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Mitigating Arsenic Pollution

A Year of Chemistry in Korea

Bologna and Beyond

From the Editor

CHEMISTRY International

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

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As IUPAC embarks on the complex but rewarding prospect of coordinating and promoting an International Year of Chemistry as recognized by UNESCO (the United Nations Educational, Scientific, and Cultural Organization) and the United Nations, I decided to explore what other International Years have for goals and pursuits. The year 2008 was claimed as the Year of the Potato, Year of Planet Earth, Year of Sanitation, and Year of Languages.

The one I find the most intriguing is the International Year of Languages. Its purpose is to recognize that genuine multilingualism promotes diversity and global understanding. The proclamation supports the premise that cultural richness is based upon diversity in languages. Essentially, we should respect other languages and seek to learn more languages in order to appreciate and communicate with people of other cultures.

While I have been working for IUPAC, I have come to appreciate the unspoken value of cultural diversity. Yet, IUPAC has only one official language—English. Is that a contradiction? Is the organization missing the point to promote plurilingualism (meaning the use of several languages by an individual) and multilingualism (meaning the coexistence of several languages within a given social group). No, on the contrary. I have come to think that IUPAC can sustain its mission because the organization empowers its members, most of whom are polyglots, to relay IUPAC findings locally and in other languages if they so choose.

IUPAC focuses on the language of chemistry. The Union has a unique role in developing new terminology and in establishing the means to communicate issues relevant to chemistry and chemical sciences. In this sense, the language of IUPAC is chemistry, not English, not French, not Chinese, etc. With a global membership of about 70 countries, the number of languages represented by individual members is probably comparable, if not more. And with such a large representation, IUPAC outreach can be ensured.

In her recent editorial "Languages Matter" that appeared in the *UNESCO Courier* (2008, Number 1), Jasmina Šopova began with a quote by Stendhal: "The first instrument of a people's genius is its language." She continued by saying that "Literacy, learning, social integration . . . Everything transits through language, which embodies national, cultural, and sometimes religious identity for each person. It constitutes one of the fundamental dimensions of a human being." As we prepare for a Year of Chemistry, may we find words as powerful as those to convey the idea that chemistry is also a fundamental dimension of human well being.

Share your thoughts and write to us!

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Cover photo: Girl from Bangladesh drinking clean water. Photo courtesy of WaterAid/Juthika Howlader. For more info, see <www.wateraid.org>.

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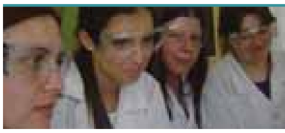

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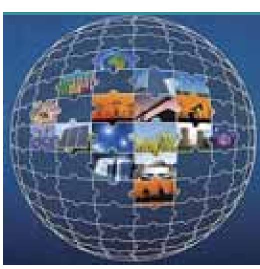
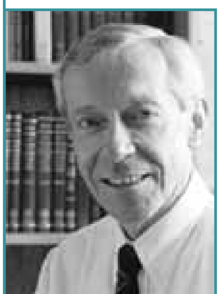


Secretary General's Column

Moving Toward an International Year of Chemistry



by David StC. Black

As I write this column, we have just received news that the Executive Board of UNESCO has endorsed the proposal for the United Nations to proclaim 2011 as the International Year of Chemistry (IYC). The wording of the proposal is as follows:

The Executive Board,

1. recognizing that humankind's understanding of the material nature of our world is grounded in our knowledge of chemistry
2. stressing that education in and about chemistry is critical in addressing challenges such as global climate change, in providing sustainable sources of clean water, food and energy, and in maintaining a wholesome environment for the well-being of all people
3. considering that the science and application of chemistry produces medicines, fuels, metals, and virtually all other manufactured products
4. taking note of the ongoing United Nations initiatives in industrial best practices
5. aware that the year 2011 provides the opportunity to celebrate the contributions of women to science on the 100th anniversary of the awarding of the Nobel Prize in Chemistry to Maria Sklodowska-Curie
6. being further aware that the year 2011 provides the opportunity to highlight the need for international scientific collaboration on the 100th anniversary of the founding of the International Association of Chemical Societies
7. having examined document 179 EX/47 and Add. Rev., [containing supporting letters and statements from numerous National Adhering Organizations and delegations]
8. welcomes the unanimous resolution of the International Union of Pure and Applied Chemistry, at its 2007 Council meeting, to declare 2011 as the International Year of Chemistry and to play a lead role in coordinating and promoting chemistry activities at the national and regional levels around the world
9. invites the director general to support all efforts leading the United Nations General Assembly to declare 2011 the International Year of Chemistry
10. recommends that the General Conference adopt, at its 35th session, a resolution on this subject.

The proposal was placed before the UNESCO Executive Board by the Ethiopian representative and supported officially by approximately 25 other countries. IUPAC is grateful to all those involved in the enormous amount of careful work to reach this point. The effort was coordinated brilliantly by a project task group led by Peter Mahaffy, which was charged with discovering and launching the correct process for the designation of an International Year. Of course, there is still a long way to go, and we call on all our National Adhering Organizations (NAOs) to encourage further diplomatic support from their respective United Nations delegations to achieve "International Year" status, as a formal request will go to the next United Nations General Assembly.

Since a decision will not be made for some time, the Bureau decided at its meeting in March 2008 to proceed at full speed with the necessary planning on the assumption that the proclamation will be successful. If it is not, all the activities can take place under a slightly different name, such as the IUPAC World Year of Chemistry.

At this stage, a relatively small but broadly representative Management Committee has been set up to supervise the project, with John Malin as chair. This will be assisted by a larger Advisory Board designed to bring in ideas, expertise, and links to national organizations. A website will be maintained to inform NAOs of developments and to coordinate and publicize reports of activities around the world.

Broadly speaking, the IYC is designed to promote chemistry, which, as we know, is the central and controlling ingredient in life itself. Chemistry is the only creative science available for future sustainability and development of our way of life. Indeed, chemical research is essential if we are to overcome future problems relating to food, water, health, energy, transportation, and lifestyle.

More specifically, the IYC will:

- enhance international cooperation
- serve as a focal point for activities by national chemical societies and other national bodies,

educational institutions, and nongovernmental organizations
- improve the understanding and appreciation of chemistry among the public
- promote the role of chemistry in contributing to solutions to global problems
- build capacity by engaging young people with scientific disciplines, especially the scientific method of analysis developed by hypothesis, experiment, analysis and conclusions

IUPAC will plan for some key events, such as launching ceremonies in December 2010 at PACIFICHEM and in January 2011 (probably in Paris and hopefully in liaison with UNESCO), a major celebration at the IUPAC Congress in San Juan, Puerto Rico in August 2011, and a closing event in December. However, most of the activities will be organized by the various national chemical societies, and in many cases will be similar to those already being undertaken, such as a science day or an exhibit, but with the added publicity value and international linkages that a formal International Year will provide. Some proposed activities have already been collected in a background document that accompanied the proposal to UNESCO:

- developing a web-based "toolkit" of ideas for use by organizers of IYC events
- creating, on the IUPAC website, a "page" for IYC with links to national chemistry celebrations worldwide, including a listing of Green Chemistry activities
- interacting with government leaders to educate them about the importance of a strong chemical community
- providing practical, appropriate chemistry demonstrations for all levels for students, from preschool to university
- organizing visits to industrial sites, including chemical companies, energy facilities, metal factories, petroleum refiners, food producers, breweries, vintners, or distillers
- publicizing the contributions that chemistry makes to every nation's economy by submitting articles to periodicals and newspapers
- sponsoring poster exhibitions highlighting the usefulness of chemistry
- organizing problem-solving projects through which students can use their knowledge of chemistry to develop solutions to local problems
- developing television and radio programs explaining the necessity, ubiquity, and benefits of chemistry
- publicizing the contributions that chemistry has made to improving our lives, particularly through recent developments in chemical research
- holding career fairs and inviting professionals to talk about how they use chemistry in their jobs
- organizing hands-on activities and demonstrations to help participants gain an understanding of what it would be like to work in a chemistry-related field

One of the early acts of the Management Committee will be to consider ways to raise funds to promote the IYC. The aim is to be able to assist NAOs and national chemical societies, especially the smaller ones, to run a full range of excellent programs. Interested parties should refer to the website of the World Year of Physics 2005 <www.wyp2005.org> and the International Year of Planet Earth 2008 <www.yearofplanetearth.org> for examples of effective programs.

In summary, this is your year and your opportunity to promote chemistry in your region in the context of dynamic international cooperation that will showcase the wonders and opportunities of chemistry, and celebrate its achievements and capacity for the enhancement of our quality of life.

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.

The 2006 Year of Chemistry in Korea

by Choon H. Do

As IUPAC begins planning for an International Year of Chemistry in 2011, it may be helpful and inspirational to consider the success of South Korea's Year of Chemistry, which took place in 2006. Timed to coincide with its 60th anniversary, the Korean Chemical Society (KCS) held many nation-wide, local, and international activities for students and the general public in celebration of the Year of Chemistry.

The Year of Chemistry was part of an effort by the Korean government to enhance science in Korea. The Ministry of Science and Technology initiated a Science Korea Project and declared 2005 as the Year of Physics, 2006 as the Year of Chemistry, and 2007 as the Year of Biology.

