductive toxicity testing, which is estimated to consume at least 60% of all animals required for Reach ' adds Marcel Leist, University of Konstanz, Germany, who is working on the project with West.

The real test will be whether NFA is adopted and accepted by regulatory authorities, adds West. *Janet Crombie*

Reference
J-P Frimat *et al*, *Lab Chip*, 2010, DOI: 10.1039/b922193j

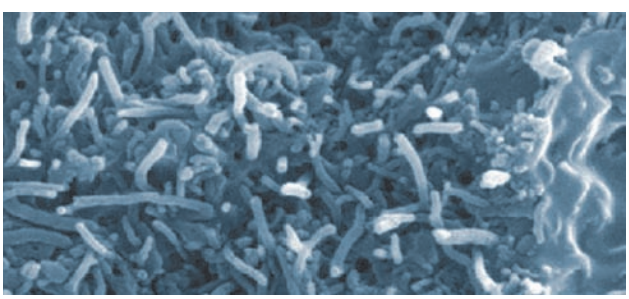
Versatile carbon nanotube-based material makes cheap and easy to prepare electrodes

Exploiting nanotubes for sensors

Scientists in China have developed a versatile new carbon nanotube (CNT)-based composite material for electrochemical sensors that is cheap and easy to prepare.

Carbon nanotubes are a popular material for electrochemical sensors thanks to their high electrical conductivity, mechanical strength, and chemical stability. Exploiting their properties, however, has remained a challenge.

Now, Gang Chen and colleagues at Fudan University, China, have developed a versatile new CNT-based composite material for electrodes. Their CNT-poly(urea-formaldehyde) (PUF) composite material is fabricated by in situ condensation of a mixture of CNTs, urea and formaldehyde. The fabrication method is cheap and simple, and the resulting composite not only shows excellent electrocatalytic properties but is also very versatile, due to the numerous reactive groups in the PUF.



Easy and low cost preparation of the nanotube material is an attractive prospect

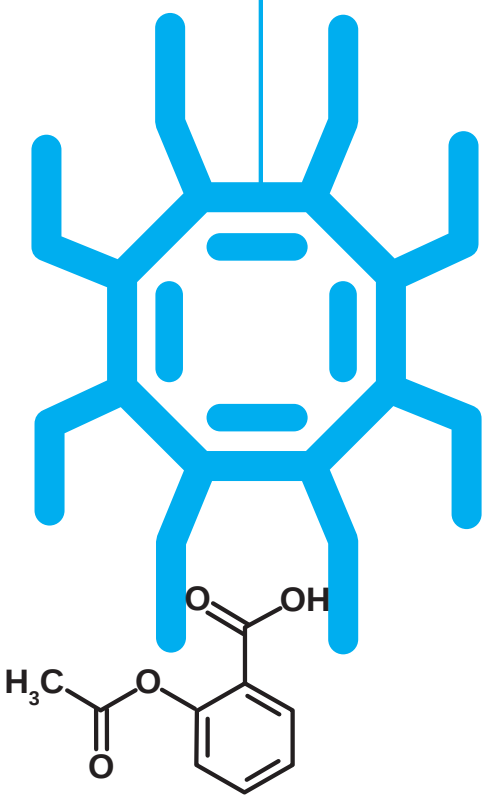
'Our results indicate that CNTs are well dispersed and embedded throughout the PUF matrix, and an interconnected CNT network forms,' explains Chen. 'This conductive CNT network can establish electrical conduction pathways throughout the whole system, which is responsible for the electrical conductivity and electrochemical sensing.' The ease, versatility and low cost of the novel preparation method means that mass production of the CNT–PUF composite is a straightforward and attractive prospect, says Chen.

Alberto Escarpa, an expert in analytical microchips at the University of Alcalá, Spain, sees possibilities for the composite in microfluidics. 'This approach allows us to creatively manipulate new materials to improve analytical performance for lab-on-a-chip devices, where a simple way to enhance sensitivity is highly needed,' he says.

