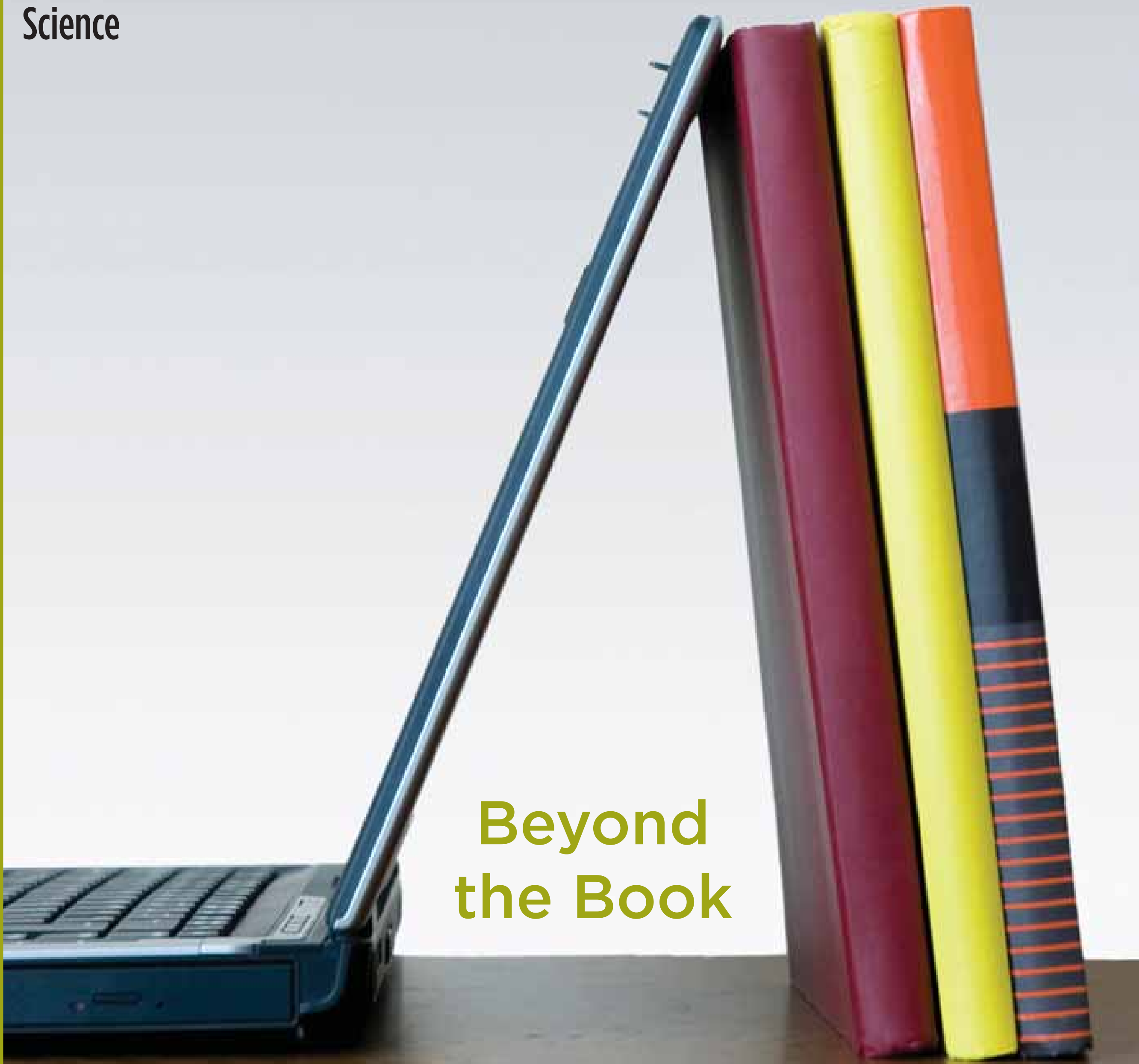
The News Magazine of the International Union of Pure and Applied Chemistry (IUPAC)

CHEMISTRY International

May-June 2009
Volume 31 No. 3

What Is Materials Chemistry?

Scientific Method and the Public Appreciation of Science



Beyond the Book

From the Editor

CHEMISTRY International

The News Magazine of the International Union of Pure and Applied Chemistry (IUPAC)

www.iupac.org/publications/ci

Managing Editor: Fabienne Meyers
Production Editor: Chris Brouwer
Design: CB Communications

All correspondence to be addressed to:
Fabienne Meyers
IUPAC, c/o Department of Chemistry
Boston University
Metcalf Center for Science and Engineering
590 Commonwealth Ave.
Boston, MA 02215, USA

E-mail: edit.ci@iupac.org
Phone: +1 617 358 0410
Fax: +1 617 353 6466

Printed by:
Cadmus Professional Communications, Easton, MD, USA

Subscriptions
Six issues of *Chemistry International* (ISSN 0193-6484) will be published bimonthly in 2009 (one volume per annum) in January, March, May, July, September, and November. The 2009 subscription rate is USD 110.00 for organizations and USD 50.00 for individuals. Subscription orders may be placed directly with the IUPAC Secretariat. Affiliate Members receive *CI* as part of their Membership subscription, and Members of IUPAC bodies receive *CI* free of charge.

Periodicals postage paid at Durham, NC 27709-9990 and additional mailing offices. POSTMASTER: Send address changes to *Chemistry International*, IUPAC Secretariat, PO Box 13757, Research Triangle Park, NC 27709-3757, USA.

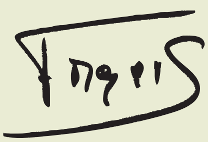
ISSN 0193-6484

Scientific method and public appreciation of chemistry . . . the subject was tantalizing for David Evans, a recurrent contributor to *Chemistry International*. Fortunately for us, Evans didn't shy away—see page 12. He is passionate, even relentless, over this topic. Admittedly, for those of us who share a scientific culture—by practicing science or simply having an interest and curiosity about scientific clues and methods—it is at times difficult to comprehend that for many people, science—including chemistry—is more often fiction than fact.

Evans reminds us that public appreciation of chemistry varies greatly from place to place, and that there is no magic recipe for arousing everyone's interest and appreciation. Culture and education are also variables to the problem. Evans believes, however, that scientific method applied simply in various contexts can facilitate constructive dialog regarding contentious issues. I take his account as an invitation to talk to our friends, and in particular to nonscientists, and challenge them (gently) on their unsubstantiated beliefs. I notice Evans' enthusiasm to speak up and his incitation to all of us to add our voice to the public debate by writing to our local newspapers and exploring new ways of communication, including blogs and chat rooms, to share our interests. Evans' argument is fueled by Ben Goldacre's advice: "To academics, and scientists of all shades I would say this: You cannot ever possibly prevent newspapers from printing nonsense, but you can add your own sense into the mix. E-mail the features desk . . . and offer them a piece on something interesting from your field. They'll turn you down. Try again."

Then, changing gears somewhat (although it relates to the value of publishing), Peter Atkins, in a feature on page 9, ponders the future of books. Being in the midst of the e-book revolution, Atkins sees opportunities to explore new ways of conveying concepts that are not so easy to explain with only a static medium. Enhanced visual tools and interactivity are key features for chemists that will allow us to view living graphs or see molecular structures from all angles, similar to an architect's virtual tour of a future building. Atkins acknowledges that integrating these capabilities into an e-book is a huge undertaking, requiring imaginative contributions from authors, and interfaces and devices that are comfortable and convenient for readers.

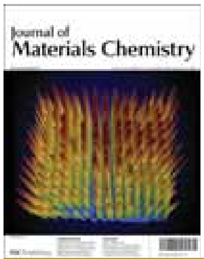
Meanwhile, before the publishing world goes completely "e", you can still take this simple newsmagazine in your briefcase, read it on the train or in a plane, or any place at your leisure. It is also at your fingertips wherever you have online access, providing handy reference once you have recycled this paper version! Write about what you *chem* do, and send us your ideas for feature stories. We always like to hear from you.

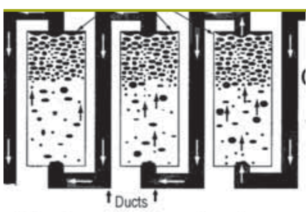


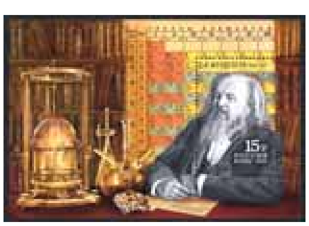
Fabienne Meyers
fabienne@iupac.org
www.iupac.org/publications/ci

Contents

CHEMISTRY International May-June 2009 Volume 31 No. 3







Secretary General's Column

Moving Ahead with the International Year of Chemistry

by David StC. Black

In my previous column (July-August 2008 *CI*), I wrote about the proposal to stage the International Year of Chemistry (IYC) in 2011 and outlined the key aims (see box below). I also reported the progress at that time in seeking official United Nations (UN) approval and designation of the International Year. Many readers are now aware that in December 2008 the UN did officially designate 2011 as the IYC. IUPAC issued a press release at the end of December 2008 to this effect.

Because IYC 2011 is now official, we can move ahead with greater purpose and certainty. The reason for the much-earlier-than-expected approval is that the initial recommendation of the UNESCO Executive Board was introduced (by the vigilant Ethiopian delegation) under the banner of the UN long-term program on Sustainable Development. The designation immediately gave IUPAC a clear thematic focus that not only is a key element in the prospectus but is also completely in harmony with the capacity of chemistry to deliver.

This year has seen increasing engagement with leaders of national chemical societies to inform them on progress and to seek their ideas related to IYC 2011 (see Wire, p. 16). These meetings will continue, and ideas are being generated. But, before I proceed any further, I should say that the main purpose of this column is to seek input from individuals about innovative events that can make IYC 2011 a spectacularly successful achievement. On the organizational front, we are moving forward on the development of a dedicated state-of-the-art IYC 2011 website, which not only is essential to handle the complex interactions and outreach to the general community that will be needed but will in turn translate into a modern interactive web presence for IUPAC long after 2011 ends. We now have a logo, which is an important symbol for us to use to our advantage. We also have the tagline "Chemistry—our life, our future," which neatly captures the omnipresence, the scientific centrality, and the undeniable importance of chemistry. The IYC 2011 website, which is now running <www.chemistry2011.org>, contains the prospectus. The website will be expanded over the next few months to become a fully functional interactive tool for communication and collaboration.

To make a suitable global publicity impact, we need to design some unifying events that will catch people's imaginations.

The IYC 2011 prospectus outlines a range of worthy reasons to justify mounting this endeavor. However, I would like to be somewhat controversial and suggest that the simple answer to the question, "Why are we doing IYC?" is, "For publicity, both for chemistry and IUPAC." Regarding the latter (and less important) area, IUPAC is increasingly being called upon to act in an advisory capacity as a non-governmental organization (NGO) to help lay down strategic guidelines that are chemically logical, coherent, and sound. In January 2009, IUPAC President Jung-Il Jin visited the UN headquarters in New York and had an official meeting with fellow countryman Secretary General Ki-Moon Ban and the senior officers of the most relevant departments (see Wire, p. 16). IUPAC is being encouraged to become an official NGO of the UN Economic and Social Affairs Council, and we shall certainly consider the implications of this offer. We shall also work closely with relevant UN agencies and commit-

Celebrate the Achievements of Chemistry

Goals of the International Year of Chemistry:

- Increase the public appreciation of chemistry in meeting world needs
- Increase interest of young people in chemistry
- Generate enthusiasm for the creative future of chemistry
- Celebrate the 100th anniversary of the Mme. Curie Nobel Prize and the 100th anniversary of the founding of the International Association of Chemical Societies

tees to maximize the impact of IYC 2011. Already, the publicity generated by this UN visit is immensely valuable, and Secretary General Ban is almost certainly the first UN secretary general to be aware of IUPAC.

Global publicity for chemistry is much more important and requires our best efforts. Although national chemical societies will collaborate to engage with local communities to promote chemistry, they will benefit from the stimulus of being part of a truly global operation. To make a suitable global publicity impact, we need to design some unifying events that will catch people's imaginations. So far, events based on a "Spectacle of Chemistry," on "Experiment and Excitement," and on "Interactivity and Dialogue" have been suggested. International competitions can also be directed toward students: These could include essay writing, poster designing, or crystal growing, for example. An event (or events) that could be held simultaneously around the world would draw considerable publicity.

As a resident of Sydney, Australia, it occurs to me that we can use the start of the year 2011 to publicize chemistry in connection with fireworks displays. The Sydney display from the harbor bridge is a famous tourist attraction and is nothing if not chemistry in action! It is almost the first New Year's display, as the clock moves around the world to the West and sets off similar displays in many cities. We need to get the fireworks chemistry and IYC information to our respective organizers and broadcasters so that the message can be spread widely. Not only are the fireworks themselves chemical, but people watching on television are dependent on the chemistry involved in that technology. Thousands of people will photograph the fireworks, making use of the chemistry intrinsic to color photography, be it traditional or digital. Even those who just look at the fireworks to enjoy the wonderful colors will do so because of the chemistry involved in vision itself.

Each time an Olympic Games is held, the Olympic torch being carried around the world, transferred from person to person and country to country, creates a publicity spectacle. Perhaps we could stage a similar event by transferring a specially significant chemical or chemicals. I cannot think of what that might be, but perhaps readers can! One problem will be the difficulty with the various customs regulations in moving chemicals around the world. But even that obstacle could generate publicity to highlight our message. Perhaps the regional winning products of an international crystal-growing competition could all be transported to a central place for final adjudication.

Publicity in itself is one thing, but an essential and dominant part of publicity for us, as a serious professional organization and promoter of genuine substance, is education. IYC 2011 will be a wonderful opportunity to help provide an educational message to the general public, and we must take full advantage of it as best we can. We need to educate adults, and particularly parents, so they are no longer terrified of chemicals and are not misled to believe that, for example, they should not eat food that contains chemicals! We also need to educate children in primary schools about the fact that everything in the world around them—including themselves—is made up of chemical molecules, and, furthermore, everything they do is controlled by chemical reactions and processes. Although these are very sophisticated concepts even for chemical professionals, I think young children can grasp the main ideas. Children learn to read, to write, and to do arithmetic. Why not also teach them the language of molecular structure, so they become familiar and comfortable with molecules? So many challenges can be taken up at any time, but we shall have a special advantage in the context of IYC 2011.

IYC 2011 will be a wonderful opportunity to help provide an educational message to the general public, and we must take full advantage of it as best we can.

So, we need your creative ideas and suggestions for how to celebrate IYC 2011, which can be shared all around the world and used to highlight the wonders and fascination of chemistry. These ideas can be communicated at any time, and opportunities for more formal planning discussions will be available at the IUPAC General Assembly in Glasgow in August 2009. We look forward to your input.

IUPAC Secretary General David StC. Black <d.black@unsw.edu.au> has been involved in IUPAC since 1994 as a committee member of the Division of Organic and Biomolecular Chemistry. He served as division vice president during 2002–2003. He has served as secretary general since 2004.

What Is "Materials Chemistry?"

by Peter Day, Leonard Interrante, and Anthony West

The words "materials" and "chemistry" have only been linked relatively recently, yet "materials chemistry" now accounts for a significant fraction of chemical science. The phrase has often been used quite indiscriminately, so IUPAC launched a project to try to define it. This article presents some of the background and conclusions to the study.

The Rise of Materials Chemistry

What do the following topics in contemporary chemistry have in common? (1) Using NH_3 incorporated in simple inorganic solids as a medium for storing hydrogen; (2) designing and assembling chemically patterned or anisotropically shaped colloidal particles into arrays with predefined geometries; (3) predicting the structures of molecular and hybrid crystals through computer simulations; (4) creating porous crystals of metal oxides templated by mesoporous silica cages. The answer is that all were the subjects of recent articles published in one of the main international journals devoted to materials chemistry.[1] In view of this ubiquity, it is surprising that as recently as 20 years ago, the words "materials" and "chemistry" were rarely linked together. Now, in 2009, "materials chemistry" represents one of the major growth sectors in pure and applied chemistry and accounts for a significant fraction of all publications in the chemical sciences.

Several straightforward measures verify these assertions. As an indication of its broad global outreach, entering the phrase "materials chemistry" into the Google search engine results in a number of hits comparable to those of traditional chemistry disciplines, such as "physical chemistry," "organic chemistry," "inorganic chemistry," or "macromolecular chemistry."

Figures for citations covering these major subdisciplines in the journals of one leading chemical society are as follows (2006 figures):

Organic chemistry	115 968
Physical chemistry	108 742
Macromolecular chemistry	76 448
Inorganic chemistry	58 002
Materials chemistry	38 890

The figure for materials chemistry is especially impressive, because it has risen from nearly zero in just a short period of time.

The number of articles submitted to *Chemistry of Materials*, one of the major journals in the field, increased 18-fold over the first 19 years of its existence. Similar increases in submissions over the last decade have been noted in other journals that focus partly or entirely on materials-related chemistry, such as the *Journal of Materials Chemistry* (RSC), *Advanced Materials and Advanced Functional Materials* (Wiley), *Nature Materials* (NPG), *Journal of Solid State Chemistry* (Elsevier), and many others dealing with more specialized areas of materials chemistry and materials science. The number of citations of papers from these materials chemistry journals, and their corresponding "Impact Factors," has also increased enormously.