The events and activities that comprised the year of chemistry fell into three broad categories:

- academic, including annual meetings of KCS, symposia, international conferences, and publications
- mass media, including TV documentaries on chemistry and newspaper articles
- educational, including a mobile chemistry museum, a chemistry shock exhibition, and demonstrations for students and the public

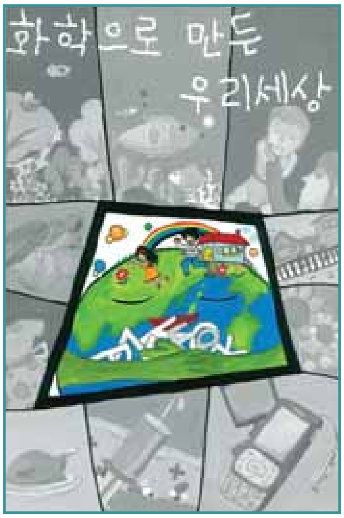
The most popular activity of the year-long celebration was the mobile chemistry museum, which was unveiled at the KCS Spring Annual Meeting, held in Kintex in Ilsan, Gyunggi-do in April 2006. More than 10 000 people visited the museum in each large city in which it stopped, including Seoul, Busan, and Daegu. The more than 2 000 attendees at the spring meeting were among the first to experience the large, multi-domed structure that housed the museum. Filled with air and shaped like a benzene molecule, the museum included 16 compartments with 10 rooms dedicated to different functions such as exhibitions, lectures, workshops, and chemistry demonstrations and shows. The purpose of the museum was to show students and the general public that chemistry is a central part of daily life, is integral to new technologies and materials, and is an interesting subject to study.

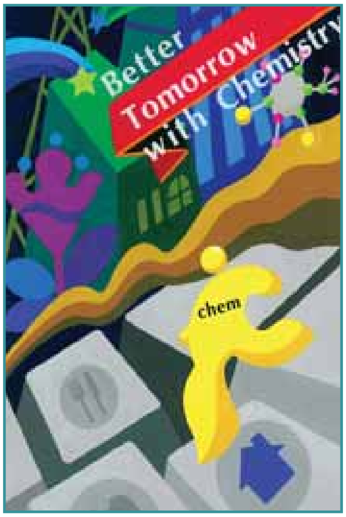
Logo of the 2006 Year of Chemistry in Korea.

Another activity that proved popular with students was a chemistry poster contest in which more than 900 middle and high school students participated. The contest encouraged kids to think about the roles and effects of chemicals and chemists. The wining posters were shown during the Fall Annual Meeting of KCS.

Each local chapter of KCS produced its own Year of Chemistry events such as chemistry camps, chemistry exhibitions, and symposiums. Two highlights were the very successful Young Ambassadors for Chemistry workshop put on by the Gwangju-Chonnam Chapter and held 20–24 February 2006 (see Sep-Oct 2006

Award-winning entries in the third-annual chemistry poster contest for middle and high school students.





CI, p. 25), and a chemistry quiz competition called the Challenge Golden Bell in Chemistry, held 19–29 May 2006 by the Chonbuk Chapter.

In order to emphasize to the public the role of chemistry and chemical compounds in improving our quality of life, KCS collaborated with a major TV station, the Korean Broadcasting System, to produce and air special documentaries. KBS 1TV aired two two-part documentaries, one in August and the other in November 2006. Part 1 of the first documentary, entitled "Searching for an Elixir of Life," dealt with the development by Swiss and Japanese scientists of medicines intended to extend the human life span. One of the examples in the documentary involved a study on the effects of Korean ginseng. Part 2, entitled "Secret of Invisible Cloak," discussed the role of chemistry in developing new materials.

The second documentary was related to natural toxins and the development of new medicines. Part 1 "Chemical War in the Wild" dealt with the development of medicines from animal poisons. Part 2, entitled "Future of Life: Keep Toxic Species," dealt with the development of medicines from natural products obtained from plants. Nakjoong Kim of the Department of Chemistry at Hanyang University and others served as advisers to KBS during production.

Theater and science mixed as the public was treated to two plays involving chemistry that were part of the Year of Chemistry celebration. *Aladdin and the Magic Lamp*, attracted more than 1 800 people to performances held 28 and 29 December 2006 at Paiknam Music Hall of Hanyang University, located in Seoul. The 90-minute play, composed of five acts, followed the original story of Aladdin's adventure, but with chemistry demonstrations at key junctures. It was adapted and directed by Bookee Hwang and produced by Junghoon Choi, both of Hanyang University in Seoul.

More than 14 000 people saw the other featured play, *Oxygen*, written by chemists Carl Djerassi and Roald Hoffmann, during its 19 showings in six cities. The play was translated into Korean by Chul-ri Kim and directed by Kwangbo Kim.

There were a variety of academic activities during the Year of Chemistry, including the Forum on New Chemistry, Academic-Industry Collaboration Symposium, and My Story Related to Chemistry, which featured famous chemists discussing their lives and research. All of these events were open to chemists, the public, and news media.

The following international chemistry conferences incorporated aspects of the Year of Chemistry into their events: 19th International Conference on Chemical

As part of a science festival, a chemistry exhibition was organized in front of Seoul's City Hall.

Participants in the Challenge Golden Bell in Chemistry present their answers to a chemistry quiz.

A plenary lecture at the 19th International Conference on Chemical Education.

The 2006 Year of Chemistry in Korea

Education (Jan-Feb 2007 *CI*, p. 32), 38th International Chemistry Olympiad (Nov-Dec 2006 *CI*, p. 22), and the 18th International Symposium on Chirality. A number of chemistry-related organizations also participated in the activities of the Year of Chemistry, including the Korean Union of Chemical Science and Technology Societies, the Korean Institute of Chemical Engineers, the Polymer Society of Korea, the Korean Society of Industrial and Engineering Chemistry, and the Korean Ceramic Society.

South Korea's experience with the 2006 Year of Chemistry demonstrated that students of all ages, the public, administrators, and legislators will support the chemical sciences if they are exposed to chemical facts and activities and educated about the benefits of chemistry. However, it is necessary to maintain the momentum and energy behind this effort to continuously enhance the chemical sciences.

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Poster for the play Oxygen, *which was seen by more than 14 000 people during its 19 showings in six cities.*

Stamps International

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

Petrochemicals Galore

Countries sometimes use postage stamps to highlight their economic growth and promote their industrial prowess or development plans. Such is the case with South Korea, which issued a set of eight stamps on 15 March 2006 to recognize its key export industries, including automobiles, semiconductors, electronics, textiles, steel, machinery, ships, and petrochemicals. Accounting for nearly three quarters of the country's total exports (worth some $360 billion in 2007), these industries have made South Korea one of the world's leading industrialized and most technologically advanced nations.

The stamp illustrated in this note draws attention to the petrochemical industry in South Korea and displays the structural formulas of benzene, ethylene, propylene, and butadiene. In particular, ethylene is the most important petrochemical feedstock in the world in terms of both production volume (about 120 million metric tons) and number of derivatives. About half of the world's output of ethylene is converted to polyethylene (that's a lot of plastic bags!) and in the manufacture of ethylene dichloride, vinyl chloride, ethylene oxide, styrene, vinyl acetate, ethanol, acetaldehyde, and other organic compounds, with applications ranging from solvents and detergents to chemical fibers and adhesives. Interestingly, ethylene is also an important plant hormone and is extensively used as a ripening agent for fruits and vegetables.

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

Bridging the Gap Between Knowledge and Practice*

by Hemda Garelick and Huw Jones

Access to uncontaminated water in sufficient quantities may be the most important requirement for healthy human societies. However, the relationship between the water supply in developing countries and the health of citizens is complex since the relationship is dependent on the provision of both appropriate quantities and quality of water. Attempts to understand this relationship began in the 1970s with the "Bradley Classification" of water-related infection. This was followed by efforts to predict the effect of variations in water quality and supply on morbidity and mortality, particularly of children under five (Cairncross and Valdmanis, 2006). Among the indicators of water quality, the feco-oral (specifically infectious diarrhea) group has historically been important and remains one of the largest water-related contributors to disease on a global scale.

According to some current estimates, approximately 1.8 million people, 90 percent of whom are children under 5, still die every year from diarrheal diseases—mostly in developing countries (WHO, 2008). It is estimated that in industrialized countries, 60 percent of diarrheal disease is attributed to unsafe water, sanitation, and hygiene, whereas in developing countries as much as 85-90 percent of diarrheal illness can be attributed to these causes (Keusch et al., 2006).

While the microbiological quality of water is directly related to human health impacts, access to appropriate quantities of water is an additional health benefit that should not be underestimated. Adequate quantities of water enable people to have improved hygiene, leading to a reduced infectious burden (Cairncross and Valdmanis, 2006). In addition, water availability beyond that required for sustenance and hygiene can confer further health benefits by allowing increased food production in the dry season.

The years 1980–1990 were declared as the U.N. Water Decade. This influenced the work of governments and international agencies in the drive to provide clean and affordable water supplies to all. As part of this drive, international collaborative efforts led by UNICEF resulted in the sinking of millions of tubewells to extract groundwater, which is typically of superior microbiological quality when compared to surface water.

In Bangladesh alone some 10 million tubewells were drilled. UNICEF figures published in 1998 show a 47 percent reduction in infant and under 5 mortality rates in Bangladesh in the years 1980–1996 (UNICEF, 1998). However, many of the tubewells were unknowingly sunk into arsenic-contaminated aquifers. As a consequence, although microbiologically superior water supplies were obtained, some 40 million people subsequently were exposed to toxic levels of arsenic, sometimes exceeding the World Health Organization (WHO) Guideline value by a factor of 20 or more. Of 64 districts within Bangladesh, 59 were reported to contain unsafe levels of arsenic (Caussy and Priest, 2008). The situation in Bangladesh has been described as the biggest case of mass poisoning in recent history.

High levels of arsenic in drinking water have also been found elsewhere in Asia (e.g., Cambodia, China) as well as in the USA and South America. The WHO and U.S. Environmental Protection Agency (EPA) recommended limit for arsenic in drinking water is currently 10 $\mu g/L$ (WHO, 2006).

There is clearly a pressing need to mitigate the problem. However, it is not so much the difficulty of removing arsenic from water, as it is the extremely low levels to which it must be reduced to ensure safety that presents the challenge to water treatment initiatives, especially in developing countries where the issues of cost and expertise often make "high-tech" solutions impractical. The challenge is not only to provide cheap and efficient treatment but also to develop technologies that are suitable for the large number of small and isolated point sources that are typical of affected rural populations.