Chen also sees lots of potential for the new material. 'The composite is also a promising electrode material for the preparation of batteries, supercapacitors, electrolysis cells, and more,' he says.
Edward Morgan

Reference
G Chen *et al*, *New J. Chem.*, 2010, DOI: 10.1039/b9nj00670b

New adventures on the web



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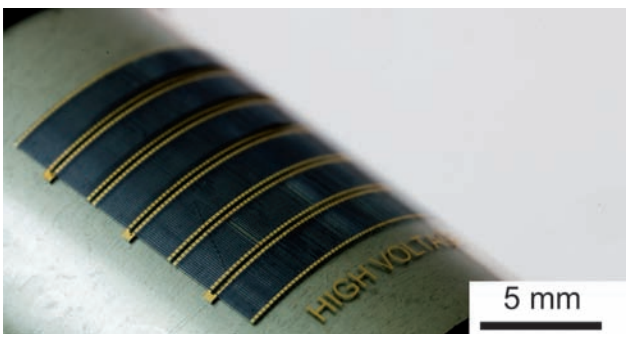
Flexible solar cells could soon be on their way

Printing solar panels

Solar cells could now be part of your coat or backpack thanks to flexible silicon technology developed by US scientists.

Silicon is a high performance, reliable material used in solar cell technology, normally in the form of thick, planar rigid structures that restrict its applications. John Rogers at the University of Illinois at Urbana-Champaign and colleagues have developed a way to make very small (micrometre size) silicon cells that connect together to form flexible solar panels.

By stamping hundreds of these microcells onto plastic substrates, Rogers' team obtained lightweight, flexible devices that bend without measurable changes in their electrical or mechanical properties, making them ideal for integration on fabrics such as backpacks, clothes and cases. They could also prove invaluable in special operations or expeditionary missions when size, space or weight are an issue says Rogers. High or low voltage devices can be made simply by arranging the microcells in different ways.



The flexible panels can be printed onto a variety of fabrics

'We foresee a much more widespread penetration of silicon-based technologies into areas that are currently served only by devices that use organic semiconductors for the active materials – with comparatively poor performance and reliability,' says Rogers. This would bring many benefits as 'mechanical flexibility also reduces the cost of transport and installation,' he adds.

'The high voltage silicon solar cell modules are another very interesting application of printable silicon,' comments Heiko Jacobs, an electrical and computer engineering expert from the University of Minnesota, Minneapolis, US. 'The process lends itself to the realisation of modules that produce high voltages enabling a compact and mechanically flexible design,' he adds.

Amaya Camara-Campos

Reference
A J Baca *et al*, *Energy Environ. Sci.*, 2010, DOI:10.1039/b920862c

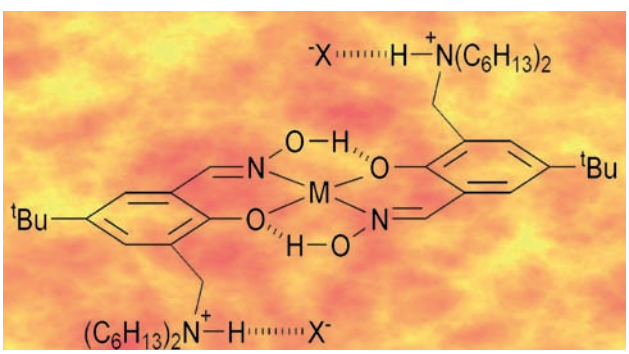
A new ligand for base metal recovery

Zwitterionic metal salt extractants

UK scientists have developed zwitterionic salicycladoxime ligands that could allow industrially important metal ions to be selectively recovered from mixtures. The molecules bind both ions of a metal salt independently, improving the efficiency of extraction processes.

Around 25 per cent of the world's copper is recovered using conventional phenolic oxime extractants, which only bind the copper cation, not its companion anions. When such extractants transfer copper cations from an aqueous solution to an organic phase, there is a build up of acid in the aqueous phase, which must be neutralised, complicating the extraction process. Using metal salt extractants eliminates this acid build up and hence does not require any adjustment of pH, says Peter Tasker from the University of Edinburgh. The technology could find commercial applications in the recovery of a variety of base metals.

Tasker and colleagues made dialkylaminomethyl-substituted salicyclaldoximes that are capable of binding a metal cation and attendant anions in separate sites of a zwitterionic form of the extractant making a charge-neutral assembly. Tasker explains that 'these new reagents extract metal salts, which is in contrast to the conventional oxime reagents which transport metal cations' and as a result there is no net exchange of cations or anions, which makes them better suited to treating waste streams, he adds. The *trans* structure formed by bis-salicyclaldoximato complexes of Cu(II), make them tritopic (they have three binding sites) meaning that divalent metals can be transported with both their accompanying mono-anions, increasing the efficiency.