Increasingly, however, the phrase "materials chemistry" is being bandied about indiscriminately, often by those merely in search of a buzzword. What does it really mean?

Defining Materials Chemistry

Given that the phrase "materials chemistry," although coined only recently, has become so popular within the chemical community, it is pertinent to ask how materials chemistry should be defined—what it is and (perhaps more importantly) what it is not. Because one of IUPAC's roles is to provide internationally agreed-upon definitions and standards, it was reasonable to take up this question; a project was launched in 2005 with this goal:

> *To assemble, collate, and disseminate information about the scope of the newly emerging discipline of materials chemistry, leading to an authoritative definition of the subject within the family of chemical sciences.*

The objective was not so much to produce lists of specific topics or categories of compounds and phenomena, which would quickly become out of date, but to establish some principles that could be deployed by IUPAC and the chemical community at large to help structure this new discipline within the broad family of chemical sciences.

The Origins of Materials Chemistry

Chemistry began, and largely continues today, to be inextricably associated with preparing, processing, and utilizing "materials," both natural and synthetic. Early examples include tanning and dying skins and fibers; extracting metals from their ores and the developing cement and concrete for construction.

Following World War II, “solid-state chemistry” developed as a distinct branch of knowledge focused on inorganic compounds. In parallel, and quite separately, “coordination chemistry” developed within inorganic chemistry, concentrating on molecular species in which a metal ion was enveloped by (mostly organic) ligands, in contrast to the solid state in which compounds had continuous non-molecular lattices. “Organometallic chemistry,” concerned exclusively with molecular species, evolved some 10 years later. “Organic chemistry,” which originated in the 19th century, also concentrated on discrete molecules, albeit sometimes very large ones, leading to the emergence of “macromolecular chemistry” (effectively, polymer chemistry). In the early to mid–20th century, synthetic polymers began to revolutionize the science and technology of materials, a development that continues today as one of the main areas of research that can be included under the materials chemistry umbrella.

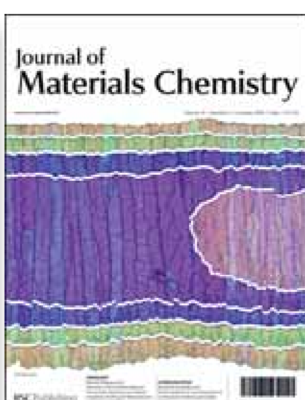
. . . as recently as 20 years ago, the words “materials” and “chemistry” were rarely linked together.

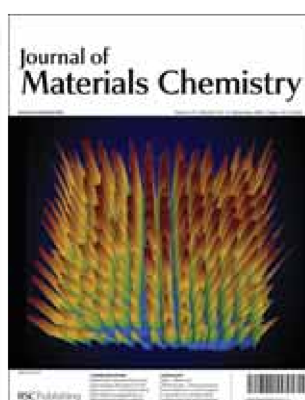
Starting in the late 1960s and continuing into the 1970s, the simple subdivision of chemical compounds as extended network solids or largely isolated molecules began to break down with the increasing interest in solid-state properties of molecular and polymeric metal-organic and organic compounds. From one side, solid-state chemists discovered more complex lattices, often with a mixture of inorganic and organic components; from the other, synthesis specialists began to attack selected targets, not so much for their behavior as individual molecules (e.g., reactivity, catalysis) as for the resulting properties when the units were packed into lattices. An additional strand was the increasingly important part played by molecular chemistry—organic, inorganic, and macromolecular—in fabricating integrated circuitry for microelectronics (photo-resists, molecular beam epitaxy precursors, etc.).

The discovery of conducting polymers in the 1970s and the widespread use of liquid crystals in displays gave these developments increased impetus; from the purely inorganic side, the spectacular developments in high-temperature superconductivity in the late 1980s drew attention to the opportunities for unlooked-for properties provided by complex metal-oxide structures. The latter in particular focused attention on careful, chemically based control of composition, phase purity, and microstructure. Later, and equally significantly, came the phenomenon of colossal magneto-resistance in perovskite structures, with similar implications.

Two other developments in the last decade illustrate how the field that we now recognize as materials chemistry has grown increasingly complex in its ramifications. First, chemical routes are increasingly being used to synthesize extended structures, either in the form of discrete (“zero-dimensional”) clusters, such as dendrimers and tailored metal-organic clusters, or in selectively modified semiconductor or metal (“two-dimensional”) surfaces by attaching electro-active molecules. Second, the entire field of nanoscience developed over the last decade depends on chemical design and control (nanotubes, “functionalized” metal, semiconductor particles, etc.).

Finally, and perhaps with the greatest long-term potential for expansion, chemistry has moved into the area of biomaterials. Starting with bulk (although highly textured) substances, such as bone or spider silk, scientists are developing heterogeneous struc-





tures involving surface modification and the medically important issue of biocompatibility. Among biomaterials, one can distinguish between materials produced by life-forms and those made by humans, through chemical synthesis, for use in living organisms as prostheses or other purposes. However, this distinction is becoming increasingly blurred as chemists adapt natural materials to meet specific needs in non-biological applications or develop synthetic materials designed to bio-degrade in nature.

Given the multiplicity of substances and techniques just summarized that cluster under the portmanteau phrase “materials chemistry,” one may legitimately ask whether enough common ground exists between them to constitute a valid new subdivision of chemical science.

What Is a Material?

A key to defining “materials chemistry” lies in defining what constitutes a “material” versus a chemical. Some dictionary definitions follow:

- the matter from which an article, fabric, or structure is made[2]
- the matter from which a thing is made[3]
- a physical substance from which things can be made[4]
- a substance having properties that make it useful in machinery, structures, devices, and products[5]

To devise a more generic definition, the ideas of functionality and application (at least, the potential for application) should be considered. A material is something with properties that give it the potential for a particular application, either structural, as with a building material; functional, as with materials used to make devices (electronic, optical, or magnetic); or biological, with biomedical applications. A material is generally thought of as a solid or an organized liquid (e.g., liquid crystal) in which interactions between the entities forming the assemblage play large roles in determining the resulting properties.

Another key concept is that of “emergent properties,” as understood in the new science of complexity. Materials are assemblages of subunits. The properties of a material emerge from the way these subunits are put together. Although a single molecule has properties related to its chemical structure, which remain constant irrespective of its state of aggregation, the properties of a material depend on how its subunits are assembled. Some such emergent properties are called “collective,” because they are only found in assembled samples. For example, ferromagnetism is a property not of a single atomic or molecular unit but only of an ensemble of units. In addition, properties can arise from structural defects, and materials made of the same chemical subunits but with different defects can have different properties. This relationship between structure and property could be used to define a material and differentiate it from a chemical.

Characterizing Materials Chemistry

Building on the definition of a material, it is now possible to create an approach to the cohesive body of practice called “materials chemistry” by developing several key aspects.

Application-Oriented or Curiosity-Driven

Much of the focus of materials chemistry in discovering and developing materials that may be exploited for desired applications. Although this is an essential motivating factor, structure-property relations crucial for further advances also need to be studied and developed. Chemists may generate new materials before their potential applications have been conceived. The discipline must include the ability to synthesize, to study, and to assess new materials.

Structural, Functional, or Biological

Today, many materials chemists are synthesising functional device materials, and the discipline is often seen as directed towards producing materials with function—electrical, optical, or magnetic. The production of structural materials, such as alloys, composites, and plastics, is seen traditionally as the province of materials scientists. Polymer science has not always been strongly connected historically to other materials chemistry, largely due to the number and strength of journals devoted to macromolecular chemistry alone. However, with the development of conducting polymers, the materials chemistry and polymer science communities are moving closer together. The development of new nanostructured, smart materials is also uniting communities and bringing together the science involved in functional and structural materials. Materials chemistry encompasses both structural and functional materials. Structural properties, such as strength or flexibility, should be considered types of functionality. The fact that chemists are currently more interested by other types of functionality may change in the future, and, certainly, a huge expansion in the area of biological materials is anticipated.

. . . the materials chemist tries to manipulate the synthetic process to produce a desired function.

Designing and Processing Materials

The concept of “design” is important in defining the work of materials chemists. Rather than purely investigate properties, the materials chemist tries to manipulate the synthetic process to produce a desired function. The relationship between the method of synthesis and the design of the final product is crucial to a materials chemist.

Characterization and Analysis

Characterization techniques are important to the work of all chemists. However, although many mainstream chemists are primarily concerned with characterizing chemical or molecular structures, materials chemists are often interested in looking at structures at all levels, ranging from defect and unit-cell scales to nano- and microstructures. Microscopy in all its forms—from optical to electron to scanning probe—is important in the work of materials chemists. “Analysis” can take the form of a theoretical analysis or a model of a material’s electronic or molecular/crystal structure and even the interactions that occur when a molecule is present in a solid state or in another medium. In this manner, important insight can be gained regarding the structure-macroscopic property relationships of a material.

What Is *Not* Materials Chemistry?

It may be agreed that simply synthesizing a new chemical substance in nano- or macroscopic form is not materials chemistry but just chemical synthesis. For it to be considered materials chemistry, an element of application, function, or design needs to be present. For example, in the case of “nanomaterials,” there should be some indication of special or potentially useful properties that result directly or indirectly from the small size or exceptionally high surface-to-volume ratio of the substance. Work on novel materials linked to a particular property must be included as materials chemistry, because chemists may generate new types of materials with previously unknown properties, thus leading to unimagined applications.

Research in nonmaterials chemistry is directed toward building understanding of the science of chemistry itself, of how matter is composed and interacts, and of how fundamental properties arise. It is also quite properly concerned with synthesizing and identifying completely new assemblies of atoms in the form of molecules and solids that may demonstrate unsought behaviors. In addition, nonmaterials chemistry tends to focus on reactivity, which makes it a vital resource for the chemical industry, whether pharmaceutical or petro-chemical.

Toward a Working Definition

A definition was previously suggested in 1992 in an article by one of the Working Group members in the *Materials Research Society Bulletin*[6] and again later in a chapter of a book on materials chemistry,[7] which is: “Chemistry related to (or directed at) the preparation, processing, and analysis of materials.” A number of definitions of materials chemistry can be found on the websites of university chemistry departments. Here are a few examples:

> *The branch of chemistry aimed at the preparation, characterization, and understanding of substances/systems that have some specific useful function (or potentially useful function). (University of Wisconsin)*

> *Materials chemistry involves the synthesis and study of materials that have interesting and potentially useful electronic, magnetic, optical, and mechanical properties. (Washington University)*

> *Materials chemistry is a relatively new discipline centered on the rational synthesis of novel functional materials using a large array of existing and new synthetic methods. (University of Oregon)*

> *Materials chemistry differs from classical chemical research in that it is generally concerned with interactions that arise from organizing molecules, polymers, and clusters over length scales beyond*

typical small molecule dimensions (nanometres to centimetres). (Massachusetts Institute of Technology)

In addition, a number of definitions were suggested during the workshop (see acknowledgements below):

Materials chemistry is the chemistry of the design, synthesis, and characterization of assemblies of molecules whose properties arise from interactions between them.

Materials chemistry is the understanding, synthesis, processing, and exploitation of compounds or substances in their assembled form.

Materials chemistry is the synthesis, processing, characterization, understanding, and exploitation of compounds that have useful or potentially useful properties and applications.

We propose the following working definition, based on a synthesis of the above suggestions and the currently accepted meaning of materials in most dictionaries and books:

Materials chemistry comprises the application of chemistry to the design, synthesis, characterization, processing, understanding, and utilization of materials, particularly those with useful, or potentially useful, physical properties.

This definition draws upon the existing definitions for the terms "chemistry" and "materials," while acknowledging that the materials that have been (and are likely to continue to be) of particular interest to the practitioners are generally those that have certain properties—e.g., mechanical, electrical, magnetic, optical, etc.—that make them useful, or potentially useful, in a functional sense. Thus, the keywords "useful" and "properties" were added to further define the materials that are most likely to be the subject of investigation in this field as well as to acknowledge the fact that functionality, or the prospect of functionality, is a major driver for research and development in the field.

Acknowledgements

The Task Group is grateful for the input it received from practitioners and from the journals principally devoted to the subject, as well as from representatives of other IUPAC divisions, members of the chemistry community who contributed to the debate, and the RSC staff. In particular, we appreciate the efforts of Graham McCann and Rachel Brazil, who organized a workshop sponsored by the Materials Chemistry Forum of RSC in London on 12 April 2006. MCF brought together representatives not only of the relevant subject groupings within RSC but also from contiguous disciplines, such as physics and materials science, all of whom contributed, in addition to international speakers.

References

1. *J. Mater. Chem.*, 2007, **17**, (41); ibid., 2007, **17**, (47); ibid., 2008, **18**, (19); ibid., 2008, **18**, (20); ibid., 2008, 18, (24).
2. *Oxford English Dictionary*, 1971, Oxford University Press, Oxford.
3. *Concise Oxford Dictionary*, 8th ed., 1990, Clarendon Press, Oxford.
4. *Webster's Collegiate Dictionary*, 11th ed., 2003, Merriam-Webster.
5. M. Cohen, ed., 1974, "Materials Science and Engineering: Its Evolution, Practice and Perspectives," *Materials Science and Engineering*, **37**, 1; M.B. Bever, 1986, *Encyclopaedia of Materials Science and Engineering*, Vol. 1.
6. L.V. Interrante, "Materials Chemistry—A New Subdiscipline?" *MRS Bulletin*, January 1992, p. 4.
7. L.V. Interrante and M. Hampden-Smith, eds., 1998, "Introduction to Materials Chemistry," in *Chemistry of Advanced Materials—An Overview*, chap. 1, Wiley-VCH, New York.

Image Credits

Peter Day <pday@ri.ac.uk> chaired this IUPAC project and is a professor from Davy Faraday Research Laboratory, University College, in London, UK; Leonard Interrante <interl@rpi.edu>, task group member, is an editor for *Chemistry of Materials*, and secretary of the IUPAC Inorganic Chemistry Division, and professor at Rensselaer Polytechnic Institute, in Troy, New York, USA; Anthony West <a.r.west@sheffield.ac.uk>, task group member and past president of the IUPAC Inorganic Chemistry Division, is a professor at the University of Sheffield, UK. Other task group members were M. Prato, chair of the Editorial Board of *Journal of Materials Chemistry* and a professor at the Universita Trieste, Italy; and Y. Shirota, former member of the Editorial Board of *Journal of Materials Chemistry* and a professor at Osaka University, Japan.

www.iupac.org/web/ins/2005-001-1-200

Beyond the Book*

by Peter Atkins

Is the book dead? Will the e-book become the norm? Does the e-book have overwhelming advantages or is it, perhaps, not superior in every respect? These are some of the questions that I explore in this article. To help with the discussion, I refer to the conventional paper-based book as a "p-book."

The p-book, in the form emerging from the printing press rather than the monastery, was responsible for a social revolution when it emerged over 500 years ago, putting knowledge into the hands of the populace and enabling information to spread like wildfire through civilizations. That original form has undergone only cosmetic evolution in the five centuries of its existence. The paper has become whiter and lighter; black and white has given way to full color; and textbooks have acquired pedagogical apparatus that, although breaking up the flow of the text, are invaluable for developing understanding. Worked examples, full-color illustrations, lists of key concepts and equations, and end-of-chapter exercises and problems are really all products of the twentieth century and have made the textbook a central accompaniment of instruction and education. All this apparatus continues to evolve, with special attention still being given by all authors and their publishers to the seemingly intractable problem of developing problem-solving skills and attacking in a variety of ways the challenge of encouraging inductive processes.

Books have also become heavier. They are not all weighted down with new information (molecular biology is an exception) but with pedagogical apparatus. To satisfy the demand for help with problem-solving, the author has to provide worked examples by the score or even by the hundreds. Many students, wanting the instant gratification of good grades, cannot be bothered with the text and merely hunt for a worked example that has at least a vague resemblance to the problem in hand. For them, text is clutter. I am reminded of some genres of pornographic videos that proudly proclaim "No story!" on the boxes, knowing that a storyline gets in the way of the action. We are drifting perhaps toward a textbook that proudly proclaims "No text!" on the cover, promising only the action of worked examples. The loss, of course, is learning.

Books have also become more expensive. Their price is still negligible compared with the overall cost of a college education, but their cost is perceived rather than largely concealed and perhaps forgotten. The rise in expense springs from two sources. One is the absolute cost of producing a highly sophisticated product. Even if the authors in due course discover that they have been working for less than the minimum wage when, after several years of hard labor, a derisory royalty payment finally appears, and they comfort themselves with pride rather than wealth, the cost accruing from the production process remains. Editors, of the flavors commissioning, developing, copy-editing, and production, must be paid, and so must expensive marketing departments, as must the cost of each volume as it rolls off ever-more-expensive presses. Then, because paper and ink are composed of heavy fundamental particles (I shall refer to these baryons again), costs arise from storage and distribution. But there is a more pernicious contribution to cost: the secondhand market.