The IUPAC Project

By the end of the millennium, the problem of arsenic contamination, particularly in Bangladesh was well documented. The implications to human health from arsenic exposure have been widely investigated by the scientific community. However, from the perspective

*This article arose from work carried out by an IUPAC project (2003-017-2-600) sponsored by the Chemistry and the Environment Division (VI). The participants were F. Ahmed, G. Borbély, M.K. Bux, D.H. Caussy, A. Dybowska, J.B. Ellis, J. Feldmann, R. Földényi, Z. Galbács, H. Garelick, H. Jones, N. Kováts, N. Priest, Y. Shevah, E. Valsami-Jones, and P. Visoottiviseth.

of those living in affected areas, these problems are not fully understood and solutions for mitigation have not been adequately evaluated or communicated. It is against this background that an IUPAC project (#2003-017-2-600), established under the auspices of the Chemistry and the Environment Division, aims to accomplish the following:

- provide a global overview of natural and anthropogenic sources of arsenic in the water environment and to assess its behavior
- critically review field testing kits intended to provide cheap, quick, on-site measurements so that contamination can be accurately mapped and remediation efforts effectively monitored
- assess the health risk of arsenic contamination, with special reference to technical challenges for optimizing arsenic remediation measures that are acceptable to affected communities
- conduct critical analysis of appropriate methodologies, evaluate their suitability for different situations, and address the transferability of specific technologies that are currently associated with local conditions

For mitigation/remediation action to be taken, the interrelationships and complexities inherent to the processes need to be recognized and understood. To help achieve this, a conceptual model describing these relationships is presented (figure 1). It serves as a framework for the integration of these factors and as a basis for discussion in this article.

Source Term

Distribution

The environmental presence of arsenic derives from both natural and anthropogenic sources. Globally, most arsenic contamination of water occurs naturally when aquifers pass through bedrock containing arsenic. Significant amounts of arsenic are also introduced into the environment from anthropogenic sources, metal mining and smelting being the most important (Garelick et al., 2008).

The main regions of the world affected by arsenic contamination are depicted in figure 2, which also indicates the scale of chronic human exposure. Four principal sources of arsenic are also shown. As can be discerned from the map, areas having natural (geological) contamination of aquifers and regions with mining sources dominate. For coal burning sources, only the Guizhou region of China is shown since this region has the most serious documented problems of this type. Arsenic has also been introduced into the environment through extensive use of arsenical compounds in pesticides. It is also a constituent of wood preservatives (e.g., as copper chromate arsenate). Many sites used by the timber industry to treat lumber have been contaminated with arsenic. Agricultural and/or wood preserving sites of contamination have been reported in South Africa, Zimbabwe, and Australia, but are not included on the map as they are small localized areas.

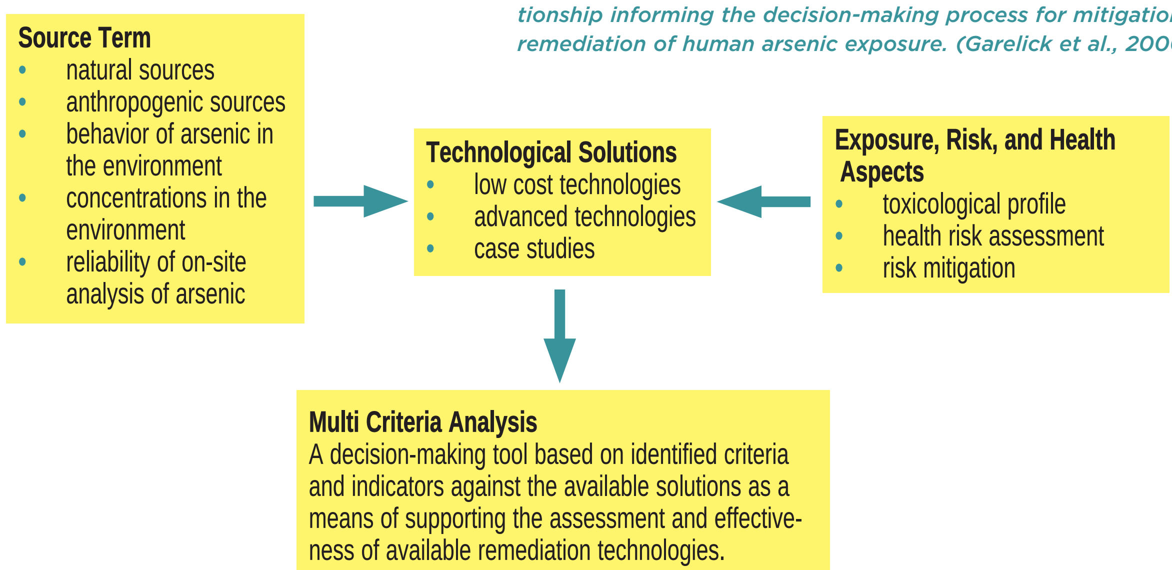

Figure 1: A conceptual model describing the factors and relationship informing the decision-making process for mitigation/remediation of human arsenic exposure. (Garelick et al., 2006)

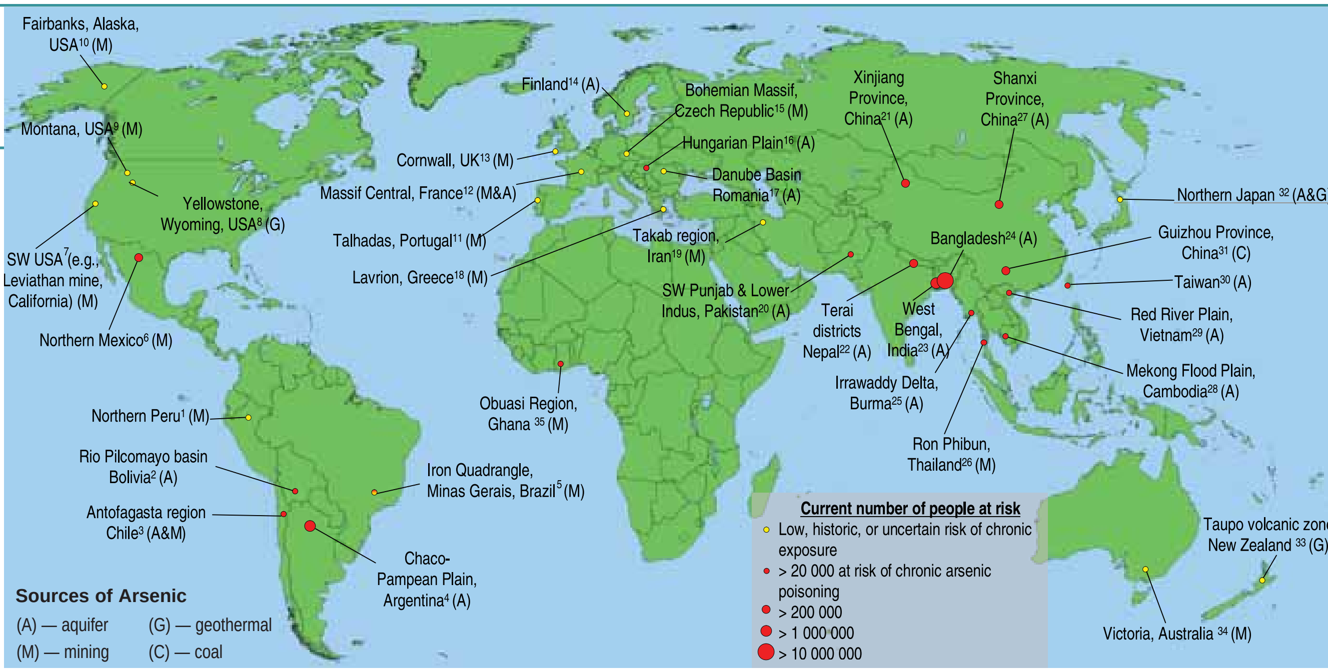

Figure 2. Worldwide distribution of arsenic contaminated regions, showing source of arsenic and numbers of people at risk of chronic exposure. *References can be found online at <www.iupac.org/publications/ci/2008/3004/2_garelick.html>. Note: estimates of people at risk of poisoning are very difficult to quantify, particularly in areas where geochemical surveys are limited. These estimates are broad and are based on four criteria: 1) prevalence of current recorded cases of arsenicosis, 2) likelihood of ingested concentrations exceeding 50 µg/L) number of people living in exposed areas, 4) likely ability of region to mitigate/remediate against contamination.*

Analysis and Environmental Sampling

Arsenic's highly variable distribution in the environment makes it difficult to establish reliable environmental sampling regimes that accurately portray the true status of arsenic contamination. In addition, accomplishing rapid on-site sample analyses at acceptable costs remains a challenge even when reliable sampling has been achieved. A review of these methods is provided by Feldmann (2008). Monitoring for arsenic has historically been centered on drinking water, but more recently monitoring of soil and staple foods has become important because of their potential contribution to human arsenic exposure. On-site analyses of water, soil, sludge, and foodstuffs are essential to ensure that environmental risk assessments properly reflect arsenic residue burdens. Further, those undertaking environmental risk analyses have to consider additional criteria as discussed below.

Exposure, Risk, and Health Aspects

Toxicity

A range of arsenic species is present in the environment, which exhibit complex environmental behavior and large variations in toxicity. The pronounced differences in relative toxicities of six arsenic species are demonstrated in figure 3. The figure, although based on acute studies, further highlights significant differences in toxicity between organic and inorganic species of arsenic. These differences are also supported by a number of field studies, although it is less clear whether these differences are similarly pronounced under conditions of chronic exposure.

Exposure

Humans may be exposed to inorganic arsenic *via* air (significant intakes by inhalation occur in residents living near industrial sources where exposures to arsenic trioxide are possible), drinking water, food, and soil. However, there are strong indications that consumption of arsenic polluted water is the most important contributor to arsenic-related morbidity. The areas exhibiting the highest levels of human exposure, such as Bangladesh and West Bengal (figure 2), are known to also have the highest occurrence of arsenic contamination of ground water (Caussy and Priest, 2008).