The *trans* structure formed by bis-salicyclaldoximato complexes of Cu(II) have three binding sites

'Core principles of supramolecular chemistry have been used to solve an extremely important industrial problem' says Jonathan Steed, an expert in supramolecular chemistry from the University of Durham, UK. 'As sources of industrially important metals become increasingly rare, techniques such as this will allow the extraction of important metal from lower grade sources, at lower concentration or from more complex structures,' he adds.

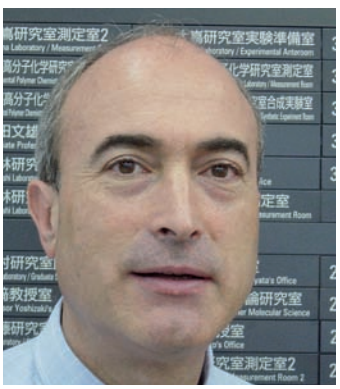
Tasker points out that a major challenge associated with the commercial exploitation of these reagents is obtaining high selectivity of both cation and anion transport. But the co-operative cation and anion binding may solve this problem. He adds that the group are hoping to 'extend this approach to the recovery of precious metals, lanthanides and actinides'. *Nicola Wise*

Reference
R S Forgan *et al*, *Dalton Trans.*, 2010, DOI: 10.1039/b916877j

Interview

The beauty of fullerenes

Nazario Martín talks about C_{60}, the energy crisis and chemistry in Spain. Interview by Joanne Thomson



Nazario Martín

Nazario Martín is professor of organic chemistry at the Complutense University of Madrid, Spain. His research interests include the chemistry of fullerenes and carbon nanotubes and the synthesis of photo- and electro-active molecular materials in the context of supramolecular chemistry and nanoscience.

Your work focuses on the chemistry of carbon nanostructures. What attracted you to this area of research?
When I saw the molecule of fullerene (C_{60}) for the first time, I was strongly affected by its beauty and, soon afterwards, by its outstanding properties. I decided to work on it, learning with one of the pioneers of fullerene chemistry, Fred Wudl, with whom I worked at the University of California, Santa Barbara, US, in 1994.

What are you working on at the moment?
We are currently working on the use of fullerenes and endohedral fullerenes as materials for photovoltaics. Another important issue in my research group is the use of the convex surface of fullerenes and carbon nanotubes (CNTs) to interact electronically and geometrically with concave electron donors, such as those derived from the well-known π-extended tetrathiafulvalenes (exTTFs). Concave–convex interactions are an important and less known issue in supramolecular chemistry. The curved surface of fullerenes and CNTs is a unique scenario for testing new chemical reactions and we are also investigating this aspect.

What is your biggest achievement to date?
In collaboration with Dirk Guldi, we have developed a thorough study on the photoinduced electron transfer processes involving fullerenes and CNTs which, I hope, will be a significant contribution to this field. However, recent excitements in our laboratory came from the formation of photo- and electro-active supramolecular polymers and dendrimers from fullerenes and exTTFs. Actually, we saw that fullerenes are able to do the conga! We recently reported the first example of enantiomerically pure fullerenes prepared by using asymmetric catalysis, which opens a new avenue in the synthesis of chiral fullerenes.

You are vice-director of the new Madrid Institute of Advanced Research in Nanoscience. What is the aim of this institute?
To create an atmosphere in which young scientists grow up working with colleagues from other areas in the search for common scientific goals in nanoscience. It is an ambitious project which will become a stronger reality in 2011 when our new building will house 150 to 200 scientists.

Currently, you are also president of the Spanish Royal Society of Chemistry. What are your key objectives while in this role?
Our main purpose is to improve our presence within the European Association for Chemical and Molecular Sciences (EuCheMS) and, therefore, to reinforce our collaboration with other European Chemical Societies. In this regard, we have bilateral agreements with many European Chemical Societies, including the Royal Society of Chemistry. We also aim to maintain and improve the level of chemical science in Spain by means of the many activities that we are currently developing through our specialised groups and territorial sections. A major objective is engaging young chemists.