The secondhand market is largely responsible for the high cost of textbooks, and the high cost of textbooks is largely responsible for the existence of the secondhand market. Because the secondhand market is so well organized (in some countries at least, especially the USA), a publisher can be confident of good, investment-rewarding sales for only the first year or so after launching the book into the marketplace. After this time, so many secondhand copies are in circulation that the publisher and author can only look on as the commodity moves from brain to brain with no financial recognition of their input. Although file-sharing is perceived as illegal in the music industry, book-sharing in the textbook industry (like music DVD- and CD-sharing) is regarded as entirely legitimate and, indeed, the only way of recovering the purchaser's financial investment and, perhaps, putting the sale price toward the purchase of another book. Thus, a publisher must set the cost of the book high in order to cover costs within a year or so and is under pressure to produce new editions before they are scientifically necessary merely to thwart the secondhand market.

* This article is based on a lecture given by the author at the International Conference on Chemical Education-20 in Mauritius in August 2008.

To some extent, the virulence of the secondhand market (which its proponents will argue is not virulence but economic balm for the hard-pressed student) reflects the structure of courses. Where courses last for a single year, a textbook new at the beginning is still acceptable at the end of the year, and intelligent annotations might even be regarded as adding value. Where courses span several years, a book is more heavily used and much lower in value; moreover, a new edition is crossing the horizon. In such cases, a secondhand market is much less intrusive, and books can be cheaper.

That having been said, a p-book is a beautiful thing. It smells good when new, it generally looks good, and it has the virtue of serendipity, for casual browsing can bring the browser to an unexpected viewpoint. The approximate location of knowledge in books can be remembered, or at least half-remembered, for years. Books are life's companions, and even the sight of a volume on a shelf can remind one of a special moment. But, most important of all, a p-book is "always on." A book can be opened at a whim and immediately offers its contents to its reader. Books can be read in the brightest sunlight, on the balmiest beach, at almost any angle, in even the most bizarre bodily posture, for hours on end, even while one's airplane is landing and taking off.

The Ascendancy of the E-Book

Nevertheless, the equivalent of a mammal is starting to nibble at the feet of the dinosaur and is poised to take over the world. An e-book is a nimble thing, and, once its current deficiencies have been eliminated, it is inevitable that it will dominate the world. While the p-book will not become extinct, it will be very much in second place and perhaps relegated to collectors rather than users, perhaps returning to the monastery from whence it sprang. As always in the e-world, we have to distinguish the e-book itself, the information content, the software, from the device itself, the hardware, the "e-reader."

. . . the equivalent of a mammal is starting to nibble at the feet of the dinosaur and is poised to take over the world.

The principal positive attribute of the hardware aspect of the e-book is its ability to put the world in one's hand. Even if one disregards the leisure aspects of e-books and focuses only on the pedagogical aspects (as I do mostly in the following paragraphs), the convenience of having all one's textbooks available, together with resources of data, in a single unit is hugely attractive. Because convergence is inevitable, packed into the ideal e-reader will be manipulative software that is immediately on hand to develop whatever the e-book itself requires.

The problems with current versions of e-readers diminish their acceptability but will vanish with time and development. We need color screens: The monochrome electronic ink offerings currently available are acceptable for e-novels, where only the words matter, but are wholly unacceptable for textbooks and will be seen as a regression to the monochrome nineteenth century. Battery life needs to be effectively infinite so the reading experience is not curtailed by extraneous cause.

Most important of all, and probably most difficult to achieve, is the re-creation of that most wonderful aspect of p-books that I allude to earlier, the opportunity for serendipitous discovery. Browsing freedom would be recreated if, instead of one screen with its Cyclops eye, an e-reader had hundreds of double-sided screens, perhaps all hinged on the left, so the reader could flip through as though using a real p-book. It is an interesting question: How many pagelike e-screens would it take to recreate the sense of using a p-book? Would it take a hundred, or could it be accomplished with two? The electronics of an e-reader also need to be shrouded in some way so it is possible to use them at all times on an aircraft, for otherwise one would have to pass away the time by reading the safety card in the seat pocket. The ideal e-reader also needs to have wireless connectivity built in so one can download e-books on the move and thus not only have the convenience of accessibility but also enhance the browsing experience.

The principal advantage of the e-book itself, the software, is its potential for interactivity. This is the heart of the e-book revolution, with—like all revolutions—losses and gains. Interaction takes a variety of forms. At its simplest, it provides the opportunity for exploring the consequences of changing parameters in graphs (features that in another context I call "Living Graphs") and calculations. This type of interaction could be a seriously useful pedagogical tool, exploring how temperature affects a property or a composition, how changing dimensions of a container, masses of atoms, force constants, and so on, almost without end.

There is another simple kind of interactivity that we chemists (as well as our macroscopic cousins, the architects) will welcome, which is the opportunity to view illustrations, especially molecular and crystal structures, from different viewpoints. Stereoscopic and perhaps holographic images will add to the e-experience. The color-blind will perhaps be able to select a more appropriate palette of colors. Related to this type of visual enhancement is the capacity to show animations of appropriate concepts.

Then there is a deeper kind of interactivity, that of successive expositional depth. Confronted by a puzzling point, either verbal or mathematical, there would be a real advantage to being able to open up a new, more detailed level of explanation, with more mathematical steps displayed, with more commentary, and so on. One could turn this type of interactivity on its head and perhaps select an overall level of exposition for an entire text, and then progressively deepen it as one became intellectually more secure. Related to this feature is the potential opportunity to link to other texts carried in one's reader or out there on the web.

The E-Book's Shortcomings

Not everything, though, in the e-book garden is rosy. One advantage of a p-book is its intellectual rigor: It starts on page one, and the author leads the reader through an intellectual development, sometimes leaving tough precipices to negotiate. There are two points here. One is the simple but psychologically comforting fact that with the linear exposition characteristic of a p-book, one knows how far one has gotten and how far one has to go simply by glancing at how much paper is on the left and how much remains on the right. An e-book, other than simple linear novels, does not have the same immediacy: Because an e-book can potentially be explored nonlinearly by pursuing links that might be presented, there is no way of telling how much farther there is to go. An ideal e-book would have some kind of meter to display the volume of material covered and how much remained to give heart to the despairing or fatigued student. The second point is that intellectual struggle can be an excellent way of learning: It may turn out that all the easing of the learning experience that e-books strive toward actually diminishes the capacity of the student to understand deep down. Moreover, the temptation to slip away into byways when confronted by a hill to struggle over could diminish the acquisition of intellectual rigor.

There is another, related point. A novel stimulates the imagination: One has to invent one's own image of the characters and their environment. Illustrated novels, movies, and videos are all very well, but they leave the imagination unstimulated. Could it be that the provision of too much visual help in an e-book would undermine the imaginative capacity of students? Might it be better to force them to develop their own images rather than to lie back and let another's images wash over them? Perhaps the imaginative opportunities that e-books will unleash would be undermined by their failure to stimulate the imaginative enterprise that is so vital to science.

Another feature will, I suspect, be viewed with concern. I have mentioned already factors that contribute to the cost of p-books. By stripping away the baryons and leaving only electrons as the carriers of information, the problems of weight, storage, and distribution are overcome at a stroke. It would be naïve to expect a reduction in cost, however, because all the bells and whistles that must be developed incur huge costs, and the sales base does not match that characteristic of computer games. However, that other contribution to cost, the secondhand market, could be thwarted, for e-books could be time limited and turned off after a year to be made not sharable with other users. I would greatly regret my own library gradually disappearing unless I renewed a subscription to maintain the lives of books that one day I might find an opportunity to use again, but that might be the price to pay for the future. A minor point is that almost certainly "editions" will disappear, and, like the software model, publishers will release "versions" instead, with incremental update patches instead of corrected reprints.

Conclusion

Let me say that the e-book revolution—for it will be one—has scarcely started. We need seriously improved e-readers before an e-book can become a comfortable, colorful, rewarding, convenient device. We should expect to be drawn in by interactivity but not always to be developed intellectually. We need imaginative contributions from authors; indeed, e-books by single authors might not be feasible, as so many talents must be brought to bear. We should expect the convenience of being able to transport whole libraries in our pocket but not necessarily cheapness. We should, in a word, expect the future.

Peter Atkins <peter.atkins001@btinternet.com> was an Oxford professor of chemistry and fellow of Lincoln College until his retirement in 2007. He has written more than 60 books, the best-known of which is *Physical Chemistry*, which will soon be published in its ninth edition. His other major textbooks include *Inorganic Chemistry*, *Molecular Quantum Mechanics*, *Physical Chemistry for the Life Sciences*, and *Elements of Physical Chemistry*. Until 2005, he chaired the IUPAC Committee on Chemistry Education.

Can It Help Promote the Public Appreciation of Science?

by David A. Evans

At a Committee on Chemistry and Industry (COCI) meeting in 2007 attended by then-President Bryan Henry, I flippantly stated that the principles of scientific method could be used as a blueprint for living one's life. Henry immediately contradicted this comment and pointed out that the method had no relevance to emotional issues, such as love. Of course, Henry was right, but I still contend that many aspects of day-to-day life would be better explained and understood if scientific method were applied. This article illustrates some examples.

Both the Committee on Chemistry Education (CCE) and COCI have programs dedicated to the public appreciation of chemistry. CCE and COCI are notably diverse in the range of countries they represents. One lesson that we have learned is that public appreciation of chemistry varies greatly from country to country, and it is clear that tailored local initiatives are usually much more appropriate than generalized global programs. However, some issues warrant a universal approach, and scientific method is one of them.

What Is Scientific Method?

No singular definition of "scientific method" exists. A simple Google search provides numerous populist articles that reveal simple definitions of the type shown below, taken from *Science Buddies*[1]:

> *The scientific method is a way to ask and answer scientific questions by making observations and doing experiments.*

In short, this is simply the way in which good science is properly conducted. A Google search of "scientific method steps" provides another delightful list of articles, aimed at all ages and levels of sophistication, which includes pictograms, songs, and mnemonics to help remember the steps. The following provides a fair summary:

1.1 Make observations
1.2 Relate causes to effects via propositions
1.3 Test propositions experimentally
1.4 Analyze the data and draw conclusions
1.5 Publish results following peer review

During this journey, the status of a proposition might move to a hypothesis to a theory and even to a law, but facts are elusive and only arrive when all attempts to disprove them are defeated. Chapter 3 of *The Complete Idiot's Guide to Chemistry*[2] provides a simple description of what can be involved in the various steps. However, the purpose of this article is not to critique the descriptions of these steps, but rather to indicate useful ways to promote the public's appreciation of the method.

1.1. Make observations: In response to an observed effect, it is tempting to jump to a conclusion regarding the cause based upon our past experience, values, and prejudice. In a world where many people wear their ignorance of science as chic badges of honor, we are often faced with dialogue based on beliefs rather than evidence. Perhaps the most important first question for everyone—sadly, frequently ignored—is whether an observation is a one-off or can be repeated.

1.2. Relate causes to effects via propositions: As a hypothetical example, imagine that your headache disappeared after drinking an infusion of daffodil petals; therefore, it is obvious to you that daffodils cure headaches. But headaches disappear over time (this is often called "regression to the norm") or for a variety of reasons (e.g., drinking water), so you are simply indulging your beliefs if you insist that daffodils cure headaches. Nothing is wrong with holding certain beliefs, but if you stop at this stage, that is all you have!

A very important lesson here is that *association is not equivalent to causation*. A good example of this lesson comes from the observation in a UK town that the incidence of child asthma had doubled in a period when the number of motor cars registered had also increased similarly. One feasible proposition is that car exhaust fumes were responsible for the increase in asthma. However, it was observed that the number of Asian restaurants in the town had also doubled in that period! In addition, it was pointed out that the south island of New Zealand had a high rate of child asthma, despite having very low traffic levels and lots of fresh air. The lesson to be learned is that data based upon good science is essential to determine causation. Furthermore, even if it were shown that car exhaust fumes were responsible, it would be vital to know the extent to which the effects were due to gaseous or particulate emissions in order to implement the correct engineering solution. Good science, technology, and engineering can solve problems. Traveling in hope based upon beliefs is usually a waste of time and resources.

1.3. Test propositions experimentally: Here, it is important not only to design experiments to test your hypothesis but also to consider alternative and null hypotheses as part of the process. A crucial factor is the inclusion of appropriate control experiments—failure to include these invalidates the whole study. A populist description of the intricacies of control experiments in clinical work is provided by Ben Goldacre in his recent book, *Bad Science*.[3] This excellent volume, written by a practicing physician, provides compelling examples of the pitfalls caused by failure to follow scientific method. It is clear that proper design and execution of experiments is the heart of the process. A section about the placebo effect and how to include it in experimental design is particularly informative[3] and illustrates the importance of the inclusion of control experiments. People outside this field would have been skeptical if informed that the number and color of sugar pills used as placebos have different positive effects on patients—but they do!

1.4. Analyze the data and draw conclusions: This is also a vital step—whereas the data are the ultimate product of the experimentation, their treatment and interpretation are open to bias and misrepresentation. This misrepresentation underpins the necessity for full publication of the raw data, discussed in the next section. In *Bad Science*,[3] in addition to a chapter on the misuse of statistics, there is discussion of numerous instances of biased interpretation—some unconscious, and others willful. The dangers of "cherry picking" from within the data and from differing statistical treatments of outliers can lead to selective interpretation. Furthermore, the consideration of your data as part of a wider dataset published elsewhere is always wise. In clinical studies, a "Cochrane review"[4] represents a pooling of data from similar trials to improve the accuracy of conclusions and to help deal with outliers.

At this point, you will have generated consistent evidence to support or rebut your hypothesis. In some branches of science, and particularly in chemistry, further research to relate causes to effects by establishing the mechanism will add significant value.

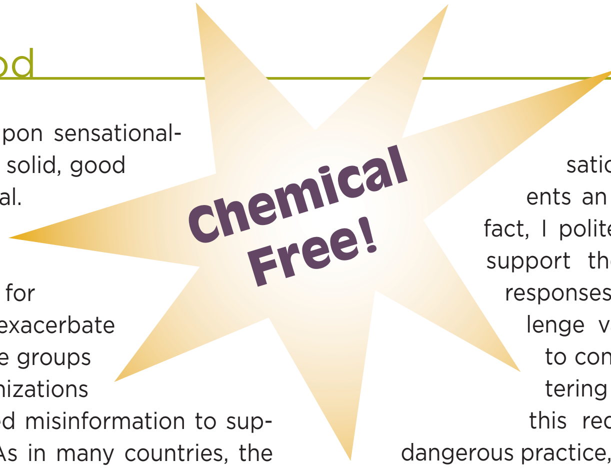
1.5. Publish results following peer review: The most important features here are the provision of all the data on which conclusions are based and the description of the arguments that are used to derive these conclusions. Peer review should not be claimed as an infallible process that guarantees the results, but it does provide a vital check of the validity of the experimental methods and the conclusions drawn. Peer reviewers cannot be expected to repeat the experiments, but subsequent full publication does allow anyone to check the data for themselves by using the methods described in the paper. Good data, widely communicated, are the bedrock on which future scientific endeavor is based.

The Public, the Media, and Scientific Method—A Personal Perspective

The principles of scientific method have relevance to members of the public who are not scientists. The problem is to introduce the public to the method in a way that is neither patronizing nor antagonistic to their beliefs, many of which reflect their experiences and lifestyles. Much of the information on which they base their opinions and beliefs will be derived from the media and press. In the UK, we are blessed with many newspapers that have almost zero scientific

. . . the utterances of vacuous celebrities rank much higher with the public than those of expert scientists and clinicians.

competence and that rely upon sensationalism to sell their copy—and a solid, good science story does not appeal. Several first-rate science correspondents are available, but they are bypassed for sensationalist scoops. To exacerbate matters, single-issue pressure groups and nongovernmental organizations (NGOs) jump on exaggerated misinformation to support dogmatic viewpoints. As in many countries, the utterances of vacuous celebrities rank much higher with the public than those of expert scientists and clinicians. Many of these, published in glossy magazines or autobiographies, are based upon the celebrities' singular personal experiences. Again, *Bad Science*[3] contains breathtaking examples of the ways in which pseudoscience and dogma are celebrated in the media in spite of the total lack of evidence for the benefits claimed. And we should be very worried—it was Jonathan Swift who observed, "You cannot reason a person out of a position he did not reason himself into in the first place."



So what can promotion of the virtues of scientific method contribute to the public debate? It is my belief that many of the large, well-organized initiatives that have been produced have created limited impact precisely because of their grand scale. Furthermore, it is arrogant of scientists to believe that the public has a duty to understand our viewpoint, and it is unrealistic to believe that we could educate the public to the point of meaningful understanding of a large number of complex issues. Education is surely a task that must be tackled incrementally—but on a broad front.

Some of my very modest personal experiences with promoting the virtues of scientific method follow in the paragraphs below.

The easiest place to start is with your nonscientist friends. Numerous sources referenced in this article provide fascinating, and sometimes amusing, stories in which the failure to employ good science produces nonsensical claims. Many of these fallacies are topical and include such subjects as detoxification, nutritional claims, and diets. I have committed these stories to memory and often introduce them in conversation with nonscientists. In the UK, we are fortunate to have pubs in which we can informally meet friends and acquaintances, and this atmosphere provides fruitful educational opportunities. In fact, this approach frequently leads to animated debates! I am becoming conscious of the pitfalls of preaching, but I do not believe that I have lost any friends—yet.

In response to a conversation in which someone presents an unsubstantiated belief as fact, I politely ask whether any data support the fascinating claim. The responses to this perceived challenge vary from stunned silence to constructive debate, to spluttering indignation. Accordingly, this request for data can be a dangerous practice, putting further invitations to supper in jeopardy.