Most food products usually contain less than 250 µg/kg of arsenic. However, seafood, including demersal fish, crustaceans, and marine algae, may contain up to ~100mg/kg of arsenic. The low levels of arsenic in plants contrast with the much higher levels in soil, ~40mg/kg, and may reflect the insolubility of many arsenic-containing minerals such as pyrite under normal soil conditions. The average U.S. daily dietary intake of arsenic is estimated to be 10 to 20µg. In Japan, however, where the seafood content of the diet is high, intakes are much larger (70 to 370µg per day) (Caussy and Priest 2008). The likely predominance of

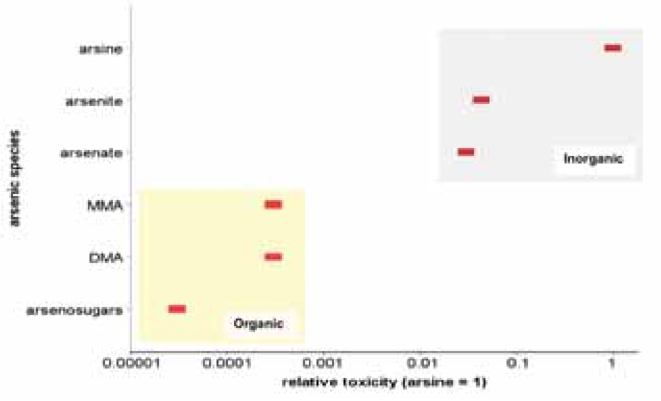

Figure 3: Relative toxicity of arsenic species (MMA = monomethylarsonic acid, DMA = dimethylarsinic acid). *Adapted from Vaughan (2006). [Arsine toxicity is based on rat LD_{50} of 3 mg/kg body weight normalized to 1].*

the less toxic organic species of arsenic in foodstuffs may render this source less important in morbidity. However, this is an area that has been less well researched.

Standards and Guidelines

In most countries, the maximum contaminant level (MCL), which is used as an important field monitoring criterion for total arsenic in ground- or potable-water, is set at 50 µg/L. The MCL is either a guideline or an enforceable standard, depending on the country, and is the highest level of a contaminant allowed in drinking water. However, the more stringent WHO guideline value of 10 µg/L has been set as the MCL in recent years. This has now been approved by an increasing number of countries across the world, and has been enforced in the USA since the beginning of 2006. The MCL does not distinguish arsenic species, although as shown in figure 3, speciation is clearly an important factor in arsenic toxicity.

Arsenic levels in soil, sludge, and foodstuffs are less well regulated. Some countries, such as the UK and Canada, have environmental quality criteria for soil (10–50 mg/kg) that are use-dependent. Guidelines for arsenic in foodstuff have not yet been so widely agreed upon. At present, only Australia has established a guideline (1 mg/kg) for total arsenic (no discrimination among species) in foodstuff. China has so far introduced maximum levels for different foodstuffs and was the first country to incorporate arsenic speciation into its guidelines (e.g., 0.15 mg/kg inorganic arsenic for rice). However, the importance of distinguishing among arsenic species in guidelines is an area that requires further progress (Feldmann, 2008).

Risk Considerations

The health outcomes from exposure to arsenic depend not only on the source and chemical species of arsenic, but on dose, modality, and duration of exposure. Both acute and chronic intakes result in toxicity, although drinking contaminated water is only likely to produce effects under conditions of chronic intake. These effects include skin lesions, disturbances of the peripheral nervous system, anemia, and leucopenia, liver damage, circulatory disease, and cancer. Many of these effects have been observed in populations in Taiwan, Argentina, and Bangladesh that consumed contaminated water. The bioavailability of arsenic is a key determinant of the health outcomes of exposure because it is related to the ability of arsenic to be liberated from ingested matrices (e.g., soil, water and food) and thus enter into the blood stream where it exerts its toxic effects. Studies from human volunteer and animal experiments show about 90 percent of ingested, dissolved, inorganic arsenic salts are absorbed from the gut and enter the blood stream. This percentage is much higher than for most other ostensibly non-essential elements and, in part, is a feature of the similar chemical properties of the arsenate (AsO_4^{3-}) and phosphate (PO_4^{3-}) ions, the latter being an essential body component that is avidly absorbed from the gut (Caussy and Priest, 2008).

Technological Solutions

Substantial efforts have been invested in developing techniques for removing arsenic from water in both field and laboratory conditions. For any technology to be effective and appropriate for use in affected areas of developing countries, it should use local resources and be low-cost, versatile, transferable, and simple to operate and manage. It is essential that such technologies are accessible to local communities and especially to women. Throughout the developing world, women collect and carry water for their families, use water for cooking and cleaning and for growing food, and therefore should be at the forefront as users of arsenic treatment technologies. Even treatment systems that are highly successful from a technological viewpoint may not succeed in rural areas, such as villages of India and Bangladesh, unless they mesh with local circumstances and are well accepted by the local population.

Although water treatment is central to arsenic pollution mitigation, it is important to recognize that a change in the source of water, rather than treatment of the water locally, may be the most appropriate solution in some cases.

Where municipal piped water supplies exist, connecting to these may provide the appropriate solution for those using contaminated private sources. Even in areas where no municipal piped supplies are provided, switching to a different source well or to harvesting rain water may still be the best solution (Jones et al., 2008). An example of how this may be managed is illustrated by the practice in rural Bangladesh of color-labelling tubewells that provide water deemed unsafe for consumption (figure 4).

Conventional treatment plants may employ several methods for removing arsenic from water. Commonly used processes include oxidation and sedimentation, coagulation and filtration, lime treatment, adsorption onto sorptive media, ion exchange, and membrane filtration. However, in the most affected regions large conventional treatment plants may not be appropriate and factors such as cost and acceptability as well as performance must be considered. A summary of mitigation options, arsenic removal performance, and relative costs are presented in table 1 (page 12).

Multi Criteria Analysis

The identification and selection of best practices for arsenic mitigation options requires careful evaluation of economic, technological, and environmental factors. Regional social values and inter-disciplinary and inter-institutional contexts are also important considerations. Procedures designed to resolve arsenic remediation must also address complex problems in a manner that is comprehensible to and auditable by stakeholders. Where divergent-minded stakeholders are involved, multi-criteria analysis (MCA) is an approach that can facilitate optimal decision-making.

Figure 4. Color labelling of safe (green) and unsafe (red) tubewells in Bangladesh. [Photographs courtesy of Feroze Ahmed, Department of Civil Engineering, Bangladesh University of Engineering & Technology, Dhaka, Bangladesh.]

MCA is a decision-making tool originally developed to help evaluate options that rely on values that are not easily assignable. Cost-benefit analysis is an example where a range of defining criteria (or influencing factors) important to stakeholders are considered. The facilitation of discussions and increased transparency of decision-making processes are possible through MCA since it enables stakeholders to process large amounts of complex information, thereby helping them see the "bigger picture."

MCA procedures utilize a performance matrix (consequence table) in which options for arsenic remediation are presented (and described) in columns, and performance values for options are presented in rows against predefined criteria. Data may be entered in the matrix as utility scores in various forms, such as numerical, semi-quantitative, and/or descriptive. The performance of each option can then be aggregated against all the criteria from which an eventual overall comparison and decision on the best mitigation option can be made.

Source-exposure vector, health risk, cost, social acceptance, and technical competency are the primary MCA criteria on which a judgement or decision is reached in relation to arsenic treatment options. An example of such a matrix is available online at <www.iupac.org/publications/ci/2008/3004/2_garelick.html>. The table tracks relevant and appropriate properties for each of the listed criteria that may influence outcomes. Data in the performance matrix is converted into numerical values through application of a specific utility scale scoring and weighting technique for each criterion. A detailed account of these procedures is provided by Ellis and Garelick (2008).

Utility scores and/or weights will clearly influence performance matrix outcomes. Sensitivity analysis can also be performed by reiterating the analysis using different scores or weightings. This is a useful and important approach that enables the MCA methodology to be used as a negotiating tool in the decision-making process, allowing areas of stakeholder agreement and disagreement to be highlighted.

A substantial knowledge pool exists about human exposure to arsenic contamination; the scale of contamination in many regions is well documented, human health effects are known and understood and potential technological solutions have been elucidated. However, the implementation of successful mitigation requires this knowledge to be applied more effectively. This can only be achieved by enhancing the understanding of the interactions between socio-economic and scientific

Mitigation Options		Potential for Arsenic Removal (where applicable)		Installation Cost	O&M Cost
		As(III)	As(V)		
alternative source	dug wells			medium to low	medium to low
	rainwater harvesting			medium	low
	deep tube-well source			medium	low
chemical treatment	precipitation/coagulation/adsorption	-/++	+++	medium	medium
	ion exchange/reverse osmosis	-	+++	high	high
bioremediation		+++		medium to low	low
physical treatment	membrane technology	+++	+++	high	high
	solar still	+	+	high	medium to high
	slow sand filters	++/+++		medium to low	low

Table 1. Evaluation of Performance and Costs of Arsenic Pollution Mitigation Options. Adapted from Visoottiviseth and Ahmed (2008) and Ellis and Garelick (2008).

issues, thus enabling practitioners to develop effective and appropriate mitigation programs.

References

Cairncross, S. and Valdmanis, V. (2006) "Water Supply, Sanitation, and Hygiene Promotion." In Jamison et al. (eds): *Disease Control Priorities in Developing Countries* (2nd Edition),ed. , 371-388. New York: Oxford University Press. <www.dcp2.org/pubs/DCP/41/>.

Caussy, H. and Priest, N. (2008) "Introduction to Arsenic Contamination and Health Risk Assessment with Special Reference to Bangladesh." *Reviews of Environmental Contamination and Toxicology*. **197**. [In Press].

Ellis, J.B. and Garelick, H. (2008) "A Multi-Criteria Approach for Assessing Options to Remediate Arsenic in Drinking Water." *Reviews of Environmental Contamination and Toxicology.* **197**. [In Press].

Feldmann, J. (2008). "On Site Testing for Arsenic: Field Test Kits." *Reviews of Environmental Contamination and Toxicology*. **197**. [In Press].