As a member of the ChemComm Editorial Board, what is your vision for the journal in 2010?
I think ChemComm is among the best and renowned chemistry journals, with a long tradition as a flagship for quality and novelty. I am sure the remarkable impact factor of the journal (5.34) will increase further in 2010, which clearly reveals that the journal is publishing seminal works.

The energy crisis is one of the biggest challenges facing civilisation. How can chemical technology address this problem?
The only certainty is that without the engagement of the chemists, the problem will not be solved. Chemistry will produce new and more efficient materials for renewable energies and will improve the transformation of residues in more conventional energies, including nuclear power. In this regard, organic photovoltaics – in which we are very much engaged – will complement silicon cells and, hopefully, very soon we will see their use for practical applications.

Has Spanish chemistry been affected by the global recession?
Spain and its chemistry have suffered the recession along with the rest of the world. However, Spanish chemical companies are quite solid and the Spanish Ministry, as well as the regional governments, has decided to strongly support basic research. The recession has not, therefore, been as dramatic for chemistry as it has for other fields in Spain.

If you weren't a scientist, what would you be?
It is difficult for me to imagine! But my father always said I would make an excellent bishop. I would like to have been a writer or literature professor.

Essential elements

Launch of new beta platform

In early February, RSC Publishing will launch a new integrated content delivery platform allowing over 500 000 journal articles, book chapters and database records to be searched through one simple interface. The new platform will deliver faster browsing, intelligent searching and more intuitive navigation. It will be launched as a public beta.

A key benefit of releasing the platform as a beta is that early and frequent software releases help create a tight feedback loop between the platform development and our users, enabling us to listen and respond to user requirements. The 'release early, release often' philosophy empowers the user to help define what the platform will become.

Graham McCann, publisher at RSC Publishing is spearheading the project. His enthusiasm for the platform makes it clear something exciting is happening: 'user testing and feedback has been integral to the development process, aiding our design and helping us to produce something that offers a superior online experience.'

RSC Publishing^{beta} is powered by Mark Logic Server, the industry's leading XML content server, which enables dynamic use of content in innovative new ways. State of the art navigational tools such as faceted browsing and topic clouds help users to find the content they are looking for quickly and discover related content simultaneously.

Here is a sample of some of the features on offer:

- Single search interface for journal, book and database content
- Faceted browsing – a technique that allows rapid filtering of search results
- Integrated tools for bookmarking, saving and sharing information
- Topic clouds to highlight latest research
- Saved searches and alerts
- Librarian login area and branding
- Latest news dynamically fed from blogs

Innovation has been at the forefront of the new platform. Expert software engineers worked closely with the RSC to architect, design, develop and integrate the new content delivery platform into RSC's existing technology infrastructure. 'RSC Publishing^{beta} is one of the most interesting and innovative sites we have developed. It has raised the bar as to how chemistry content can be engagingly presented' commented Melvyn Burgoyne, managing director at Rave Technologies, UK.

RSC Publishing^{beta} will run alongside the existing RSC Publishing website for the first phase of beta testing. Links encouraging users to try the new beta site are available across the existing publications website.

We would love to hear your feedback about the new site. For example, tell us about:

- Functionality: what features do you like, what features are missing?
- Usability: what do you think about the user interface, could it be clearer, more intuitive?

Please test our new publications platform rigorously and share your experience using the feedback form available online.

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RSC Publishing's exciting new journal, *MedChemComm*, is now open for submissions. *MedChemComm* will be a high-impact, peer-reviewed journal for the rapid publication of research in medicinal chemistry. Monthly issues will contain a mix of vibrant and concise research and review articles. Submit your work today.
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We are pleased to announce that *Integrative Biology* has now been selected by the National Library of Medicine to be indexed and included in their database, MEDLINE. The selection of *Integrative Biology* reflects its appeal to scientists in biomedicine, This will be a big step in increasing the visibility of the journal.
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Free access expired

Energy & Environmental Science, launched in 2008, has now reached the end of its free access period. We recommend that you contact your librarian to ensure your access in 2010 to the journal is secured.

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Highlights in Chemical Technology (ISSN: 2041-5826) is published monthly by the Royal Society of Chemistry, Thomas Graham House, Science Park, Milton Road, Cambridge UK CB4 0WF.

Editor: Sarah Dixon

Essential elements: Daniel Bradnam, Kathrin Hilpert, Lyndsey Fairweather

Publisher: Bibiana Campos-Seijo