Letters to newspapers that correct unscientific statements are published surprisingly frequently, especially in the local media. Ben Goldacre[3] has strong advice for individuals: "To academics, and scientists of all shades I would say this: you cannot ever possibly prevent newspapers from printing nonsense, but you can add your own sense into the mix. E-mail the features desk . . . and offer them a piece on something interesting from your field. They'll turn you down. Try again."

Goldacre also encourages scientists to start blogs—his can be found at www.badscience.net—an opportunity for some of us to enter the modern world! Indeed, the Internet offers limitless opportunities for communication ranging from blogs and science chat sites to published articles—and the audience is potentially in the millions.

Contributions by Learned Societies

The Royal Society of Chemistry, justly irritated by advertisements for products that claim to be "chemical-free," has offered a large cash prize for anyone who can present the society with a material that does not contain a single chemical—knowing that its money is safe! Many of our learned societies have similarly accepted the challenge of providing better outreach to the public, and they can contribute much more. I offer the following suggestions:

- Enhance the media centers of learned societies to develop improved relationships with the media via assistance with material and copy while helping rebut scientific nonsense at its source.
- Criticize advice or legislation in which lack of adherence to the principles of scientific method could produce negative consequences.
- Produce authoritative independent position papers on hot topics, written in jargon-free script.
- Ensure that web searches on science topics initiated by members of the public favor articles

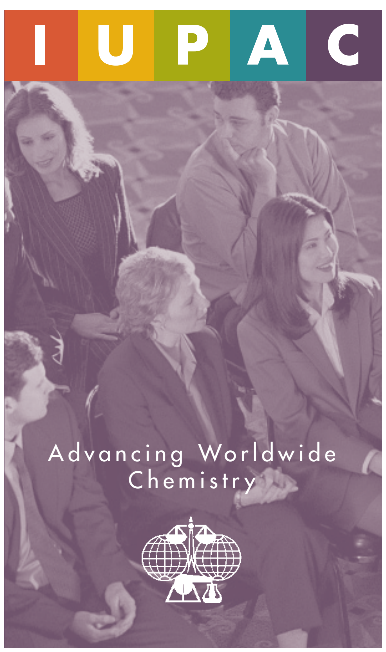
produced by learned societies. In my experience, Wikipedia—which can be edited by anyone—is often one of the top sites listed in response to a general query, whereas a learned society reference rarely makes the first results pages for a Google search.

We need to recognize that we can learn much from the NGOs whose communication skills and media awareness are awesomely developed. Perhaps the best way forward is for learned societies to become accredited as NGOs themselves and thereby gain seats around the tables of relevant international organizations, such as the United Nations Environment Programme and the World Health Organization. It is pleasing to note that IUPAC is already taking positive steps in this direction.

Finally, Peter Mahaffy and his colleagues in CCE, in their review entitled "Chemists' Understanding of the Public,"[5] conclude that one of the most important contributions for IUPAC would be to provide assistance to chemists in honing their public communication skills. One component of this movement would be to help ensure that all forms of communication should always pay heed to the principles of scientific method and should clearly enunciate the data on which the communications are based and the arguments used to draw conclusions. As such, this is akin to a teaching seminar—which is exactly what it needs to be!

References
1. *Science Buddies*, www.sciencebuddies.org.
2. Ian Guch, *The Complete Idiot's Guide to Chemistry*, Alpha Books, New York, 2006.
3. Ben Goldacre, *Bad Science*, Fourth Estate, London, 2008.
4. The Cochrane Library, www.cochrane.org, published and hosted by Wiley InterScience.
5. Peter Mahaffy, "Chemists' Understanding of the Public," July-Aug 2006 *Chemistry International*, p. 14 (www.iupac.org/publications/ci/2006/2804/4_Mahaffy.html).

David A. Evans <dae.jeevans@btopenworld.com> is a member of the IUPAC Committee on Chemistry and Industry (COCI). Evans's interest in public appreciation of science predates his retirement as head of Research & Technology at Syngenta.



IUPAC President Publicizes the International Year of Chemistry

IUPAC President Jung-Il Jin spent much of January 2009 travelling the globe to publicize and plan for the celebration of 2011 as the International Year of Chemistry, which was proclaimed by the United Nations General Assembly on 19 December 2008. After meetings in Cairo and Frankfurt, the most notable stop on Jin's tour was a meeting with UN Secretary General Ki-Moon Ban on January 17 at UN Headquarters in New York City.

IUPAC President Jung-Il Jin (left) with UN Secretary General Ki-Moon Ban at UN Headquarters in January 2009.

During the meeting, Jin thanked Ban for his cooperation and help in the promulgation of the IYC proclamation and took the opportunity to explain the history of IUPAC and its recent activities. The secretary general stated that aside from the UN Educational, Scientific, and Cultural Organization (UNESCO), the Department of Economics and Social Affairs (DESA) is the best suited UN department for IUPAC to work with in many areas, including sustainable development.

Jin asked Ban if he would consider delivering a special lecture at the August 2011 IUPAC General Assembly and Chemistry Congress, to be held in San Juan, Puerto Rico. Ban has demonstrated an understanding of the importance of basic sciences and also a keen interest in environmental protection, energy-related matters, and preservation of natural resources. According to Jin, the secretary general responded positively to the invitation.

IUPAC President Jung-Il Jin (left) meets with Nikhil Chandavarkar of the UN Department of Economics and Social Affairs.

Following his meeting with Ban, Jin had a fruitful discussion with Nikhil Chandavarkar of DESA, who suggested that in order to broaden the collaboration between IUPAC and the DESA:

1. IUPAC should take steps to become an accredited NGO of the UN Economics and Social Affairs Council.
2. IUPAC and DESA should arrange a formal meeting to discuss the future cooperation.

According to Jin, his meetings made it clear that IUPAC can work with the UN on a broad range of issues in addition to the IYC.

Cairo, Egypt

From 4–6 January 2009, Jin joined IUPAC Secretary General David Black in Cairo for meetings of the Federation of African Societies of Chemistry (FASC) and Arabian Chemical Societies. Following introductory remarks by Ahmed Galal, dean of the Faculty of Science, Cairo University, to begin the FASC Chemical Congress, Jin gave a brief introduction about IUPAC and noted that the organization currently has close to 75 regular and associate members. He stressed that IUPAC is aiming to increase its membership to 100 countries by 2019, which will be the hundredth anniversary of IUPAC. He urged all participants to help IUPAC achieve this goal, pointing out the importance of recruiting more members from African and the Arab states.

Temechegn Engida, President of FASC (left), with IUPAC President Jung-Il Jin in Egypt in January 2009.

Frankfurt, Germany

Shortly after the UN proclaimed the year 2011 as the International Year of Chemistry, IUPAC called for a meeting of presidents and other representatives of EuCheMS (European Association for Chemical and Molecular Sciences) member organizations. On 9 January 2009, Jin met up with IUPAC Vice President Nicole Moreau, IUPAC Executive Director John Jost, and David Black for such a meeting at the headquarters of the Gesselschaft Deutscher Chemiker (GDCh) in Frankfurt.

GDCh President Klaus Müllen opened the meeting by wel-

Leaders gather for the EuCheMS meeting in Frankfurt, 9 January 2009. Seated (from left), Nicole Moreau (IUPAC vice president), Luigi Campanella (Italy), Paul Baekelmans (Belgium), Malgorzata Sobieszczak-Marciniak (Poland), and Janusz Lipkowski (Poland). Standing (from left), David Black (IUPAC secretary general), Olivier Homolle (France), Peter Kündig (Switzerland), Lukas Weber (Switzerland), Klaus Müllen (Germany), John Jost (IUPAC executive director), Jung-Il Jin (IUPAC president), Jose Manuel Pingarron (Spain), Jan Apotheker (Netherlands), Pauline Meakins (United Kingdom), and Kurt Begitt (Germany).

coming participants (see group photo google IYC Frankfurt) and briefly describing the Year of Chemistry celebrated in Germany in 2003 (see May-June 2004 *CI*, p. 4). This had been a very successful event with extensive coverage in the general media. He expected that the GDCh would be able to replicate that success with the IYC in 2011.

Jin expressed his appreciation that representatives of so many major European chemical societies could come to the meeting and thanked Müllen and the GDCh for helping to organize it. Jin observed that the IYC Management Committee had representatives from IUPAC and the regional chemistry federations, EuCheMS, Latin American Federation of Chemical Associations, Federation of Asian Chemical Societies, and Federation of African Societies of Chemistry, as well as the International Council of Chemical Associations.

John Jost reported that the World Chemistry Leadership Meeting to be held in August 2009 in Glasgow during the IUPAC General Assembly would have as its theme the International Year of Chemistry. The meeting would be used to promote cooperation among chemical societies and others, such as industry organizations, in planning for the IYC. It was expected that this would be an opportunity for organizations to share their plans and to provide inspiration for events that could be held nationally and locally as well as to inform the participants about IUPAC's plans for major international events.

Black reported that the PACIFICHEM conference to be held in Honolulu, Hawaii, in December 2010 would be used as a pre-launch publicity event to announce the IYC in advance of the official launch of the IYC in Paris on 27–28 January 2011. This was viewed as an excellent opportunity because of the large number of participants at this conference from both North America and the Asia-Pacific region.

Nicole Moreau briefly reviewed plans for an opening event in Paris in January 2011. The event would be organized in cooperation with UNESCO. There was some discussion of the kinds of events that might be part of the launch of the IYC. It was agreed that it was important to try to communicate the excitement of chemistry.

Jin reminded the participants that the success of the IYC depended on the national chemical societies and on national and local events. Events directly organized by IUPAC would in practice have only a limited impact. In the ensuing discussion a number of the participants described their plans to reach out beyond their chemical societies to the broader chemistry community. It was emphasized by a number of speakers that the chemistry community included many who did not normally think of themselves as chemists, but who were in fact involved in the use and application of chemistry. It was also noted a number of times that it would be necessary to involve the chemical industry and not to view the industry only as source of funds.

www.chemistry2011.org

L'Oréal-UNESCO Awards Bestowed Upon Five Exceptional Women Scientists

The laureates of the 11th L'Oréal-UNESCO Awards for Women In Science received their recompense at a ceremony in Paris on 5 March 2009. The laureates, who work across the spectrum of the physical sciences, were chosen on the basis of their groundbreaking achievements and potential contributions to scientific progress.

The award winners were selected by an international jury of 16 eminent members of the scientific community. Chosen in recognition of her exceptional achievements, one Award Laureate is named from each of five continents: Africa, Asia-Pacific, Europe, Latin America, and North America. The laureates receive individual awards of USD 100 000. Physical sciences and life sciences are recognized in alternating years. The jury was presided over by Ahmed Zewail, 1999 Nobel Laureate in chemistry.

The laureates for the L'Oréal-UNESCO Awards for Women in Science 2009 are as follows:

Africa & the Arab States: Tebello Nyokong, professor in the Department of Chemistry at Rhodes University in South Africa, for her work on harnessing light for cancer therapy and for environmental clean-up.

Asia-Pacific: Akiko Kobayashi, professor and chair of the Department of Chemistry, College of Humanities and Sciences at Nihon University in Japan, for her contribution to the development of molecular conductors and the design and synthesis of a single-component molecular metal.

North America: Eugenia Kumacheva, professor in the Department of Chemistry at the University of Toronto in Canada, for the design and development of new materials with many applications including targeted drug delivery for cancer treatments and materials for high density optical data storage.

Europe: Athene M. Donald, professor of Experimental Physics at the Cavendish Laboratory in the Department of Physics at the University of Cambridge in the United Kingdom, for her work in unravelling the mysteries of the physics of messy materials, ranging from cement to starch.

Latin America: Beatriz Barbuy, professor at the Institute of Astronomy, Geophysics, and Atmospheric Sciences at the University of São Paulo in Brazil, for her work on the life of stars from the birth of the universe to the present time.

Created in 1998, the L'Oréal-UNESCO Awards for Women in Science were the first international awards dedicated to women scientists around the world. More than 10 years and 57 laureates later, the program is a benchmark of international scientific excellence, and an invaluable source of motivation, support, and inspiration for women in the scientific field. The laureates serve as role models for future generations, encouraging young women around the world to follow in their footsteps. In addition, the L'Oréal-UNESCO program has to date granted 120 international fellowships and 340 national fellowships to female doctoral and postdoctoral students, fostering a global community of scientific talent that continues to grow each year.

About L'Oréal

The L'Oréal Corporate Foundation is committed to three areas of action: encouraging education, fostering scientific research, and creating bonds of solidarity for those in fragile circumstances. The L'Oréal Foundation, which presently regroups a number of major existing corporate philanthropy initiatives including the L'Oréal-UNESCO Awards for Women in Science will strengthen these actions and ensure their continuity, as well as develop new programs in the coming years.

About UNESCO

Since its creation in 1945, UNESCO has pursued the mission of promoting science—the "S" in its acronym—for peace. Today, UNESCO notably aims to reinforce international cooperation in the basic sciences among its 193 Member States and promotes ethical norms in science. The organization has also been dedicated to eliminating all forms of discrimination and promoting equality between men and women. As well as developing educational programs in science particularly designed for girls, UNESCO has established a network of academic chairs creating links between women in science around the world.

www.loreal.com/_en/_ww/for-women-in-science.aspx

Javier Garcia Martinez Named a Young Global Leader

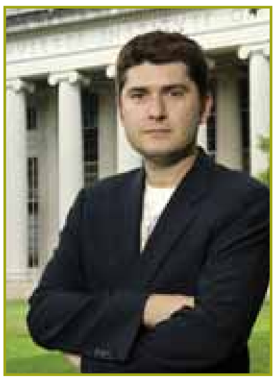
The World Economic Forum (WEF) has recognized Javier Garcia Martinez as one of the 2009 Young Global Leaders for his pioneering work in nanotechnology and energy, his leadership, and his commitment to shaping a more sustainable global future. Martinez is a titular member on the IUPAC Inorganic Chemistry Division and associate on the Committee on Chemistry Education.

Each year, WEF recognizes distinguished young leaders below the age of 40 from around the world.

This year, 230 individuals, including Javier Garcia Martinez, were selected from a pool of almost 5000 candidates.

"I am honored that the World Economic Forum has chosen me as a Young Global Leader out of thousands of highly qualified individuals," said Javier Garcia Martinez. "I am excited to be a part of such an outstanding community of young leaders that share my passion to work towards a better global future."

In 2005, Javier cofounded Rive Technology, Inc., to commercialize the technology that he developed during his post-doctoral stay at MIT. The technology is a proprietary method of modifying the pore structure of a zeolite, making it more accessible to larger molecules in a feedstock. Rive selectively introduces mesopores (pores nearly four nanometers in diameter) into a zeolite, allowing larger molecules to access the zeolite and get "cracked" into valuable products. As a result, petroleum refiners obtain a higher yield of desirable products such as gasoline, diesel fuel, and propylene, and less of undesirable products like heavy cycle oil and coke. Rive was recently honored with AlwaysOn's GoingGreen East 50 award for the disruptive potential of its catalyst technology as a cleantech solution.



Javier Garcia Martinez

Javier received his BS, MS, and Ph.D. in chemistry at the University of Alicante, Spain, where he currently leads the Laboratory of Molecular Nanotechnology.

www.weforum.org
www.rivetechnology.com

Deliang Chen Takes the Helm at ICSU

Professor Chen will provide critical leadership as ICSU moves into the exciting second stage of its Strategic Plan 2006–2011.

On 1 February 2009, Deliang Chen became executive director of ICSU, a non-governmental organization with a global membership of national scientific bodies representing 136 countries. In announcing the news, ICSU President Catherine Bréchignac said "This appointment reflects ICSU's commitment to strengthening international science for the benefit of society. [Chen] brings with him a wealth of expertise, as a leader and an academic, at a key point in ICSU's evolution."

Chen is an internationally renowned climate researcher and is currently a professor of Physical Meteorology and the August Röhss Professor of Physical Geography at the University of Gothenburg in Sweden. He completed his Ph.D. under the guidance of Nobel Prize winner Paul Crutzen, before joining the University of Gothenburg in 1993, where he became a full professor in 2000—at the age of 38. His research interests include regional climate change and variability in Sweden and China, climate dynamics, air pollution, and geostatistics. He is a prolific author with more than 100 peer-reviewed scientific publications, including contributions to the Assessment Report of the Intergovernmental Panel on Climate Change, and has served as an editor on many leading journals.

"I am very excited at the prospect of leading ICSU as it continues to be one of the world's foremost organizations for science," said Chen, "and I look forward to expanding ICSU's activities with integration and interaction among different disciplines, young scientists, and the developing world."

Chen replaces Thomas Rosswall who is retiring after seven years at the helm.