Garelick, H. et al. (2006). "Remediation Technologies for the Removal of Arsenic from Water and Wastewater." An IUPAC project presented at the IUPAC 43rd General Assembly, Beijing, China.

Garelick, H. et al. (2008). "Arsenic Pollution Sources." *Reviews of Environmental Contamination and Toxicology.* **197**. [In Press].

Jones, H. et al. (2008). "Case Report: Arsenic Pollution in Thailand, Bangladesh and Hungary." *Reviews of Environmental Contamination and Toxicology.* 197. [In Press].

Keusch, G.T. et al. (2006). "Diarrheal Diseases." In Jamison et al (eds): *Disease Control Priorities in Developing Countries* (2nd Edition), ed. , 371–388. New York: Oxford University Press. <www.dcp2.org/pubs/DCP>; Chapter 19.

UNICEF (1998) The State of the World's Children 1998. <www.unicef.org/sowc98>

Vaughan, D.J. (2006) "Arsenic" *Elements* 2: 71–75.

Visoottiviseth, P. and Ahmed, F. (2008) "Technology for Remediation and Disposal of Arsenic." *Reviews of Environmental Contamination and Toxicology*. 197. [In Press].

WHO (2006) *Guidelines for Drinking-Water Quality.* Volume 1—Recommendations. First addendum to third addition. <www.who.int/water_sanitation_health/dwq/gdwq0506.pdf>

WHO (2008) "Water Quality Interventions to Prevent Diarrhoea: Cost and Cost-Effectiveness" (T.F. Clasen, L. Haller) Geneva 2008 WHO/HSE/WSH/08.02

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Opportunities and Obstacles

by Eva Åkesson, Maja Elmgren, and Kristina Edström

The Bologna process is a voluntary joint venture among 46 European countries, which has as its objective the creation of a European Higher Education Area (EHEA) by 2010. The EHEA will cover all of Europe including European Union newcomers Armenia, Azerbaijan, Georgia, Moldova, and Ukraine. Its aim is to allow for degrees and qualifications awarded in one country to be understood and recognized in other countries, thereby facilitating mobility and enhancing employability. The EHEA's overarching goals will be achieved by providing common tools and fostering cooperation in quality assurance. The common tools in the emerging EHEA, such as the European Credit Transfer and Accumulation System, Diploma supplement, a three-cycle system, and qualification frameworks, all aim to provide a system that is easy to comprehend for students, institutions, and employers.

A Slow Start in Sweden

Sweden was one of the last countries within the Bologna family to implement the three-cycle system (bachelor, master, and Ph.D). The Bologna process has now encouraged a major reform of higher education in Sweden, which passed a bill known as New World–New University. It came into effect 1 July 2007 and brought about changes in the Higher Education Act and Higher Education Ordinance. Within the second cycle, a new two-year master's degree has been introduced. The credit system has been reformed and is now aligned with the European Credit Transfer and Accumulation System. With the introduction of a three-cycle system, all degree descriptions have been reviewed and the degrees have been placed at either first, second, or third level.

The new degree descriptions are based on the expected learning outcomes of the student and are related to the Qualifications Framework of the Bologna Process. These are formulated for general qualifications (i.e., Bachelor's, Master's, and Ph.D.) and professional qualifications as objectives under three headings: knowledge and understanding, skills and abilities, and judgement and approach. Universities in Sweden have the autonomy to establish programs and decide the certain field of specialization and establish more precise requirements within the framework of the national qualification description. There is no external accreditation or validation prior to the start of a university program, with the exception of professional qualifications. The validation is performed by the universities' internal quality assurance systems. However, all programs are evaluated periodically by an external quality assurance agency.

So, even though Sweden was one of the last countries to implement the three-cycle system, it carried out the reforms quickly and thoroughly. Universities have now formulated expected learning outcomes for each course/module and program.

From Teaching to Learning

One ambition with the Bologna process is to promote a shift from teaching to learning, from inputs to outcomes. Such a shift, it is thought, will be welcomed by most teachers and students in Sweden. The Bologna Process is also seen as an opportunity to leverage further educational reform; to enhance pedagogy, assessment, and quality assurance.

Another positive outcome of the Bologna Process is how it widens the perspective about education, from a focus mainly on knowledge as the learning outcome to competencies and skills. This is of great significance to chemistry education because of the strong tradition of lab practice. The competencies and skills of chemists from now on will be explicit in terms of learning outcomes. This will facilitate their educational progression and be advantageous for communicating with future employers.

The intentions were good, but what is the result of the Bologna Process? The report *TRENDS V, Universities*

Shaping the European Higher Education Area, [by David Crosier, Lewis Purser, and Hanne Smidt, EUA 2007 (isbn: 9789078997023); available on the the European University Association website <www.eua.be>] states: "The focus has shifted from governmental actions, including legislation, to implementation of reforms within institutions, with broad support for the underlying idea of more student-centered and problem-based learning." The authors of the report note a difference among countries that have only met the basic requirement with new legislation and those that have used the implementation as a strategy for further reforming their educational system.

For chemistry educators in Sweden, the critical question is: Did the universities and chemistry education make use of the opportunities for reform or did they stumble on the obstacles? Sweden was lagging behind at first but got more or less a jump-start in 2007. Those involved foresee a risk with a forced process and fear a consequence could be a structural reform instead of the desired change and quality enhancement of chemistry education.

Status Report for Chemistry in Sweden

In practice, the forced process of implementation has meant that the whole structure of courses available to chemistry students has had to be revised. Earlier, in Sweden, we gave students the choice of selecting among a large number of courses; which often resulted in only a few students per course at the advanced level. The implication of the Bologna process means not only a possible educational gain but also a necessary economical restructuring of the university education in chemistry for the whole of Sweden. This is a consequence of the problem of recruiting students to chemistry that we see in the whole western world today.

The concentration of fewer courses in chemistry as a result of Sweden's educational reforms has been approached differently at different universities. At some universities, the new curricula, especially at the bachelor level, has been based on integrating knowledge from the different subdisciplines to develop new courses. This effort had a positive outcome since it generated intense discussions among lecturers from different disciplines (analytical-, inorganic-, organic-, physical-, and theoretical chemists and biochemists) as well as discussions about how mathematics, physics, and biology could be integrated into chemistry education.

A multidisciplinary approach to chemistry means that there must be a team of lecturers interacting and formulating the goals and learning outcomes for each specific course. Additionally, they must agree and clearly state how the course will fit into the progression of chemistry education. A drawback of this system is that it is difficult to find literature and materials that adequately cover the course contents. At other universities, a more traditional approach has been taken, with the different subdisciplines offering their own courses. This means that in Sweden different universities will be providing different routes to a degree in chemistry.

The Bologna process and life-long learning. Reproduced from TRENDS V report—see text for reference.

So far, most of the energy and time invested in the new education system has been for "laying out the track," with some early steps toward formulating learning outcomes. A quick glance at some selected chemistry courses, at both bachelor's and master's levels, shows that Sweden will need more time to resolve differences among universities regarding specific skills and abilities, judgments and approaches, as well as knowledge and understanding needed to attain a degree in chemistry. The process can be summarized as "Nice try, try again."

The European Chemistry Thematic Network (ECTN) has launched a 180-credit framework bachelor program in chemistry called the Chemistry EUROBACHELOR, which is intended to set a standard for chemistry higher education in Europe (see Sep-Oct 2004 *CI*, p. 11 and Jul-Aug 2007 *CI*, p. 12). The degree is designed to be comparable and easily readable in terms of learning outcomes, skills, and competences. So far, interest in the Eurobachelor has been mild in Sweden. The suggested framework would restrain the course curriculum and the students' freedom of choice even more than the new Bologna-adapted education system we have reached in Sweden today. However, the international discussion around chemistry that was initiated by work on the Eurobachelor was very useful in Sweden and could be useful to countries outside Europe.

Meanwhile, the internal discussion within Sweden has resulted in a chemistry collaboration between three universities: Lund, Karlstad, and Uppsala. The purpose of the project is to enhance the quality of chemistry teaching by benchmarking the impact of educational reforms, sharing experiences, and establishing good practices. One of the strategies for the project is to compare the descriptors/learning outcomes for the bachelor's and master's degrees and for each module/course. The research so far suggests the different strategies have led to different outcomes. This poses interesting questions regarding the overall goals of the Bologna process, such as mobility, recognition, and employability.

New curricula and new expected learning outcomes might be influenced by many different parameters. The three different universities involved are different in many respects. Lund University has the largest chemistry department of the three selected. Karlstad University is the youngest and the chemistry department is the smallest. Uppsala University's chemistry department combines both engineering and science education in a way that is distinct from the other two universities.

These differences influence how the universities have adapted to the Bologna process. The universities in Lund and Karlstad have found no reason to change their course structures, which are based on classical chemistry subdisciplines. The adaptation is mainly focused on developing expected learning outcomes. Uppsala University introduced a set of new thematic courses, with names like Chemical Principles, Chemical Reactions, and Structure and Function of Chemical Substances. Another novelty is joint studies for science and engineering students during the first year. This is in line with a general tendency in Sweden towards designing the different programs in a more similar way, where insight into research is emphasized in engineering programs and employability in science programs.

The project involves workshops in which lecturers and administrators from the three universities meet to discuss the different strategies they are employing to reach the goals outlined in the Higher Education Act. Between the workshops each university-specific group continues its discussion and works on assignments that have been developed during the workshops. The project will conclude two years from now. Hopefully, by that time the Bologna process as it pertains to chemistry in Sweden will have been more than just a paper tiger.

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Green Chemistry Course for Teachers

Latin American High School Teachers Learn About Sustainable Chemistry

by Norma Sbarbati Nudelman

Since 2005, the Argentine National Academy of Sciences (ANCEFN) has been organizing one-week courses on sustainable/green chemistry for high school teachers. The courses have been popular because the principles of sustainable/green chemistry are not well understood in Latin America although the subject is especially relevant to education and industrial development in the region.