About ICSU

Founded in 1931, ICSU is frequently called upon to speak on behalf of the global scientific community and to act as an advisor in matters ranging from the environment to conduct in science. ICSU's activities focus on three areas: planning and coordinating research; science for policy; and strengthening the Universality of Science. IUPAC is a member of ICSU.

www.icsu.org

Postgraduate Course in Polymer Science

The thirteenth presentation of this course, offered at the Institute of Macromolecular Chemistry, Academy of Sciences of the Czech Republic, Prague, Czech Republic, has been in progress since October 2008 and will end with a final seminar in July 2009. IUPAC support has enabled the organizers to increase the number of students participating in the course to eight. The lecture course of 50 hours in advanced polymer science is still in progress. Most of the time, the students work on research projects under the supervision of senior scientists of the institute. The names of the students, their home countries, their project titles, and names of their supervisors are as follows:

Student (Country): *Project*	**Supervisor**
Mohammed El Amine Belaouedj (Algeria): *Biomaterials for Tissue Engineering*	Dr. Jiri Michalek
Patrycja Bober (Poland): *Synthesis and Characterization of Polyaniline and Its Nanostructures*	Dr. Jaroslav Stejskal
Katarzyna Depa (Poland): *Hybrid Materials and Hydrogels*	Dr. Adam Strachota
Bojan Dimzoski (Macedonia): *Rheology and Phase Structure of Immiscible Polymer Blends*	Prof. Ivan Fortelny
Ricardo Kejtek Donato (Brazil): *Nanocomposite Systems Based on Organic-Inorganic Polymers*	Dr. Libor Matejka
Alessandro Jager (Brazil): *Design, Preparation, and Characterization of Polymeric Nanoparticles for Biological and Technical Applications*	Dr. Petr Stepanek
Samrana Kazim (India): *Plasmonic Polymer Nanocomposites for Optoelectronic Applications*	Dr. Jiri Pfleger
Valentin Sukhanov (Russia): *Multiphase Matrix Nanocomposites: FEM Modeling*	Dr. Ivan Kelnar

More than half of the projects are likely to be published in international journals or communicated at meetings. Detailed information about the course can be found at <www.imc.cas.cz/en/imc/unesco.html>.

Cumulative results from the 13 times the course has been offered so far include 104 graduates and current students; 16 nationalities represented; 132 publications in international journals; 187 communications at international meetings; and 1 169 citations, excluding self-citations (as of December 2008).

For more information and comments, contact Task Group Chair Pavel Kratochvil <krat@imc.cas.cz>.

www.iupac.org/web/ins/2007-049-1-400

Toward a Comprehensive Definition of Oxidation State

The purpose of this two-year project is to obtain a comprehensive definition of the term "oxidation state," which is the oxidation number of an atom in a molecular entity or an extended structure. An algorithm and its validity limits for unambiguous evaluation of the oxidation state/number will be worked out. A glossary of related terms will be produced. The project will review and evaluate the currently used definitions of oxidation state/number in textbooks and articles. These electron-counting schemes will be scrutinized for universality on chemical entities, such as uncharged and charged atoms and molecules (simple or clusterlike, ions or radicals) as well as extended structures, in order to determine whether a simple algorithm is applicable and what its validity limits are. After a reviewing process, the report will eventually be submitted as Recommendations for *Pure and Applied Chemistry*. Relevant definitions on the *IUPAC Gold Book* website will be updated.

The members of the task group are all professors with long-term experience in teaching relevant parts of chemistry: Patrick McArdle, Galway, Ireland (organometallic chemistry); Reinhard Nesper, Zürich, Switzerland (inorganic and nanochemistry); Josef Takats, Edmonton, Canada (inorganic and organometallic chemistry); Kazuyuki Tatsumi, Nagoya, Japan (clusters and organometallics); and Pavel Karen, Oslo, Norway (inorganic and solid-state chemistry).

For more information and comments, contact Task Group Chair Pavel Karen <pavel.karen@kjemi.uio.no>.

www.iupac.org/web/ins/2008-040-1-200

IUPAC International Chemical Identifier—InChI Update

The final InChI version 1.02 software was issued in January 2009 as an implementation for generating Standard InChI (see below) and the corresponding Standard InChIKey. The complete package, which can be downloaded at <www.iupac.org/inchi/download/>, contains:

- source code and Application Program Interface (API)
- stand-alone executables for Windows and Linux (stdinchi-1.exe, stdwinchi-1.exe, and stdinchi-1.gz)
- description of new features, with examples using new functionality
- copy of GNU LGPL license

Standard InChI

In response to user requests, a Standard InChI (i.e., without options for such properties as tautomerism and stereoconfiguration) has been defined as follows:

- Standard InChI is for the purposes of interoperability/compatibility between large databases/web searching and information exchange.
- Standard InChI and nonstandard InChI are always distinguishable.
- Standard InChI is a stable identifier. However, periodic updates may be necessary; they are reflected in the identifier version designation, which is included in the InChI string.
- Any shortcomings in standard InChI may be addressed using nonstandard InChI (currently obtainable using InChI v. 1.02beta).

Standard InChIKey

In response to user feedback, the format of InChIKey has been changed; it is different from that in InChI software v. 1.02 beta, having 27 characters rather than 25. Standard InChIKey has five distinct components:

1. 14-character hash of the basic (mobile-H) InChI layer
2. 8-character hash of the remaining layers (except for the "/p" segment, which accounts for added or removed protons. It is not hashed at all; the number of protons is encoded at the end of the Standard InChIKey.)
3. 1 flag character
4. 1 version character
5. a [de]protonation indicator as the last character

The overall length of InChIKey is fixed at 27 characters, including separators (dashes):

AAAAAAAAAAAAAA-BBBBBBBBFV-P

This is significantly shorter than a typical InChI string:

1. AAAAAAAAAAAAAA is a 14-character hash.
2. BBBBBBBB is an 8-character hash.
3. F is a flag indicating standard InChIKey (produced out of standard InChI), which always has the value "S."
4. V is a flag for InChI version character: "A" for version 1, "B" for version 2, and so forth.
5. P is an indicator for the number of protons; this number is not encoded in the hash but is indicated as a separate two-character block at the end where one character is a hyphen, as –N for neutral, –M for –1 hydrogen, –O for +1 hydrogen, and so forth.

Full details and examples are provided in the documentation accompanying the software download.

Software implementing the final InChI version 1.02 for nonstandard InChI (i.e., with all previous options retained and with the 27-character InChIKey) will be issued in due course.

Users are encouraged to report their experiences and any problems via the SourceForge website <sourceforge.net/projects/inchi>.

www.iupac.org/inchi/release102final.html

Humic-Metal Binding Constants Database

The physicochemical form in which a trace element occurs (i.e., its speciation) determines its mobility, bioavailability, and toxicity in the environment. In natural waters and soils, trace element reactions with natural organic matter (NOM) have been shown to play decisive roles in trace element chemistry. In particular, the fraction of NOM more refractory to degradation, often known as "fulvic" and "humic" compounds, has proven to be particularly important, and a significant amount of research has been devoted to its characterization as well as to the determination of binding constants with trace elements. However, in spite of this effort, the difficulties encountered when trying to compare complexation constants reported in the literature or to find constant values for less-studied elements are well known. This is because our ability to measure and interpret the complexation equilibria of NOM is severely constrained by its complex characteristics that hinder the application of common experimental and interpretation methods. This has led, for instance, to the development of a wide range of interpretation models for the representation and quantification of its binding properties, making it more difficult to apply such data.

Because no systematic compilation of published data exists, this project is gathering data published over the past 40 years. The long-term aim is the critical analysis and interpretation of all data published for complexation of trace elements with NOM in natural water systems. This will provide a robust framework for further research. The first step of the project is to develop a comprehensive database of published values for humic substances. At present, some information is difficult to access, because it has been published in journals or reports not readily available. For this reason, the project initially will be devoted to the collection of all available data. Any scientist willing to collaborate is encouraged to send to the project team copies of articles and reports containing data on binding of trace elements by humic substances.

For more information and comments, contact Task Group Chair Montserrat Filella <montserrat.filella@cabe.unige.ch>.

www.iupac.org/web/ins/2008-025-1-500

Provisional Recommendations

Provisional Recommendations are drafts of IUPAC recommendations on terminology, nomenclature, and symbols made widely available to allow interested parties to comment before the recommendations are finally revised and published in Pure and Applied Chemistry. Full text is available online.

www.iupac.org/reports/provisional

Convention on the Use of Units for Time in Earth and Planetary Sciences

The units of time (both absolute time and duration) most practical to use in Earth and Planetary Sciences are multiples of the year, or annus (a). Its proposed definition in terms of the fundamental SI unit for time, the second (s), for the epoch 2000.0 is 1 a = 3.1556925445×10^7 s. Adoption of this definition, and abandonment of the use of distinct units for time differences, will bring the Earth and Planetary Sciences into compliance with the SI standard regarding units of time.

Comments by 30 June 2009
Dr. Igor Villa
Institut für Geologie
Universität Bern
CH-3012 Bern, Switzerland
E-mail: igor@geo.unibe.ch

Explanatory Dictionary of Key Terms in Toxicology, Part II

The objective of the Explanatory Dictionary of Key Terms in Toxicology is to give full explanations of the meaning and usage of toxicological terms chosen for their importance and complexity with regard to the merging of chemistry into toxicology. This requires a full description of the underlying concepts, going beyond a normal dictionary definition. Often linguistic barriers lead to problems in obtaining a common understanding of terminology at an international level and between disciplines. The explanatory comments should help to break down such barriers.

This dictionary is a follow up and continuation of part I published in 2007 (*Pure Appl. Chem.*, 2007, Vol. 79, No. 9, pp. 1583-1633; doi:10.1351/pac200779091583). It consists of a collection of terms chosen from the IUPAC Glossary of Terms Used in Toxicology. These terms are organized under 19 main headings.

Comments by 31 August 2009
Monica Nordberg
Institute of Environmental Medicine
Karolinska Institutet
SE-171 77 Stockholm, Sweden
E-mail: monica.nordberg@ki.se

Immunological Effects of Mercury (IUPAC Technical Report)

by Michael Schwenk, Reinhild Klein, and Douglas M. Templeton

Pure and Applied Chemistry, 2009
Vol. 81, No. 1, pp. 153–167

Various chemical species of mercury differ considerably with regard to their route of absorption and their distribution in the body, yet many of them and their metabolites exhibit high-affinity binding to sulfanyl groups of proteins. Among all metals, mercury appears to have the most diverse effects on the immune system. Depending on the animal species and experimental conditions, mercury compounds may cause immunosuppression or immunostimulation, autoimmune reactions, or hypersensitivity. Mercury-sensitive strains of rats and mice are often used as model organisms to study the time course and events in autoimmunity. Within about 14 days after the onset of oral mercury (II) exposure, levels of immunoglobulins E and G (IgE and IgG) increase, including autoantibodies to biomolecules, such as laminin and fibrillarin. Antigen-antibody complexes are formed and are the cause of subsequent autoimmune diseases of blood vessels and organs. Mercury may induce local mercury hypersensitivity in humans, but the evidence for mercury's role in autoimmune disease in humans is weak at best. Models for the immune effects of mercury are presented on the basis of current knowledge.

This report completes a project of the Chemistry and Human Health Division on the immunochemistry of metal sensitization (project 1999-047-1-700).

http://dx.doi.org/10.1351/PAC-REP-08-04-02

Teaching High-Temperature Materials Chemistry at University (IUPAC Technical Report)

by Giovanni Balducci, Andrea Ciccioli, Giovanni de Maria, Fiqiri Hoda, and Gerd M. Rosenblatt

Pure and Applied Chemistry, 2009
Vol. 81, No. 2, pp. 299–338

Over the last four to five decades, high-temperature materials chemistry (HTMC) has flourished and expanded as a challenging area of scientific and applied research, spurred by a growing demand for new inorganic materials (such as neoceramics, intermetallics, superalloys) able to withstand extreme thermal and chemical environments. Such high-temperature environments are ubiquitous in combustion, nuclear energy, and space technologies and are also encountered in new, more efficient processes for the synthesis, recycling, and refining of materials. The advancement of HTMC has seen a synergic interchange between basic and applied research, with the application of thermodynamics, kinetics, and a variety of physical, chemical, and modeling techniques. This fertile field of interdisciplinary research has its origins in modern high-temperature chemistry, which led to an understanding of the fundamental ways in which chemical properties and behaviors differ at high temperatures from those encountered at more moderate temperatures.

As systematic knowledge of the chemical and physical behavior of materials at high temperatures accumulated—accompanying progress in the production, control, and measurement of temperatures up to 3 000 degrees K and beyond, and by the extension of the high-temperature regime to most measurement and diagnostic techniques—the unusual high-temperature behavior of materials' properties and reactivity emerged, often dramatically different from those expected near to room temperature. Accepted generalizations in chemical behavior at ordinary temperatures are no longer valid at high temperature: The high-temperature reactivity of materials is ruled by thermodynamic properties rather than kinetics; condensed phase–gas phase processes become increasingly important in the number and complexity of chemical species; reactions tend to be entropy rather than enthalpy, controlled with increasing temperature; and unusual new compounds and molecular species appear with unfamiliar oxidation states stabilized by the high-temperature conditions. Also, stoichiometric solids extend their range of homogeneity, and often unstable, nonstoichiometric phases are stabilized in the high-temperature domain. This chemical behavior influences the physical properties of materials and renders invalid predictions based on extrapolation from room-temperature properties.

Despite the important role played by HTMC in modern advanced technology and the considerable progress by research in the field, HTMC topics are rarely addressed in chemistry and materials science programs at the university level, and no textbook exists that is specifically devoted to HTMC topics. It is therefore important to make efforts to fill this educational gap and to introduce students of chemistry and materials science to the concepts underlying the behavior of materials and chemical bonding at high temperatures. IUPAC project 2000-024-2-200 (Teaching High-Temperature Materials Chemistry at University), under the auspices of the IUPAC Inorganic Chemistry Division, aimed to fulfill this function. The final report of the project task group is a resource book on the properties and behavior of high-temperature materials for those teaching materials science or physical or inorganic chemistry at various levels. The report includes an introduction and seven sections covering historical background, chemical behavior of condensed phase–gas phase systems at high temperatures, basic concepts of materials thermodynamics, experimental techniques, use of thermodynamic data and modeling, vaporization and decomposition processes, and gas-solid reactions. The ninth section covers more specific topics, mostly concerning applications of high-temperature materials and processes. Each recommended topic is accompanied by a bibliography of helpful references, a short introduction or explanation that includes areas of application, and some relevant teaching suggestions. An extensive annotated resource bibliography is an appendix to the report.

http://dx.doi.org/10.1351/PAC-REP-08-05-01

Guidelines for Rheological Characterization of Polyamide Melts (IUPAC Technical Report)

by Dick J. Dijkstra
Pure and Applied Chemistry, 2009
Vol. 81, No. 2, pp. 339–349

Most producers of polyamide have their own characterization methods to study the rheological properties of polyamide 6 (PA6). However, the measured rheological properties depend strongly on the sample preparation method, humidity regulation, and time-temperature history during the measurement, not to mention the kind of rheometer being used. This investigation is the result of an IUPAC project initiated by the Subcommittee on Structure and Properties of Commercial Polymers (project 2004-009-1-400). Members of several industrial organizations, universities, and institutes cooperated, with the aim of formulating a guideline to measure reproducible rheological properties of PA6. The results of the investigation show the changes in molecular weight during different kinds of rheological measurements due to hydrolysis and amidization reactions. A guideline is introduced that can be used to make comparable rheological measurements on PA6.

http://dx.doi.org/10.1351/PAC-REP-08-07-22

Dispersity in Polymer Science (IUPAC Recommendations 2009)

by Robert F.T. Stepto
Pure and Applied Chemistry, 2009
Vol. 81, No. 2, pp. 351–353

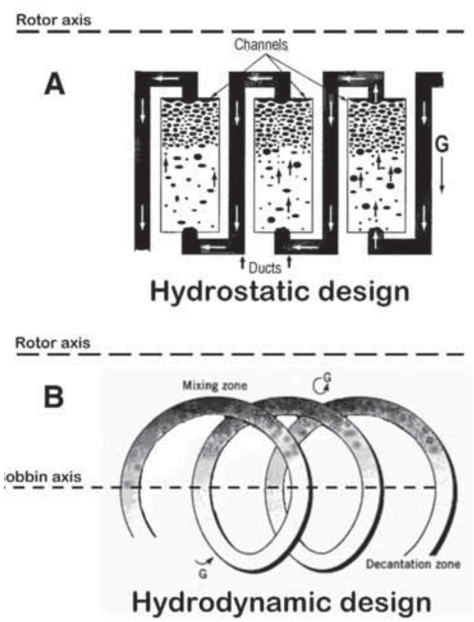
This recommendation defines just three terms: (1) molar-mass dispersity, (2) degree-of-polymerization dispersity, and (3) dispersity. “Dispersity” is a new word, coined to replace the misleading but widely used term “polydispersity index” for $\overline{M}_w/\overline{M}_n$ and $\overline{X}_w/\overline{X}_n$. The document, although brief, also has a broader significance in that it seeks to put the terminology describing dispersions of distributions of properties of polymeric (and nonpolymeric) materials on unambiguous and justifiable footing. The general symbol *Đ*, pronounced “D-stroke,” is introduced for dispersity to avoid confusion with the conventional use of *D* for diffusion coefficient.

http://dx.doi.org/10.1351/PAC-REC-08-05-02

Countercurrent Chromatography in Analytical Chemistry (IUPAC Technical Report)

by Alain Berthod, Tatyana Maryutina, Boris Spivakov, Oleg Shpigun, and Ian A. Sutherland
Pure and Applied Chemistry, 2009
Vol. 81, No. 2, pp. 355–387

“Countercurrent chromatography” (CCC) is a generic term covering all forms of liquid-liquid chromatography that use a support-free liquid stationary phase held in place by a simple centrifugal or complex centrifugal force field. Biphasic liquid systems are used, with one liquid phase being the stationary phase and the other being the mobile phase. Although initiated almost 30 years ago, CCC lacked reliable columns. However, the newly designed centrifuges appearing on the market



Schematic view of the liquid motion in CCC columns.

A—Hydrostatic columns or centrifugal partition chromatographs. There is a single axis of rotation producing constant centrifugal field (G) and no phase exchanges in the connecting ducts.

B—Hydrodynamic columns. There is a variable and cyclic centrifugal field (G) produced by the planetary rotation of the bobbin around its own axis and the central rotor axis. Contact between the two liquid phases occurs throughout the tubing. The mobile phase is pictured in black, and the stationary phase is white.

now make excellent CCC columns. This review focuses on the advantages of a liquid stationary phase and addresses the chromatographic theory of CCC. The main difference with classical liquid chromatography (LC) is the variable volume of the stationary phase. There are two different ways to obtain a liquid stationary phase using centrifugal forces: the hydrostatic way and the hydrodynamic way. These two kinds of CCC columns are described and compared. The reported applications of CCC in analytical chemistry and comparison with other separation and enrichment methods show that the technique can be successfully used in the analysis of plants and other natural products, for the separation of biochemicals and pharmaceuticals, for the separation of alkaloids from medical herbs, in food analysis, and so forth. On the basis of the studies of the last two decades, recommendations are also given for the application of CCC in trace inorganic analysis and in radioanalytical chemistry.

http://dx.doi.org/10.1351/PAC-REP-08-06-05

A Global Science Gateway

by Wendy Warr

WorldWideScience.org is a global science gateway connecting researchers to national and international scientific databases and portals in such fields as energy, medicine, agriculture, environment, and basic sciences. Much of the information is in the public domain. The gateway enables anyone with Internet access to launch a single-query search of 375 million pages of scientific and technical information in more than 40 databases and portals from more than 50 countries, covering 6 continents and three quarters of the world's population. This information is not typically accessible through popular search engines. WorldWideScience.org is a powerful tool for enhanced scientific communication. It is intended to accelerate international scientific progress by serving as a single, sophisticated point of access for diverse scientific resources and expertise from nations around the world.

Popular search engines, such as Google, generally cannot search in the deep web where most research is found. The deep web is huge: Some experts estimate that it is more than 500 times the size of the surface web, where popular search engines operate. Federated search tools <www.osti.gov/fedsearch> are necessary to access the deep web. WorldWideScience.org provides federated searching, allowing an information patron to search multiple data sources with a single query from the user interface. When the user enters a query in the search box, the query is sent to every individual database or portal searched by WorldWideScience.org. The individual data sources send back lists of results from the search query, and WorldWideScience.org then ranks all the hits in order of relevance. The information patron can review this hit list and travel to the host site of a particular hit for more detailed information. In one query, users can search multiple databases at one time, sort through the information in various ways, and obtain relevant results on the desktop in a matter of seconds.

Federated searches are inherently as current as the individual data sources, as the sources are searched in real time. By default, the hits are displayed in rank order, but they can be sorted by other parameters. An Advanced Search option is also offered, allowing searches of combinations of databases and in specific fields. WorldWideScience.org relies on federated search technology provided by Deep Web Technologies of Santa Fe, New Mexico <www.deepwebtech.com>.

Representatives from some of the 38 countries that signed the WorldWideScience Alliance Agreement in Seoul, Korea, on 12 June 2008.

WorldWideScience.org was modeled after Science.gov <www.science.gov/about.html>, the U.S. gateway to major government science information. The global gateway was developed and is maintained by the Office of Scientific and Technical Information, an element of the Office of Science within the U.S. Department of Energy. The WorldWideScience Alliance <http://worldwidescience.org/alliance.html> provides the governance structure for WorldWideScience.org.

The seeds of the alliance were sown in January 2007 in London, when Raymond Orbach, U.S. undersecretary for science, and Lynne Brindley, chief executive of the British Library, signed a statement of intent to create an international gateway. Since then, a multilateral partnership has been formed to provide a geographically diverse, long-term governance structure. The transition to multilateral governance began in June 2007 at the International Council for Scientific and Technical Information (ICSTI) General Assembly in Nancy, France. On 12 June 2008, officials from 11 organizations representing 38 countries gathered at an ICSTI meeting in Seoul, South Korea, to formalize their commitment to sustain and to build upon the online gateway to the world's science information. In October 2008, the People's Republic of China became the most recent nation to join the alliance. The Institute of Scientific and Technical Information of China, a component of the Chinese Ministry of Science and Technology, will represent the country. In addition to the member countries of the alliance, ICSTI will serve as a member and primary sponsor for WorldWideScience.org. Other nations are invited to participate.

Wendy Warr <wendy@warr.com> is the IUPAC representative to ICSTI.

http://worldwidescience.org

Polymer International – IUPAC Award 2009 for Creativity in Applied Polymer Science or Polymer Technology

Call for Nominations!

IUPAC POLYMER DIVISION

Recognize the achievements of your colleagues by nominating them for this award.

Your nominee could win $US 5,000!

The Executive Editors of **Polymer International** and the **IUPAC Polymer Division** are proud to announce the second award for creativity in applied polymer science or polymer technology. This award celebrates the achievements of young researchers in the polymer community.

The award will be presented at the **IUPAC World Polymer Congress – MACRO 2010**, 11-16 July 2010 in Glasgow, UK. The winner will be awarded **US$ 5,000** plus travel and hotel accommodation expenses to attend MACRO 2010, where he/she will present a keynote lecture.
The winner will be selected by the Scientific Committee, representing Polymer International and the IUPAC Polymer Division after 30th November 2009.

Please send your nominations by email to Polymer International: polyint@wiley.com before 30th October 2009.

WILEY

Nominees must be aged under 40 years on 31st December 2010, and must be available to present a keynote lecture at MACRO 2010.

Please include the following information in your nomination:

- Your name and address
- Full name and date of birth of nominee
- Business address of nominee
- Nominee's academic background and education (college or university, location, major field, degree, year awarded)
- Nominee's employment history (position, organization, duties, dates)
- Nominee's publications, patents, unpublished reports, papers presented at meetings (please include a list of those you deem pertinent)
- Nominee's Honor's and awards
- Scientific achievements for which the candidate is nominated for this award
- Self nominations will not be accepted

For futher details please go to:
www.interscience.wiley.com/polymerinternational
clicking on 'News'

Interactions of Soil Minerals with Organic Components and Microorganisms

by P. Ming Huang

The **5th International Symposium on Interactions of Soil Minerals with Organic Components and Microorganisms (ISMOM)** was held in Pucon, Chile, 24–28 November 2008. This symposium was the 2nd Inter-Congress Conference of Commission 2.5 Soil Physical/Chemical/Biological Interfacial Reactions of the International Union of Soil Sciences. The theme of this symposium was on soil-root–microbe interactions and the impact on the transformations and fate of nutrients and pollutants in the ecosystem. This symposium successfully brought together environmental chemists, mineralogists, microbiologists, ecologists, toxicologists, and soil scientists to share information, identify gaps in knowledge, and stimulate research on the physicochemical and biological interfacial interactions in soil and related environments, with special focus on the soil-root interface (rhizosphere).

Four plenary lectures, 11 keynote addresses, 47 oral papers, and 157 posters were presented over five days during the following sessions:

- Ecological Significance of Interactions among Clay Minerals, Organic Matter, and Biota
- Soil-Root Microbe Interactions and their Effects on the Transformation and Bioavailability of Nutrients
- Soil-Root-Microbe Interactions and their Effects on the Biophysico-Chemical Transformation, Fate, and Toxicity of Metals and Metalloids
- Dynamics and Transformations of Natural Organics and Xenobiotic Compounds
- Environmental Biotechnology: Biochemical and Molecular Mechanisms of Microbe-Plant-Root Interactions and their Genomic and Proteomic Advances Pertaining to Restoration of Contaminated Sites

The symposium was attended by over 200 participants from 36 countries in five continents. It was a major step forward in establishing effective avenues of communication among relevant scientists in developing and developed countries about how to protect and sustain the global environment.

Full details of the conference program, including a list of speakers and lecture titles are available at <www.ismom2008ufro.cl>.

The chair of ISMOM 2008 was Maria de la Luz Mora. This symposium was sponsored and financially supported by IUPAC, the Organization for the Prohibition of Chemical Weapons, the National Council of Science and Technology of the Chilean Ministry of Education, and La Frontera University, Temuco, Chile.

P. Ming Huang <pan.huang@usask.ca>, a professor emeritus of the University of Saskatchewan in Saskatoon, Canada, is a titular member of IUPAC Division of Chemistry and the Environment and the IUPAC representative to ISMOM 2008.

Biotechnology for the Sustainability of Human Society

by Fengwu Bai

Our society is facing unprecedented challenges such as a shortage of resources, threat of infectious diseases, loss of biodiversity, deterioration of the environment, and an imbalance of economic and social development. The **13th International Biotechnology Symposium & Exhibition (IBS-2008)**, held 12–17 October 2008 in Dalian, China was more timely than ever: Its theme was Biotechnology for the Sustainability of Human Society.

The 2001 Nobel Laureate Barry K. Sharpless, from the Scripps Research Institute, USA, opened the plenary session with a lecture on the "Secret Lives of Enzymes," in which he explained "Click Chemistry." Click chemistry is the use of chemical building blocks

Werner Arber (left), Nobel Laureate from the University of Basel, Switzerland, with Zhu Chen, Minister of Health in China.

tailored to generate substances quickly and reliably by joining small units together. Combined with combinatorial chemistry, it makes new drug discoveries faster, more efficient, and predictable. The next lecture was delivered by Huanming Yang, founder of BGI, a state-of-the-art genome research institute, and coordinator in China of the International Human Genome Sequencing Consortium. His lecture reported on the breakthrough in genomics and its impacts on various aspects of human society.

Research in marine biotechnology is addressing largely unexploited biological resources. Jan A. Olafsen, of the University of Tromsoe, Norway, and president of the European Society for Marine Biotechnology and International Marine Biotechnology Association, highlighted the prospects and challenges of marine biotechnology. Guo-Hua Miao, director and general manager of the DuPont China R&D Center, illustrated achievements in the application of biotechnology for the production of biofuels and biobased-chemicals from renewable biomass resources. Tohru Nishiyama, the former president of Ajinomoto Co., Inc., Japan, reviewed the history, current status, and prospect of bioscience and bioindustry in Japan. David A. Fischhoff, vice president of the Technology Division at Monsanto Company, USA, emphasized the importance of biotechnology in improving crop yields and traits, such as tolerance to abiotic stresses, to meet expanding demands on food, feed, and fuels.

On the last day of the conference, Zhu Chen, minister of health in China, presented the government's roadmap for the biopharmaceutical and healthcare industries, which includes a commitment of the government to the sustainability of the largest population in the world. The next plenary lecture was delivered by Werner Arber, the Nobel Laureate awarded for his discovery of restriction enzymes. Arber discussed the many positive impacts of biotechnology on society.

In addition to the 8 plenary lectures, 57 keynotes, 142 invited lectures, and 149 oral presentations were made during the 47 sessions of the conference's 9 parallel sections: I) Systems Biology, II) Tissue Engineering and Cell Cultivation, III) Medical Biotechnology, IV) Agricultural Biotechnology, V) Industrial Biotechnology, VI) Marine Biotechnology, VII) Environmental Biotechnology, IIIV) Food Biotechnology, and IX) Biosafety and Bioeconomy.

In addition, three special sessions were organized in conjunction with the conference. They addressed international collaboration, professional training and education, and development of the biotechnology industry in China and Asia . More than 2000 delegates from academia, industry, and government attended the conference. Among them, 1146 were from 80 countries other than China.

With the sponsorship of Elsevier, the proceedings of IBS-2008, including 1755 abstracts selected by the scientific committee, were published in the *Journal of Biotechnology* as a supplement (136S, October 2008).

The awards ceremony for young scientists and students at IBS-2008.

IBS-2008 featured the first-ever Young Scientists and Students Awards, sponsored by British Petroleum. The awards showcased the best of the next generation of biotechnology research leaders and their research endeavors. Twenty award winners from Australia, China, Croatia, Germany, Japan, the USA, Russia, and South Korea were honored before the closing ceremony. A medal and prize of USD 1500 were awarded to each of them by Werner Arber and Yulin Dai, deputy mayor of Dalian.

The IUPAC Subcommittee on Biotechnology held its member meeting during IBS-2008. At the meeting, it was decided to hold the IBS series every two years instead every four due to the explosion of knowledge in the field. The 14th IBS will be held 15–19 September 2010 in Rimini, Italy. For more information, visit <www.ibs2010.org>.

Fengwu Bai <fwbai@dlut.edu.cn> is a professor in the Department of Bioscience and Bioengineering at the Dalian University of Technology, China. He is a member of the Subcommittee on Biotechnology.

From Molecular Understanding to Innovative Applications of Humic Materials

by Irina V. Perminova

The **14th Meeting of the International Humic Substances Society (IHSS-14)**, held 14–19 September 2008 in Moscow-Saint Petersburg, Russia, focused on "From Molecular Understanding to Innovative Applications of Humic Materials." The IHSS meeting was the first to take place in Russia and the first with IUPAC sponsorship. The conference set fairly ambitious goals: to demonstrate the growing importance of humic substances in the context of global climate change, and to draw the attention of industrial chemists to conversion of huge resources of humified biomass to alternative feedstock for bio-based products.

The conference venue was the four-deck ship *Leonid Krasin*, which traveled from Moscow to Saint Petersburg along the Moskva and Volga Rivers and Volga-Balt Channel. Holding the conference on the ship created a very special atmosphere, making everyone feel as though they were a member of the crew. Five days of wandering through the landscapes of the Russian North—in the middle of nowhere—turned out to be very productive: both scientifically and socially. There were 261 participants, 60 of them students. The conference had strong international appeal, with participants from 35 countries and 6 continents. The major party was from Russia, which had 69 participants, followed by the USA (32), Germany (22), Brazil (18), France (15), Italy and Poland (11 each), Japan (9), and all other countries.

The topic of the conference was inspired by the movement to achieve bioeconomy, which implies a broad use of bioproducts, biofuel, and bioenergy. Humic materials occupy a transitory niche between fossil rocks and fresh biomass, with its sources encompassing different stages of biomass humification from mature lignites, peats, and sapropels, to young composts, vermicomposts, and activated sludges. Along with biomass, these significant biogenic resources can be seen as alternative stocks for green chemistry and technology implications.

Conference attendees on the ship Leonid Krasnin.

Symbolically, the opening session of the IHSS-14 conference was held jointly with the Second IUPAC Green Chemistry Conference. The conference was opened by the Academician of RAS Valery Lunin, dean of the Department of Chemistry at Lomonosov Moscow State University. Natalia Tarasova welcomed the conference participants from INTAS with an address by IUPAC President Jung-Il Jin. Two presentations followed, one by Valery Charushin (Ural Branch of RAS, Russia) on the principles of green chemistry in organic synthesis, and another by Joe Bozell (University of Tennessee, USA) on technical and macroeconomic aspects of production value-added bioproducts from lignin.

The eight invited speakers and their topics were as follows:

- Alain-Yves Huc, Institut Francais du Petrole, Paris, France: "Sedimentary Organic Matter in the Earth System: Origin and Fate"
- Philippe Schmitt-Kopplin, German Research Center for Environmental Health, Munich, Germany: "High Resolution and Hyphenated Analytics as Tools for Exploring Chemical Space of HS and NOM from Various Environments"
- Steve Cabaniss, University of New Mexico, Albuquerque, USA: "Agent-Based Modeling of Natural Organic Matter"
- Claudio Ciavatta, University of Bologna, Italy: "Standardization and Legislative Regulations of Commercial Humic and Humic-Based Products"
- John D. Coates, University of Berkley, USA: "Primary Energy Production by Photoreduced Humic Materials"
- Masami Fukushima, Hokkaido University, Sapporo, Japan: "Biomimetic Catalysts: Oxidative Degradation of Chlorophenol by Iron-Porphyrin Catalyst Bound to Humic Acid via Formaldehyde Polycondensation"
- Yona Chen, New Jerusalem University, Rehovot, Israel: "Organo-Mineral Complexes and their Effects on the Physico-Chemical Properties of Soils"

- Norbert Hertkorn, German Research Center for Environmental Health, Munich, Germany: "Depicting Molecular Dissimilarity in Complex Materials"

In addition to the invited speakers, there were 32 contributed oral presentations. The six poster sessions were lively and well attended. There were also eight particularly intense round table discussions which ran in parallel after dinner time.

Some of the products on display at the satellite exhibition on "Humic Materials—Materials for the 21st Century."

Of the five main topics for the meeting, two focused on humic substances as indicators of global climate change and anthropogenic repercussions in soil and water ecosystems, with one each on molecular understanding of humic substances and natural organic matter, knowledge-based design of new humic materials, industrial production of humates, and innovative applications of humic materials. Attendance at all sessions was generally high. Details of the program can be found at <www.ihss-14.humus.ru>.