One of the main objectives of the course is to attract interest among university professors, high school teachers, and students in the principles and activities of sustainable/green chemistry around the world, and to disseminate the ongoing research in Latin American universities as well as in leading industries. Another goal is help change the public image of chemistry, by publicizing—to governments, NGOs, and the general public—the multiple benefits that environmentally friendly chemistry provides and the ways in which it enhances our quality of life. Education plays an essential role in the dissemination of these concepts and the importance of sharing responsibilities.

The teachers engage in practical laboratory work.

Course Features

The five-days course, comprising 10 lectures, 3 practical laboratory experiments, two workshops in break-out groups, visits to two industrial plants, and written examinations, involves 50 hours of learning. The lectures are given by specialists from chemical industries and/or universities working in different fields of sustainable/green chemistry. Each lecture starts with a sound introduction to the subject and then develops to reach the "state-of-the-art" level on each topic, including up-to-date literature. The language of the course is Spanish and the main written material is the book *Quimica Sustentable*, written in 2004. As far as we know, this is the first book written in Spanish on the subject.

The course starts with a brief description of the more serious global environmental problems caused by chemicals, safe management practices, international agreements (Basilea, Stockholm, and Rotterdam), and the search for integration and synergies. Then it focuses on renewable sources, (particularly those abundant in the region) of chemicals and materials, friendly protection of crops, the difference between PICs (products of incomplete combustion) and POPs (persistant organic pollutants), and on clean technologies for pollution prevention and reduction (sustainable alternatives). Each lecture shows that a technology is sustainable as long as it meets the needs of the present without compromising the ability of future generations to meet their needs ("sharing responsibilities"). Since crop-derived feedstocks are more sustainable than oil-based ones, one lecture is devoted to the routes of transformation of abundant natural products. Catalysis is also a powerful tool for promoting the reduction of pollution. Other lectures describe recently developed environmentally friendly technologies that avoid the use of organic solvents and other potentially toxic and/or persistent chemicals. Two lectures focus on alternatives to using conventional organic solvents and techniques for the replacement of halocarbons.

The course also covers teaching methods: A lecture by a science-education specialist is included, and participants are asked to present a 10-minute presentation about how they will apply some of the principles learned during the course in their own classrooms.

The 1st Latin American Course on Sustainable Chemistry was held in Mendoza, Argentina, in November 2005. Organized by the ANCEFN and the National University of Cuyo, it received a large number of applicants, 84 from Argentina and 22 from other Latin American countries. Since no more than 40 participants could attend, the ANCEFN decided to offer a new course the following year. The second course, with 30 participants from Argentina and 10 from 10 different Latin American countries, was held in Bahia Blanca and sponsored by ANCEFN, the Inter-American Network of National Academies of Sciences, and UNESCO. The course included visits to two production centers: Petrochemical Cuyo and Bodegas San Felipe, a very well-known winery in Mendoza, gave the teachers a look at how good green chemistry practices have been achieved and how they contribute to industrial development. At Petrochemical Cuyo, an important supercritical fluids plant, participants saw how the extraction of caffeine from tea leaves that they performed during lab work with conventional organic solvent was performed with super-critical fluids in the plant.

The 3rd Course on Sustainable Chemistry was held in Corrientes, Argentina, in October 2007. It was organized by the ANCEFN and the National University of

Corrientes. Visits were organized to a plant of water potabilization that is built on the shores of the Paraná, a very large river, and also to a beer production plant, where participants observed how waste treatment and reutilization of mass residues were used for energy generation. A large number of participants from Uruguay were accepted this time in addition to participants from Chile, Brazil, Bolivia, Venezuela, and Colombia.

This year, a pre-course one-day symposium is being organized, which will provide a first formative evaluation of how the principles and other outcomes of the Sustainable Chemistry Course are being introduced in the classrooms. Participants from the three previous courses are invited to apply for it and share with the audience their experiences of teaching sustainable/green chemistry in their respective schools.

We are convinced that this kind of course and accompanying activities help underline the relevance of sustainable/green chemistry for emerging regions, emphasizing that industrial development requires proper planning and compliance with international environmental agreements, not only for technological success but also to allow future generations to meet their needs. Some local students had been invited to informally attend the courses, and their satisfaction with this "new, clean chemistry" is quite clear. And last but not least, since the three previous courses were organized in different provinces of the country, the local press, TV, and other mass media, provided wide coverage of the lectures, laboratory work, and visits to the production centers.

Teachers learn about extracting caffeine from tea leaves.

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Send your comments by e-mail to <edit.ci@iupac.org>.

Internet Chemistry for Developing Countries

by Gedion Getahun

Internet-based education holds great promise for providing students in developing countries with resources they might otherwise never see. Chemistry is one subject area in which students in these areas could especially benefit from Internet learning. However, there are currently many obstacles to Internet access.

In developing countries, only about 10 percent of the population has access to electricity, which creates a real impediment to Internet access. Even when there is electricity, a majority of people live in rural areas that lack communications infrastructure. Additionally, in many developing countries the terrestrial system for Internet access is through a slow copper-wire network.

In areas where no infrastructure exists, satellitebased systems offer a practical alternative. It is the best option for high-speed data transmissions in the absence of fiber-optic cabling. Furthermore, wireless technology has no environmental limitations, it can work on moving glaciers or deep inside rain forests, and there is no need to lay fiber underground.

The beauty of teaching over the Internet is that knowledge is distributed beyond the walls of the classroom. Web-based education is a discipline without restrictions of time and location. Apart from remote lectures, the Internet allows for the downloading of course-modules or entire courses.

The Internet provides an excellent opportunity for remote chemistry education for schools and for universities. Even though chemistry is an experimental subject, experiments can also be delivered through web-based education.

The dissemination of science and technology information on the Internet has opened many new venues for scientific inquiry in areas such as modern chromatography, on-line spectrophotometry, astronomy and cosmo-chemistry, and remote sensing. Fortunately, the Internet has provided new avenues for scientific advances to be shared between scientists in developed and developing countries. For example, some online medical and scientific journals are supplied for students, scientists, and academics in developing countries free of charge or at greatly reduced prices. The Internet can also open the information flow from developing to developed countries as well. Over 25 percent of the world's scientists are from developing countries. Providing access to journals and communications with the worldwide scientific community will encourage scientists in these areas to publish their research papers.

The Internet has proved to be an excellent resource for students in developing countries since it provides them with supplementary lessons and helps prepare them for exams with assessing tutorials, discussions, and exercises. It also offers them unlimited opportunities to get information on physical science subjects. These students frequently explore the web to search for books, references, and journals to obtain detailed information for a course they are taking.

Unfortunately, the distribution of the Internet in developing countries is frequently not a technological problem, but rather a financial one. The time allowed for school children to surf on the Internet is limited mostly due to the cost of being online. Technical solutions have to be investigated to minimize this cost. Excellent hard and software systems that support rapid data transfer are among the solutions.

While Internet technology continues its rapid advancement, the forecast for Internet availability in the developing countries is uncertain. However, the technological and the financial requirements must be solved.

Funding is needed for developing countries to acquire the technology and develop their own methods and requirements for web-based education systems. However, priority should be given to communities in remote areas or the countryside since they have far fewer educational opportunities due to a shortage of schools.

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Zhenan Bao Awarded First *Polymer International*-IUPAC Award

On 20 May 2008, the executive editors of *Polymer International* and the IUPAC Polymer Division announced that Zhenan Bao was the first winner of their award for creativity in applied polymer science or polymer technology. The award celebrates the achievements of young researchers in the polymer industry. Professor Bao, of the Department of Chemical Engineering at Stanford University, California, USA) received USD 5 000 and the opportunity to present the Award Winning Lecture at MACRO 2008. She presented her lecture on "Polymers for Flexible Electronics" on 4 July 2008 at the Taipei Convention Center, Taiwan.

Zhenan Bao, winner of the first Polymer International-*IUPAC Award.*

Zhenan Bao, a world leader in the field of organic and polymer electronics, was formerly a distinguished member of the technical staff in the Materials Research Department of Bell Labs, Lucent Technologies at Murray Hill. She pioneered the materials design concepts for high charge transport properties in polymer semiconductors and air-stable organic semiconductors that can be processed using solution techniques. This work led to the first demonstration of all-printed organic transistors, and her group was the first to demonstrate all-printed plastic circuitry, thereby opening a new era in electronics. Under her leadership, her group has developed new dielectric material systems and a new type of water-stable sensor.

Her interdisciplinary approach to technologically important issues applied in industry has now been transferred to her career in academia, with over 100 refereed publications and more than 30 patents to her name.

The winner was selected by the Scientific Committee representing *Polymer International* and the IUPAC Polymer Division:

- François Schué, editor in chief of *Polymer International* and a member of IUPAC
- Richard G. Jones, chair of the IUPAC Subcommittee on Polymer Terminology and associate editor of *Polymer International*
- Christopher K. Ober, president of the IUPAC Polymer Division
- Mitsuo Sawamoto, IUPAC Titular Member and a member of the MACRO 2008 International Advisory Committee (Eastern Hemisphere)
- Pavel Kratochvíl, member of IUPAC, *Polymer International* Editorial Board and MACRO 2008 International Advisory Committee (Central Europe)
- Robert G. Gilbert, member of IUPAC and MACRO 2008 International Advisory Committee (Australasia and the Southern Hemisphere)

IUPAC Announces 2008 Winners of the IUPAC Prizes for Young Chemists

On 21 April 2008, IUPAC announced the winners of the 2008 IUPAC Prizes for Young Chemists, awards for the best Ph.D. theses in the chemical sciences as described in 1000-word essays. The five winners are:

- **Emilie V. Banide**, University College Dublin, Dublin, Ireland
- **Christopher Thomas Rodgers**, University of Oxford, Oxford, United Kingdom
- **Akinori Saeki**, Osaka University, Osaka, Japan
- **Andrea Rae Tao**, University of California, Berkeley, United States
- **Scott Warren**, Cornell University, Ithaca, USA

The winners will each receive a cash prize of USD 1000 and a free trip to the IUPAC Congress, 2–7 August 2009, in Glasgow, Scotland. Each prizewinner will also be invited to present a poster at the IUPAC Congress describing his/her award winning work and to submit a short critical review on aspects of their research topics to be published in *Pure and Applied Chemistry*. The awards will be presented to the 2008 and 2009 winners during the Opening Ceremony of the Congress.

The essays describing the 2008 winners' theses, which cover a wide range of subject matter, can be found on the IUPAC website:

- Emile V. Banide, "From Allenes to Tetracenes: Syntheses, Structures, and Reactivity of the Intermediates"
- Christopher Thomas Rodgers, "Magnetic Field Effects in Chemical Systems"
- Akinori Saeki, "Nanometer-Scale Dynamics of

Charges Generated by Radiations in Condensed Matter"
- Andrea Rae Tao, "Nanocrystal Assembly for Bottom-Up Plasmonic Materials"
- Scott Warren, "Nanoparticle-Block Copolymer Self-Assembly"

There were 42 applicants from 16 countries. The Prize Selection Committee was comprised of members of the IUPAC Bureau with a wide range of expertise in chemistry. The committee was chaired by Bryan R. Henry, IUPAC past president.

In view of the many high-quality applications, the committee decided to also give Honorable Mention awards to:
- Luke Andrew Connal, The University of Melbourne, Melbourne, Australia
- Stefan Knippenberg, Hasselt University, Limburg, Belgium
- Takatsugu Tanaka, The University of Tokyo, Tokyo, Japan
- Hui Wang, Rice University, Houston, Texas, USA

The recipients of Honorable Mention Awards will receive a cash prize of USD 100 and a copy of *Quantities, Units, and Symbols in Physical Chemistry*, the IUPAC Green Book.

Applications for the 2009 prize are now being solicited, as described on the IUPAC website <www.iupac.org/news/prize.html>.

Jan Heeres Awarded the 2008 IUPAC-Richter Prize

Jan Heeres (center) accepts the 2008 IUPAC-Richter Prize from Robin Ganellin (left) and Janos Fischer.

On 18 June, the 2008 IUPAC-Richter Prize in Medicinal Chemistry was awarded to Jan Heeres at the American Chemical Society 31st National Medicinal Chemistry Symposium in Pittsburgh, Pennsylvania, USA. Heeres, formerly of the Centrum for Molecular Design and Janssen Pharmaceutica, Beerse, Belgium, received a check for USD 10 000 and a plaque signed by Jung-Il Jin, president of IUPAC; Erik Bogsch, chief executive officer of Gedeon Richter Plc.; and Robin Ganellin, chair of the IUPAC-Richter Prize selection committee.

Heeres received the award in recognition of his outstanding medicinal chemistry contributions to new drug discovery while at Janssen Pharmaceutica. In particular, he was recognized for the discovery of ketoconazole, the first orally active broad-spectrum imidazole antimycotic, and for 20 years of discovering other important antifungal azole drugs, such as econazole, miconazole, isoconazole, carnidazole, azanocazole, parconazole, terconazole, propiconazole, itraconazole, and saperconazole.

Heeres studied chemistry at the State University of Gröningen, The Netherlands, and received a Master's degree in 1965. He then joined the team of E.F. Godefroi at Janssen Pharmaceutica to work on azole chemistry. During the next two years this work produced the first of the substituted-imidazole antifungal drugs: miconazole and econazole. From 1971 onwards Jan Heeres was responsible for elaborating on these structures, incorporating the dioxolane ring and introducing a variety of side chains. This work led to ketoconazole, and was followed by various other improved drugs as listed above.

His research continued in various areas such as anticancer agents, anti-epileptics, lipid-lowering agents and, in 1996, he joined Paul Janssen's Centrum for Molecular Design. Here he was involved in structure-assisted drug design for antiviral drugs against HIV. This work produced dapivirine, etravirine, and rilpivirine, non-nucleoside reverse transcriptase inhibitors. Etravirine has recently been approved by the FDA and has been launched by Tibotec (a subsidiary of Johnson and Johnson) in the USA. Meanwhile, rilpivirine has successfully completed phase II clinical trials.

In 1982 Jan Heeres was awarded the J&J medal in recognition of his role in the discovery of ketoconazole and in 2002 was made Distinguished Research Fellow.

F. Dean Toste Wins 2008 Thieme-IUPAC Prize

The 2008 Thieme IUPAC Prize was awarded on 24 June 2008 to F. Dean Toste of the University of California, Berkeley, at the ICOS-17 conference in Daejeon, Korea. As the ninth recipient of the prize, Toste joins a select group of scientists under 40 whose research has had a major impact on the field of synthetic organic chemistry. The prize, which is awarded every two years and consists of Euros 5000, is sponsored by Thieme Publishers and IUPAC in collaboration with the editors of *SYNTHESIS*, *SYNLETT*, *Science of Synthesis*, and *Houben-Weyl*.

After completion of B.Sc. and M.Sc. degrees at the University of Toronto, Toste obtained his Ph.D. in 2000 from Stanford. His Ph.D. thesis received the prestigious ACS Nobel Laureate Signature Award. He joined the department of chemistry at Berkeley in 2002, and was promoted to associate professor in 2006.

Toste's research achievements include the almost unprecedented use of a high oxidation state dioxo-rhenium complex to catalyze reductions of aldehydes, ketones, and imines, an approach that is contrary to conventional wisdom. Nevertheless, he went on to elucidate a novel mechanism for the process and developed a stereoselective version.

His research has also led to a series of outstanding contributions in the use of late transition metal complexes in low oxidation states, most notably gold(I), as catalysts for advanced organic synthesis. The potential of gold catalysts has been over-looked for decades, and it is largely due to the excellent achievements of the Toste laboratory that this situation is now rapidly changing.

www.thieme-chemistry.com

continued from page 18

Up for Discussion

Web-based education for students in developing countries should include programs that enable students to develop chemical sensors, software, and small, basic scientific equipment. Using sensors and software, developed for their own needs, students can start to measure environmental samples, pH changes in river water, trace metals in soil, and more. In this way, students can start to develop their knowledge by investigating scientific assignments; for example, by asking "What happens if we alter this parameter and keep the other one constant?" Or, they might be asked about chemical equilibrium: "What happens if we keep the pressure constant and alter the concentration or temperature?"

In general, experiments and small practical work applying advanced technology encourages the young people at schools and universities. Another way of making science subjects in general, chemistry in particular, more interesting and preferable by the young generation in the developing countries is to organize competitions. Students in schools and universities compete against each other. Various competitions could be prepared. It could be basic research, laboratory work, problem analysis, homework assignments, quizzes, etc. The winners will get reward for their outstanding merits. This type of scientific work stimulates enthusiasm by the students. The programme should give an impression that high school and university students are the leaders of tomorrow. The method helps to develop a scope for individual tangential investigation through their life. This is one of the methods among several others to prepare them to take responsibility in their future carrier. Therefore, a lot can be achieved in a lesson that incorporates web-based distance education.

Dr. Gedion Getahun <gedget@radioanalytical-chemistry.org> is an environmental radio chemist, engaged as a research scientist and lecturer. He is a member of the German Chemical Society, subdivision: Analytical Chemistry & Ionising Radiation.

The Project Place

Strategic Planning for a New East Asian Network for Organic Chemistry

Since October 2005, an IUPAC project has been laying the groundwork for the establishment of an East and South East Asian Network for Organic Chemistry. It has been estimated that 30 percent of the research done in the field of organic chemistry in the world is being produced in Asia. While this statistic is encouraging, a careful inspection shows that productive research is presently concentrated in a few countries in the region, and is by no means a common phenomenon across all countries in Asia.

The Japan Society for the Promotion of Science's Asian CORE program has been designed to create world-class research hubs, "core institutions within the Asian region," in selected cutting-edge fields with topics deemed to be of high international importance, while fostering the next generation of leading researchers by establishing sustainable collaborative relations among members in seven countries/regions. The activities of the program involve scientific conferences, researcher exchanges, lectureship tours, and joint research.

The purpose of the IUPAC project (# 2005-039-2-300) is to plan the best strategy to link with the JSPS program and establish a cooperative network that will provide maximum support for organic chemists throughout the East Asian region. The proposed network would be expected to promote collaborative research work based on interactive relationships, academic exchanges, and activities. The network would be responsible for the organization of workshops on aspects of organic chemistry, chemical techniques, and current research trends, with the aim of enhancing the level of organic chemistry and research in less developed Asian countries.

A recent example of the cooperative network in action was the 2nd International Conference on Cutting-Edge Organic Chemistry in Asia, held 2–6 September 2007 in Busan, Korea. The 138 organic chemists who participated were from the 7 member regions/countries.

Prior to the conference, about 40 organic chemists attended the second workshop under the IUPAC project. IUPAC supported the lecturers as well as the organic chemists whose home countries were not part of the Asian CORE program and attendees from countries that are not National Adhering Organizations of IUPAC, such as the Philippines and Malaysia. The workshop featured two speakers who delivered lectures and gave demonstrations to update attendees on new techniques Takao Ikariya of the Tokyo Institute of Technology spoke on "Applications of Supercritical Fluids in Organic Chemistry," and Kong Hung Sze from the University of Hong Kong delivered a talk on "Application of New NMR techniques in Organic Chemistry." The workshop was recorded on video for possible use at future workshops. Extensive notes were also made available.

Group photo at the 2nd International Conference on Cutting-Edge Organic Chemistry in Asia.

The 3rd International Conference on Cutting-Edge Organic Chemistry in Asia (ICCEOCA-3) will be held 19–23 October 2008 in Hangzhou, China, This will be followed by ICCEOCA-4 in Bangkok (2009) and ICCEOCA-5 in Taipei (2010).

For more information and comments, contact Task Group Chair Minoru Isobe <isobem@ff.iij4u.or.jp>.

www.iupac.org/web/ins/2005-039-2-300

Critically Evaluated Techniques for Size Separation Characterization of Starch

A better understanding of structure-property relations for starch is needed to address human and animal nutritional needs and industrial applications such as paper manufacture. Characterizing the structure is complex because one of the two types of starch in grains, amylopectin, is hyperbranched and of very high molecular weight.