A specific feature of the conference was a satellite exhibition on "Humic Materials—Resources for the 21st Century," which contributed greatly to participation of the business sector in the conference. The exhibitors were humate-producing companies from Russia, Hungary, Belorussia, and Germany. The catalog of the exhibition included profiles of 15 companies.

One highlight of the conference was the Honorary IHSS Membership Nomination and Award, presented to Roger Swift of the University of Queensland, Australia, for his contribution to humic science and to activities of the society. Jerzy Weber, the president elect, presented the award at the General Assembly of IHSS, held during the conference. Another highlight involved the adoption of a draft set of conclusions from the conference prepared by Irina Perminova, deputy head of the organizing committee. There was some criticism from participants concerned with the environment about the conclusions. An agreement was reached to open the presented draft for online discussion by placing it on the website of the conference <www.ihss-14.humus.ru>.

The program ended with a closing ceremony that included statements by Jerzy Weber and Irina Perminova. The conference was organized by Lomonosov Moscow State University and the Non-Commercial Partnership Center for Biogenic Resources "Humus Sapiens." It was sponsored by the Russian Foundation for Basic Research, Biomir Ltd., and Biocorrection Ltd. The conference was IUPAC sponsored as well.

Irina V. Perminova <iperm@org.chem.msu.ru> is the current associate member of the Chemistry and the Environment Division and is regional coordinator of the CIS IHSS chapter. She is affiliated with Lomonosov Moscow State University's Department of Chemistry.

D.I. Mendeleev and the Problems of Sustainable Development

by N.P. Tarasova, D.I. Mustafin, and E.-M. Lee

In February 2009, the world community celebrated the 175th anniversary of the birth of Russian scientist Dmitri Ivanovich Mendeleev (1834–1907). Celebratory conferences, exhibitions, scientific fora, and memorial symposia were held at venues throughout Russia, including the Russian Academy of Sciences (RAS) in Moscow and St Petersburg, D. Mendeleev University of Chemical Technology in Moscow, St Petersburg State University, D.I. Mendeleev Russian Chemical Society, the news agency ROSBALT, and many other academic and educational institutions.

The State Post Office of Russia produced, for 2009, a souvenir sheet of postage stamps in celebration of the life of D.I. Mendeleev. The Polytechnics Museum in Moscow featured an exhibition on "Russian Genius for Humankind" dedicated to Mendeleev's multifaceted career.

The centerpiece of the month-long celebration was the International Symposium on the Periodic Table of D.I. Mendeleev, which was held on 11 February 2009

IUPAC President Jung-Il Jin attended the celebration of the 175th anniversary of the birth of D.I. Mendeleev.

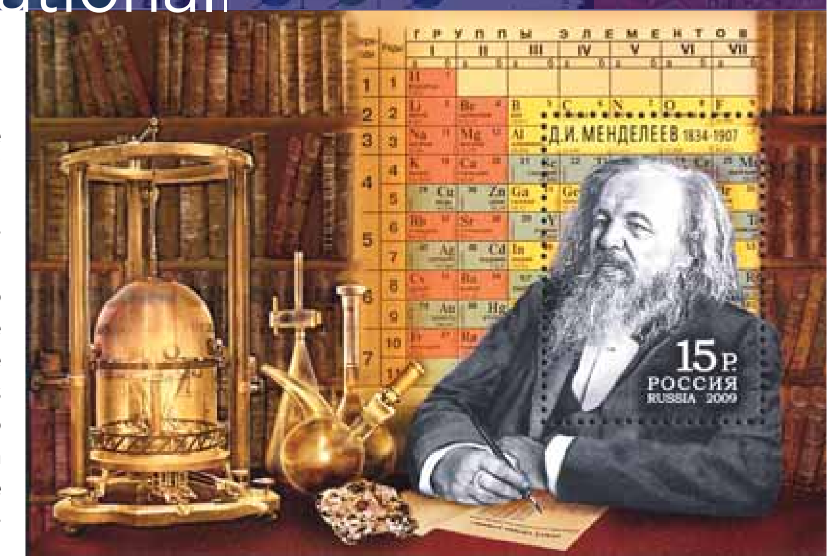
and organized by RAS. At the conference's opening ceremony, held in the great hall of RAS, the president of the RAS, Academician Y.S. Osipov, recalled a quote from the Russian chemist L.A. Chugaev about D. I. Mendeleev: "Brilliant chemist, first class physicist, faithful explorer in the fields of hydrodynamics, meteorology, geology and various branches of chemical technology and other associated disciplines of chemistry and physics; A great expert of chemical industries and industry in general. An exceptional Russian he was an original thinker in the field of the study of national economy and statesmanship, who unfortunately was not fated to become a statesman, but who saw and understood that the task and the future of Russia lay in the improvement of the representation of her official power."

In his address to the memorial conference the president of the Russian Federation D.A. Medvedev emphasized the significance of D.I. Mendeleev and his contribution to Russian science and wished all chemists a similar degree of fruitfulness in their work.

Stamps International

See also www.iupac.org/publications/ci/indexes/stamps.html

175 Candles and Counting



Much has been written about the renowned Russian chemist Dmitri Ivanovich Mendeleev (1834–1907) and the key role he played in the development of the modern periodic table. However, Mendeleev's contributions to science clearly extended beyond the realm of chemistry and ranged from the formulation of the definitive standards for the production of vodka (1894) to the introduction of the metric system (1899) in Imperial Russia. His influence was felt in fields as diverse as agriculture, physics, mineralogy and the oil industry and he was one of the most influential chemical educators of his time.

Illustrated herein is a souvenir sheet with a single stamp issued in Russia on 6 February 2009 to celebrate the 175th anniversary of Mendeleev's birth (which, according to most sources, actually occurred on 8 February 1834). Partially shown in the background is a colorful representation of the periodic table that resembles Mendeleev's 1905 version of the iconic chart, with the coinage metals incorporated into group I, and zinc, cadmium, and mercury placed with the alkaline earth metals. However, it is puzzling that radioactive elements such as francium and technetium, discovered long after Mendeleev's death, are also featured in this periodic table. In addition to a few pieces of glassware and a mineral sample, the sheet prominently displays a late-19th century precision balance, a clear tribute to Mendeleev's many contributions to metrology. This is also reflected in the name of the D.I. Mendeleev Institute for Metrology in St. Petersburg, one of the largest institutions in the world dedicated to all the theoretical and practical aspects of the science of measurement.

For a description of the different versions of Mendeleev's periodic table, see: Laing, M.J. *Chem. Educ.* 2008, 85, 63-67.

Written by Daniel Rabinovich <drabinov@uncc.edu>.

Also participating in the anniversary celebrations was IUPAC President Jun-Il Jin. His appearance in the great hall of the Russian Academy of Science was met by thunderous applause. In his lecture, Jin emphasized the outstanding results Mendeleev achieved in different fields of science and practice: chemistry, physics, hydrodynamics, meteorology, isomorphism, mineralogy, investigation of resources, geology, oil production, economics, aeronautics, Arctic exploration, state education, judicial expertise, cheese-making, the development of a customs tariff, and much more. Jun-Il Jin also emphasised the role of Russian chemical science in modern science. He noted that throughout the years there have always been distinguished Russian scientists in IUPAC: Academicians V.A. Koptyug, K.I. Zamaraev, and K.Ya. Kondratyev served as IUPAC presidents. The Academician O.M. Nefedov served a member of the Executive Committee of the IUPAC Bureau, and in the Bureau Russia is currently represented by N.P. Tarasova, the director of the Institute of Chemistry and Problems of Sustainable Development at D. Mendeleev University of Chemical Technology of Russia.

After the ceremony, Jung-Il Jin answered questions put forth by journalists and emphasized that today Mendeleev's work provides inspiration for new research, not only in chemistry but in the problems of sustainable development and ecology—fields that did not exist as individual areas of science in his time.

The celebrations in honor of the 175th anniversary of the Russian chemist occurred not only in Russia, but in many other countries around the world. They were significantly well attended and became the forerunners of the International Year of Chemistry. However, Dmitri Ivanovich Mendeleev would have given the organizers of these celebrations the cold shoulder. He did not like loud praise. When one of his students one day described him as a "genius," Mendeleev threw up his hands and cried as loudly as possible: "Some kind of genius! I've been working hard all my life, that does not make me a genius!"

IUPAC Bureau Member Natalia P. Tarasova with IUPAC President Jung-Il Jin at the D.I. Mendeleev conference.

Natalia P. Tarasova <nptar@online.ru> is the director of the Institute of Chemistry and Problems of Sustainable Development at the D. Mendeleev University of Chemical Technology, Russia. She is an elected member on the IUPAC Bureau and a member of the IUPAC Committee on Chemistry Education. Dimitry I. Mustafin <dim.moscow@gmail.com> is a professor at the. D. Mendeleev University of Chemical Technology of Russia. E.-M. Lee is a Ph.D. student at the D. Mendeleev University of Chemical Technology of Russia.

Mendeleev and Natural Resources

The opinions and views of Mendeleev are quoted in the books *Sacred Thoughts* and *To the Discovery of Russia*. His foresight about the origin and use of natural resources is no less meaningful than the periodic table of elements that made his name world famous. In Czarist Russia, Mendeleev's thoughts about resource exploration were not deservedly appreciated: Oil industry leaders were thinking only of the present day and today's issues, and not of sustainable development of the country and the communities of the future.

In the Soviet Union, Mendeleev's work in the fields of economics and resources exploration were criticized because he considered capitalism to be progressive and appreciated it's value.

The early life of the genius was not simple. The well-known Russian universities of Moscow and St. Petersburg refused to accept the 16-year old Mendeleev as a student. In 1855, he graduated from the Nature Department of the Physics and Mathematics Faculty of the St. Petersburg Pedagogical Institute and left to become a school master.

The first of Mendeleev's works, published in a scientific journal dedicated to mining while he was still a student, was concerned with resource exploration (resourceology). In this work Mendeleev considered the composition of minerals: orthite (basic silicate) and pyroxene $R2[Si_2O_6]$ R – Li, Na, Ca, Mg, Fe, Al. He was able to add new knowledge about the behavior of isomorphic crystals.

During the 1862–1863 academic year, when the University of St. Petersburg was closed due to student unrest and professors were free from teaching duties, Mendeleev became engaged in the compilation and editing of the *Technical Encyclopaedia*. This led to his enthusiasm for oil production and its enormous potential for Russia.

It is well known that Russia is considered to be the birthplace of the first industrial method of distilling oil. The first oil distillation factory was built in 1823 in the region of the town of Mozdok, by the free peasants of the brothers Dubinin. The first experiments in the distillation of oil occurred 10 years later in America. However, it was during this time that an illuminating American commodity materialized in St. Petersburg. It was first known as Photonaphtil or Photogen, and then as Kerosene. American kerosene, imported to Russia via the Atlantic Ocean became cheaper than Russian kerosene. Mendeleev became interested in this sad paradox and ascertained each overly laborious stage of the long journey of Bakinese kerosene to the capital of Russia via the Caspian Sea and Volga River in wooden barrels. He concluded that the outlay on the containers for a repeated shipment, warehouse storage, and transportation far exceeded the production cost of kerosene. Furthermore, the transportation method resulted in large amounts of wasted cargo due to contamination from other oil products.

In these conditions, Russian kerosene could not compete with American kerosene even in the internal market. Many Russian oil refining factories were functioning at a loss. In analyzing the situation, Mendeleev recommended interconnecting piping from the oil wells to the factory, and connecting pipes from the factory to the shipping dock. He suggested transferring oil products not in barrels but in specially designed tanks in the hold of the craft. Hence, the first of oil by tankers was initiated by the Astrakhan ship owners Nikolai and Dmitri Artemyevs on the freighter *Alexander*. After a prosperous journey from Baku to Astrakhan, the new method gained wide recognition not only in Russia but in the rest of the world, where it was known as the "Russian method." Thanks to the development of an economically viable method of transportation, Russian kerosene became a competitor on the export market.

Mendeleev was the first to discern the enormous value of oil for the national economy; he energetically insisted that oil be efficiently refined. As early as the 1880s he foresaw the potential of refining not just kerosene from oil but many other useful substances.

Mendeleev was aware of the dangers of creating a monopoly in oil production. He was convinced that monopolization would lead to a high price for oil, to an increase in demand, and eventually to the end of development. He advocated for the presence on the oil market of many large and small industrial developers.

In the summer of 1888, Mendeleev travelled to Donbas to study coal mining industries and sources and also potential methods for reducing the extraction of indigenous coal. As a result of his trip, he wrote a long and public article entitled "Future Strength Slumbering beneath the Banks of the Don." He was concerned not simply about his own time but about future generations. He was convinced that raw materials should be used wisely. "We could flood the world with oil, we can abundantly supply coal not just to our own industries, but to many places in Europe . . ., iron ore could be converted into any amount of cast iron, iron, and steel, and thus we could compete not only with England and Germany . . . but with the United States of America . . . Don coal, iron, and soda could supply the whole of western Europe."

Mendeleev foresaw that the extraction of coal would always be economically nonviable and exceedingly laborious. Even today, mineworkers frequently go on strike: on the Gorbaty Bridge in Moscow, in Krivoi Rog, in Donbas, in Kuzbas, as in Scotland, Wales, and Germany. Statistics show that each 1000 tonnes of coal are being paid for by one human life. Mendeleev was deeply concerned about the moral cost from coal mining. One day the idea of carbonating coal came to him, which he revealed in 1880. The idea, unfortunately, has never been realized.

The contemporary concept of sustainable development is evident in Mendeleev's work "Explanatory Tariff or Exploration of Industrial Development in Russia in Connection with the General Customs Tariff of 1891." One contemporary described it as "a bible of Russian protectionism and stimulation of industrial development in Russia." With great accuracy and attention to detail, he analyzed the raw materials of the Russian economy—from raw iron to that little known commodity "Paraguayan tea" (Herba Matte).

Sadly, political favoritism often leads to the appreciation of commodities, and this can be observed in Russia today. As Mendeleev saw it, protectionist policies regarding such commodities as soda and iron caused an increase in production within the country, which in turn produced a reduction in the sale price.

Challenges in Organic and Bioorganic Chemistry

23–26 June 2009, Paris, France

The **Tenth Tetrahedron Symposium and the 50th Anniversary of Tetrahedron Letters** will be celebrated in Paris from 23–26 June 2009. Seventeen exceptional speakers, including three Nobel Laureates, will present their latest research findings during this key organic chemistry event for 2009.

Participants at this meeting will be able to:

- learn from internationally renowned researchers in a comprehensive and wide-ranging program covering all aspects of organic synthesis; bioorganic, medicinal, and computational chemistry; molecular recognition, and the organic chemistry of materials
- understand the current state of research and the challenges to future discovery
- present the latest research at poster sessions
- network with the editors of the Tetrahedron journals, meet with international colleagues, visit the trade stands, and make new alliances

The Tenth Tetrahedron Symposium is organized by Elsevier in association with the Tetrahedron group of journals.

www.tetrahedron-symposium.elsevier.com

Biological Surfaces and Interfaces

27 June–2 July 2009, Sant Feliu, Spain

Interfaces between synthetic materials and biological systems—biointerfaces—constitute one of the most dynamic and expanding fields in science and technology. The field is driven both by a number of growing industrial and clinical applications—medical implants, biosensors and biochips, regenerative medicine, drug screening and targeting —and by the desire to understand biointerface processes at a fundamental level. It is by definition highly interdisciplinary, spanning the disciplines of physics, materials science and engineering, chemistry, biology, bioinformatics, and medicine. Education of today's students in a stimulating environment and with an interdisciplinary approach is a key factor for propelling this field forward.

The main approach in biointerfacial science involves preparation and characterization of functional surfaces for specific interactions with bio-systems, in vivo and in vitro, and studies of the molecular and kinetic processes occurring at such interfaces, ranging from small molecule and biomolecular interactions, to cell adhesion, differentiation, and tissue formation at the interface. As such, the **Biological Surfaces and Interfaces Symposium,** 27 June–2 July 2009, Sant Feliu, Spain, will span a wide range of topics including biomimetic surface platforms, biomembrane and supramolecular materials, nanotechnology, controlling cellular responses by designed surfaces with switchable properties, stem cells, cellular and molecular biomechanics, neural networks, optical, magnetic and mechanical detection systems with single molecule sensitivity, bioarrays and DNA, peptides, proteins, and enzymes at interfaces.

The program is organized into invited presentations by internationally renowned researchers, complemented by shorter contributed oral presentations and poster sessions by young scientists. Selected after-dinner keynote speakers have been invited to put the biointerface field in a larger scientific, clinical, and social context. A small group discussion session is planned to address social and ethical issues arising from the technologies and scientific knowledge being developed and used in this area. The conference will include short talks selected from the submitted abstracts as well as poster presentations.

www.esf.org/conferences/09290

Heteroatom Chemistry

30 June–4 July 2009, Oviedo, Spain

The **9th International Conference on Heteroatom Chemistry (ICHAC-9)** to be held in Oviedo (Spain) from 30 June to 4 July 2009. This conference series is an established international forum for the presentation and discussion of research results on the diverse fields of Heteroatom Chemistry.

Following the tradition of previous conferences, ICHAC-9 will be a major scientific event, bringing together organic and inorganic chemists from all over the world to share their interests in the different applications of heteroatom chemistry, such as synthesis, catalysis, polymers, and materials.

See Mark Your Calendar on page 39 for contact information.

www.uniovi.es/ichac9

Philosophy of Chemistry

13–15 August 2009, Philadelphia, PA, USA

The Chemical Heritage Foundation and University of Pennsylvania's Department of Philosophy and Department of History and Sociology of Science are organizing the **13th Summer Symposium of the International Society for the Philosophy of Chemistry (ISPC)**, which will be held 13–15 August 2009 in Philadelphia.

Submissions are now invited for ISPC 09 on any topic in philosophy of chemistry. The organizers interpret the field broadly, and welcome papers from philosophers, scientists, historians, and educators. However, the paper should deal with a conceptual issue in chemical theory or practice, whether of historical or contemporary interest.

For more information, contact Michael Weisberg <weisberg@phil.upenn.edu>.

Advanced Materials

20–25 September 2009, Rio de Janeiro, Brazil

The **11th International Conference on Advanced Materials (ICAM)** will be held at the Windsor Barra Hotel, Rio de Janeiro, Brazil, from 20 to 25 September 2009.

The International Union of Materials Research Societies organizes the ICAM every two years in a different country. This year, it is being held in Brazil for the first time. Previous conferences took place in Bangalore (2007), Singapore (2005), Japan (2003), Mexico (2001), and China (1999). More than 2000 congress participants from all continents are expected.

The conference will offer 30 technical symposia, 4 plenary lectures, an Energy Forum, and a large exhibition. A range of topics at the frontiers of material research will be highlighted:

- Nanomaterials for Medical Applications
- Advances in Nanocomposites: Synthesis and Applications
- New Developments in Biomaterials
- Advanced High-Temperature Materials
- Surface Engineering and Materials for Nuclear Power Generation

Rio de Janeiro is an exuberant and cosmopolitan city with very pleasant weather in September. Rio is not only a beautiful city but also a vibrant scientific, intellectual, and cultural center in Brazil.

For more information, please contact the ICAM 2009 Secretariat at <icam2009@icam2009.com>.

www.icam2009.com

Thermodynamics

23–25 September 2009, London, UK

As the science of energy and its effects on the material world, thermodynamics holds one of the keys to meeting the challenges that our modern society faces. Data and models that describe the thermodynamic behavior of materials are essential to the development of sustainable technologies and products. Although its origins date to the scientific revolution itself, thermodynamics has been evolving rapidly in recent years. This is partially because it has benefited from the advances in numerical simulation, which helps complement experiments and theory. Thanks to these new developments, thermodynamics now spans a large range of domains: the life sciences, with their complex supramolecular arrangements; nano-materials, where short-range interactions are dominant; complex fluids, such as liquid crystals, electrolytes and ionic fluids; critical behavior and extraction processes; the behavior of materials in extreme conditions; and many more.

The **Thermodynamics 2009** conference will bring together researchers from all over the world who are interested in these topics and in the three main tools currently used to explore them: experimental investigations, statistical mechanics and equation of state modeling, and molecular simulation.

This conference is the 21st meeting in a series of thermodynamics conferences founded in the 1960s by John Rowlinson and Max McGlashan. The conference will feature the 2009 Lennard-Jones Lecture and Prize, awarded by the Statistical Mechanics and Thermodynamics Group of the Royal Society of Chemistry, UK. In addition, the Christopher Wormald Prize will be awarded to two research students, nominated by members of the community, who have undertaken research within the broad remit of the conference.

For more information, contact Erich A. Müller <chair@thermodynamics2009.org>, chair, Thermodynamics 2009.

www.thermodynamics2009.org

Crop Protection Chemistry in Latin America

9–12 November 2009, Rio de Janeiro, Brazil

The 3**rd International Workshop on Crop Protection Chemistry in Latin America**, will be held 9–12 November 2009 in Rio de Janeiro, Brazil. This will be the eighth in a series of regional crop protection chemistry workshop-related projects sponsored by IUPAC since 1988 and the third held in Latin America.

The objectives of the workshop are as follows:

- facilitate the exchange of information and ideas regarding harmonized approaches available for the scientific evaluation and regulation of crop protection chemistry
- provide a forum for presentation of the latest research in the areas of agricultural biotechnology, environmental and human health protection, risk management, and regulation of crop protection chemicals in Latin America

Research and regulatory scientists working in the area of crop protection chemistry and biotechnology will gain new insights regarding trends and emerging developments in agricultural science. Attendees will benefit by forging new connections within a multidisciplinary, international group with similar interests and goals.

The workshop will include a plenary program with simultaneous translation from English to Portuguese and Spanish. All attendees are encouraged to present a poster of their work to be displayed throughout the workshop. Eight over-arching topics will be included:

- Innovative Chemistry and Technology for Crop Protection
- Risk Assessment Regulation and Global Harmonization
- Quality and Constituents of Pesticides
- Environmental Chemistry and Risk Assessment
- Pesticides Residues in Food
- Education and Information Management in Crop Protection

www.iupacrio2009.org
www.iupac.org/web/ins/2007-057-1-600

Mark Your Calendar

Upcoming IUPAC-sponsored events
See also www.iupac.org/indexes/Conferences for links to specific event websites

2009

IUPAC poster prizes to be awarded

21–24 June 2009 • Vacuum Microbalance and Thermoanalytical Techniques • Kazimierz Dolny, Poland
32nd International Conference on Vacuum Microbalance and Thermoanalytical Techniques (IVMTTC 32)
Prof. Piotr Staszczuk, Maria Curie-Sklodowska University, Chemistry Faculty, Dept. of Physicochemistry of Solid Surfaces, M. Curie-Sklodowska Sq. 3, PL-20 031 Lublin, Poland
Tel.: +42 81 5375 646, Fax: +42 81 5333 348, E-mail: piotrs@hektor.umcs.lublin.pl

29 June–3 July 2009 • Chemical Thermodynamics • Moscow, Russia
XVII International Conference on Chemical Thermodynamics in Russia (RCCT 2009)
Prof. J.D. Tretjakov, Moscow State University, Department of Inorganic Chemistry, Leninskiy Gory, GSP-2, RF-119991 Moscow, Russia, Tel.: +7 8 495 939 2074, Fax: +7 8 495 939 0998, E-mail: rcct2009@kstu.ru

30 June–4 July 2009 • Heteroatom Chemistry • Oviedo, Spain
9th International Conference on Heteroatom Chemistry (ICHAC-9)
Dr. Enrique Aguilar, Universidad de Oviedo, Departamento de Química Orgánica e Inorgánica, C/Julián Clavería, E-33006 Oviedo, Spain, Tel.: +34 985 104 951, Fax: +34 985 103 446, E-mail: EAH@uniovi.es

5–9 July 2009 • Polymers and Organic Chemistry • Montréal, Canada
13th International IUPAC Conference on Polymers & Organic Chemistry (POC-'09)
Prof. Will Skene, Université de Montréal, CP 6128, Succ. Centreville, Montréal, QC H3C 3J7, Canada
Tel.: +1 514 340-5174, Fax: +1 514 340-5290, E-mail: w.skene@umontreal.ca

19–24 July 2009 • Novel Aromatic Compounds • Luxembourg City, Grand Duchy of Luxembourg
International Symposium on Novel Aromatic Compounds (ISNA-13)
Prof. Carlo Thilgen, ETH Zürich, Laboratorium für Organische Chemie, Wolfgang-Pauli-Strasse 10, CH-8093 Zürich, Switzerland, Tel.: +41 1 632 2935, Fax: +41 1 6321109, E-mail: thilgen@org.chem.ethz.ch

26–30 July 2009 • Organometallic Chemistry • Glasgow, UK
15th International IUPAC Conference on Organometallic Chemistry Directed Towards Organic Synthesis
Prof. Pavel Kocovsky, University of Glasgow, Department of Chemistry, Glasgow, G12 8QQ, United Kingdom
Tel.: +44 141 330 4199, Fax: +44 141 330 4888, E-mail: pavelk@chem.gla.ac.uk

26–31 July 2009 • Ionic Polymerization • Lodz, Poland
19th IUPAC International Symposium on Ionic Polymerization (IP '09)
Prof. Stanislaw Penczek, Polish Academy of Sciences, Centre of Molecular and Macromolecular Chemistry, Sienkiewicza 1123, PL-90 363 Lodz, Poland
Tel.: +48-42-681 9815, Fax: +48-42-684 7126, E-mail: ip09@bilbo.cbmm.lodz.pl

31 July–6 August 2009 • IUPAC 45th General Assembly • Glasgow, UK
IUPAC Secretariat, Tel.: +1 919 485 8700, Fax: +1 919 485 8706, E-mail: secretariat@iupac.org
www.iupac.org/symposia/conferences/ga09/

2–7 August 2009 • IUPAC 42nd Congress • Glasgow, UK
Chemistry Solutions
IUPAC 2009, Royal Society of Chemistry, Thomas Graham House, Science Park, Milton Road, Cambridge, CB4 0WF, UK, Tel.: +44 (0) 1223 432380, Fax: +44 (0) 1223 423623, E-mail: iupac2009@rsc.org
www.iupac2009.org

2–7 August 2009 • Heterocyclic Chemistry • St. John's, NewFoundland and Labrador, Canada
22nd International Congress on Heterocyclic Chemistry (ICHC-22)
Prof. Mohsen Daneshtalab, School of Pharmacy, Memorial University of Newfoundland, St. John's, NL A1B 3V6, Canada, Tel.: +1 709-777-6958, Fax: +1 709-777-7044, E-mail: mohsen@mun.ca

21–25 August 2009 • Solution Chemistry • Innsbruck, Austria
31st International Conference on Solution Chemistry (ICSC 2009)
Prof. Bernd M. Rode, University of Innsbruck, Theoretical Chemistry Division, A-6020 Innsbruck, Austria
Tel.: +43 512 507 5160, Fax: +43 512 507 2714, E-mail: bernd.m.rode@uibk.ac.at

Mark Your Calendar

14–18 September 2009 • High Temperature Materials • Davis, CA, USA
High Temperature Materials Chemistry Conference–XIII (HTMC-XIII)
Alexandra Navrotsky, University of California at Davis, One Shields Avenue, Davis, CA 95616 USA
Tel.: +1 530 752-3292, Fax: +1 530 752-9307, E-mail: ANavrotsky@UCDavis.edu

10–14 October 2009 • Molecular Environmental Soil Science • Hangzhou, China
International Symposium of Molecular Environmental Soil Science at the Interfaces in the Earth's Critical Zone
Prof. Jianming Xu, Zhejiang University, College of Environmental & Resource Sciences, Hangzhou, 310029, China
Tel.: +86 571-8697-1955, Fax: +86 571-8697-1955, E-mail: jmxu@zju.edu.cn

18–22 October 2009 • Novel Materials and Their Synthesis • Shanghai, China
International Symposium on Novel Materials and Their Synthesis (NMS-V)
Prof. Yuping Wu, Fudan University, Department of Chemistry, Shanghai, 200433 China
Tel.: +86 21 55 664 223, Fax: +86 21 55 664 223, E-mail: wuyp@fudan.edu.cn

9–12 November 2009 • Crop Protection • Rio de Janeiro, Brazil
3rd International Workshop on Crop Protection Chemistry in Latin America: Environment, Safety and Regulation
See IUPAC Project 2007-057-1-600 or E-mail: secretariat@iupacrio2009.org

2010

IUPAC poster prizes to be awarded

7–10 March 2010 • Heterocyclic Chemistry • Gainesville, Florida, USA
11th Florida Heterocyclic and Synthetic Conference
Prof. Alan R. Katritzky, University of Florida, Department of Chemistry, Gainesville, FL 32611-7200, USA
Tel.: +1 352-392-0554, Fax: +1 352-392-9199, E-mail: katritzky@chem.ufl.edu

4–8 July 2010 • Pesticide Chemistry • Melbourne, Australia
12th IUPAC International Congress of Pesticide Chemistry
Dr. Elizabeth Gibson, RACI, 1/21 Vale Street, North Melbourne, VIC 3051, Australia
Tel.: +61 0 3 9328 2033, Fax: +61 0 3 9328 2670, E-mail: elizabeth@raci.org.au

11–16 July 2010 • Macromolecules • Glasgow, United Kingdom
43rd International Symposium on Macromolecules - IUPAC World Polymer Congress (Macro 2010)
Prof. Peter A. Lovell, School of Materials, The University of Manchester, Grosvenor St. Manchester, M1 7HS, UK
Tel.: +44 (0) 161-306-3568, FAX: +44 (0) 161-306-3586, E-mail: pete.lovell@manchester.ac.uk

25–30 July, 2010 • Solubility Phenomena • Leoben, Austria
14th International Symposium on Solubility Phenomena and Related Equilibrium Processes
Prof. Dr. Helmut Antrekowitsch, Montanuniversitaet Leoben, Arbeitsbereich Nichteisenmetallurgie,
Franz-Josef-Strasse 18, A-8700 Leoben, Austria
Tel.: +43 (0) 3842 402 – 5200, Fax: +43 (0) 3842 402 5202, E-mail: Helmut.Antrekowitsch@mu-leoben.at

8–13 August 2010 • Chemical Education • Taipei, Taiwan
21st International Conference on Chemical Education—Chemistry Education and Sustainability in the Global Age
Prof. Mei-Hung Chiu, National Taiwan Normal University, No. 88, Ding-Zhou Road, Section 4, Taipei, 116, Taiwan
Tel.: + 886 2-2932-2756, Fax: + 886 2-2935-6134, E-mail: mhc@ntnu.edu.tw

15–19 August 2010 • Green Chemistry • Ottawa, Canada
3rd IUPAC Conference on Green Chemistry (ICGC-3)
Prof. Philip Jessop, Department of Chemistry, Queen's University, 90 Bader Lane, Kingston, ON, K7L 3N6, Canada,
Tel.: +1-613-533-3212, Fax: +1-613-533-6669, E-mail: jessop@chem.queensu.ca

International Union of Pure and Applied Chemistry

Advancing the worldwide role of chemistry for the benefit of Mankind

Mission Statement—IUPAC is a non-governmental organization of member countries that encompass more than 85% of the world's chemical sciences and industries. IUPAC addresses international issues in the chemical sciences utilizing expert volunteers from its member countries. IUPAC provides leadership, facilitation, and encouragement of chemistry and promotes the norms, values, standards, and ethics of science and the free exchange of scientific information. Scientists have unimpeded access to IUPAC activities and reports. In fulfilling this mission, IUPAC effectively contributes to the worldwide understanding and application of the chemical sciences, to the betterment of the human condition.

National Adhering Organizations

Australian Academy of Science *(Australia)*
Österreichische Akademie der Wissenschaften *(Austria)*
Bangladesh Chemical Society (*Bangladesh*)
National Academy of Sciences of Belarus (*Belarus*)
The Royal Academies for the Sciences and Arts of Belgium *(Belgium)*
Brazilian Chemistry Committee for IUPAC *(Brazil)*
Bulgarian Academy of Sciences *(Bulgaria)*
National Research Council of Canada *(Canada)*
Sociedad Chilena de Química *(Chile)*
Chinese Chemical Society *(China)*
Chemical Society located in Taipei *(China)*
Croatian Chemical Society *(Croatia)*
Sociedad Cubana de Química *(Cuba)*
Czech National Committee for Chemistry *(Czech Republic)*
Det Kongelige Danske Videnskabernes Selskab *(Denmark)*
National Committee for IUPAC *(Egypt)*
Chemical Society of Ethiopia *(Ethiopia)*
Suomen Kemian Seura—Kemiska Sällskapet i Finland *(Finland)*
Comité National Français de la Chimie *(France)*
Deutscher Zentralausschuss für Chemie *(Germany)*
Association of Greek Chemists *(Greece)*
Hungarian Academy of Sciences *(Hungary)*
Indian National Science Academy *(India)*
Royal Irish Academy *(Ireland)*
Israel Academy of Sciences and Humanities *(Israel)*
Consiglio Nazionale delle Ricerche *(Italy)*
Caribbean Academy of Sciences—Jamaica Chapter (*Jamaica*)
Science Council of Japan *(Japan)*
Jordanian Chemical Society (*Jordan*)
Korean Federation of Science and Technology Societies *(Korea)*
Kuwait Chemical Society *(Kuwait)*
Koninklijke Nederlandse Chemische Vereniging *(Netherlands)*
Royal Society of New Zealand *(New Zealand)*
Norsk Kjemisk Selskap *(Norway)*
Chemical Society of Pakistan *(Pakistan)*
Polska Akademia Nauk *(Poland)*
Sociedade Portuguesa de Química *(Portugal)*
Colegio de Químicos de Puerto Rico *(Puerto Rico)*
Russian Academy of Sciences *(Russia)*
Serbian Chemical Society (Serbia)
Slovak Chemical Society *(Slovakia)*
Slovenian Chemical Society *(Slovenia)*
National Research Foundation *(South Africa)*
Ministerio de Educación y Ciencia *(Spain)*
Svenska Nationalkommittén för Kemi *(Sweden)*
Swiss Chemical Society *(Switzerland)*
Türkiye Kimya Dernegi *(Turkey)*
National Academy of Sciences of Ukraine *(Ukraine)*
Royal Society of Chemistry *(United Kingdom)*
National Academy of Sciences *(USA)*
Programa de Desarrollo de Ciencias Básicas *(Uruguay)*