Size separation techniques (size-exclusion chromatography, field-flow fractionation), with multiple detection, in principle provide powerful tools for obtaining data that are sensitive to this complex structure. However, reliable application of these methods is bedeviled by two problems: (1) not all the starch may be dissolved, and (2) shear scission may occur during separation. Recognizing these problems, several leading researchers in the field over the last few years have independently devised various protocols, typically involving the use of solvents (eluents) such as dimethyl sulfoxide of varying degrees of dryness, with or without other additives such as dimethylacetamide and LiBr, various dissolution regimens, and various flow techniques. However, there has been no comparison of the data obtained from different set-ups.

This project will bring together these leading groups to discuss the full technical details of their different procedures, including the reasons for these being chosen by the particular group, and perceived problems with these various methods. The main objective of this project is to produce a reliable means of characterizing starch by size separation techniques (such as size exclusion chromatography and field-flow fractionation), by critically examining and reconciling the various, and presently rather diverse, existing methodologies. A round-robin will then be organized to characterize the same sample by the varying techniques. The results will be used to develop improved techniques that can be used by researchers worldwide to obtain reliable and reproducible results.

For more information and comments, contact Task Group Chair Robert G. Gilbert <b.gilbert@uq.edu.au>.

www.iupac.org/web/ins/2007-058-1-400

Biophysico-Chemical Processes of Anthropogenic Organic Compounds in Environmental Systems

Anthropogenic organic compounds (AOCs) are synthetically made organic chemicals. They range from gasoline components (e.g., benzene, toluene, xylene) to emerging contaminants such as endocrine disrupting chemicals and personal care products. Due to their wide use and disposal, AOCs are commonly found in our environment, such as in water we drink, air we breathe, and soil from which we get our food. These compounds are often toxic and can severely deteriorate an ecosystem. They can also bioaccumulate through food chains and cause various diseases (and even death) to organisms including humans. AOCs behave differently in various environmental media which differ in their different physical, chemical, and biological components and processes. Therefore, an in-depth and more complete understanding of the biophysico-chemical processes of AOCs in environmental systems is essential for the development of innovative management strategies for sustaining the environment and ecosystem integrity.

Physical, chemical, and biological, interfacial interactions and processes govern the fate, transport, availability, exposure, and risk of AOCs. However, the fundamentals of many physicochemical and biological interfacial reactions of AOCs and their impacts on ecosystems largely remain unknown. As a result, predictive models for their fate, transport, and risk in different media are often off target. To advance the frontiers of knowledge on the subject matter, it would require a concerted effort of scientists in relevant physical and life sciences such as chemistry, mineralogy, geochemistry, microbiology, ecology, and soil, atmospheric, and aquatic sciences.

In contrast to the classical books which largely focus on separate, individual physicochemical and biological aspects, this proposed book aims to integrate the frontiers of knowledge on the fundamentals and the impact of physicochemical and biological interactions and processes of AOCs in soil, sediment, water, and air. The specific objectives of this proposed book are to address: (1) fundamental biophysico-chemical processes of AOCs in the environment, (2) occurrence and distribution of AOCs in air, water, and soil, and their global cycling, (3) the state-of-the-art analytical techniques of AOCs, and (4) the restoration of natural environments contaminated by AOCs. The proposed book will also identify the gaps in knowledge on the subject matter and as such provide future directions to stimulate scientific research to advance the chemical science on biophysico-chemical interfacial reactions in natural habitats.

This book would achieve this goal by bringing together world-renowned international scientists on the subject matter to integrate the current state-of-the-art, especially the latest discoveries, development, and future prospects on the research of AOCs in the environment. Thus, this book will be an important addition to the scientific literature and a valuable source of reference for students, professors, scientists, and engineers. The book will be co-edited by Baoshan Xing, Nicola Senesi, and P. Ming Huang, and published as volume 3 in the IUPAC book series titled *Biophysico-Chemical Processes in Environmental Systems*.

For more information, contact Task Group Chair Baoshan Xing <bx@pssci.umass.edu>.

www.iupac.org/web/ins/2008-001-1-600

Development of an Isotopic Periodic Table for the Educational Community

The objective of this project is to clarify the role of isotopes in chemistry and other sciences. With assistance from the Committee on Chemistry Education (CCE), this project and a follow-on project will develop learner-oriented materials on an interactive periodic table that emphasizes the existence of isotopes and the role of isotopic compositions of elements.

In order to capture the attention and interest of students and teachers at the primary, secondary, and tertiary educational levels, there is a need to make creative use of a wide range of media. Working with CCE, a periodic table will be developed that will provide a wide range of isotopic based information (e.g., number of stable and unstable isotopes, representative isotopic composition, and atomic weight values). Information, case studies, and other links about the application of isotopes to chemistry and other sciences will also be provided. CCE will provide input on topics of interest to students and will provide advice on the types of interactions, while other task group members will provide the scientific data. Advice will be sought on the best educational strategies to capture and hold students' attention. Both online and paper based versions of the materials will be developed.

For more information and comments, contact Task Group Chair Norman E. Holden <holden@bnl.gov>.

www.iupac.org/web/ins/2007-038-3-200

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.

www.iupac.org/reports/provisional

Terminology for Radical Polymerizations with Minimal Termination—The So-Called "Living" and/or "Controlled" Radical Polymerization

This document defines terms related to modern methods of radical polymerization, in which certain additives react reversibly with the radicals, thus enabling the reactions to take on much of the character of living polymerisations. In recent technical literature, these reactions have often been referred to as, inter alia, "controlled" or "controlled/living" polymerizations. The phenomenon is defined, a name for it is recommended, and definitions are provided for the relevant basic terms.

Comments by 30 September 2008
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www.iupac.org/reports/provisional/abstract08/jenkins_300908.html

Dispersity

This recommendation defines just three terms, viz., molar-mass dispersity, degree-of-polymerization dispersity, and dispersity. "Dispersity" is a new word, coined to replace the misleading, but widely used term "polydispersity index." 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 non-polymeric) materials on an unambiguous and justifiable footing.

Comments by 30 September 2008
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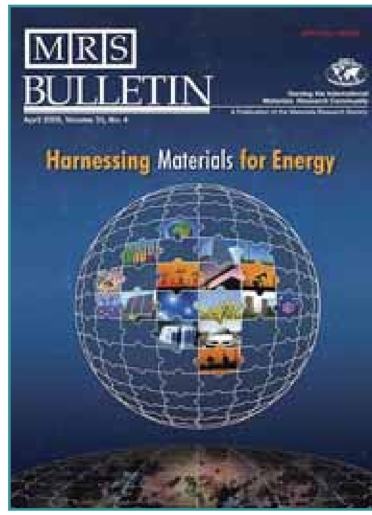
Harnessing Materials for Energy

MRS Bulletin, Special Issue
Volume 33, No. 4, April 2008

Preface* by V.S. Arunachalam and E.L. Fleischer

"Energy can be neither created nor destroyed," say our science books, "but can only be transformed from one form to another." Humankind and nature have been engaged with this transformation since life began on this planet. Nature does this with plants absorbing sunlight, an infinitely large energy resource, and producing oxygen and energy in useable forms—not very efficiently, but extensively. Humans are engaged in a similar task of transforming energy into forms they want from the sources that contain it and using this energy for their needs. With time, we have learned to produce and use energy more efficiently and economically from a variety of resources: coal, hydropower, oil, natural gas, nuclear, and so on. The energy contents of these resources vary, but the new ones are richer. Along with this search for new resources, humans have also learned to be more efficient in tapping them. Compare, for example, the animal-dung-fueled cooking stove with an efficiency of a few measly percent with a modern gas-fueled stove. An efficient fuel and better design enabled by excellent materials made this difference. For wider distribution and ease in usage, energy is now transported over long distances through electricity grids or gas pipelines from central locations. In many societies, individual needs are supplied through these centralized systems. Yet we are getting increasingly accustomed to using energy not just for basic needs of life but for enriching it. The world's primary energy consumption increased to 14 terawatt-years per year, almost 50 times the pre-industrial level of about 0.3 terawatt-years per year.

The world population grew about five times in the same period. Every source of energy is like a tributary flowing into a river of energy where all resources combine. Like rivers that enrich agricultural lands, energy streams—wherever they have flowed—have also created regions of human development and economic prosperity. Like the geography atlas, the energy atlas of the world is also uneven. There are regions of deprivation and of unmet needs. There are also countries that are racing to produce more and more energy. The statistics are compelling: Sub-Saharan Africa consumes one-tenth of the energy that North America enjoys. China, in 2006 alone, built more electric power plants than the total installed capacity of Great Britain. Even among developed countries, there are unfulfilled needs for more energy. With all countries clamoring for more energy, are there dangers of energy tributaries running dry? Some analysts suggest that oil wells might be depleted within 70–80 years. Natural gas might run out a little later. The present reserves of uranium might be adequate for only 80–90 years. Yet the fears of energy running out might be based on the present economic models. If higher costs are acceptable, oil could be extracted from oil sands, and lean uranium ores could be mined to recover the metal. There are also no imminent dangers of running out of coal, which remains a vital workhorse for energy generation. Moreover, one hour of solar radiation has energy equivalent to the world's annual primary energy consumption.



This cover of MRS is an artist's rendition of the energy puzzle the world must solve. The pieces represent the many facets of the energy challenge, from source to use, echoed in the materials reflected below. This issue of MRS describes the materials challenges that must be addressed to move toward secure, affordable, and environmentally sustainable energy to meet the world's accelerating energy needs.

If we analyze the energy challenges of today, running out of resources does not emerge as the major worry. Yet there is another worry, greenhouse gas emissions, that is becoming more insidious and urgent. Energy production from fossil fuels results in CO_2 emissions. Coal expels the most, almost 1 kg for every kilowatt-hour of power produced. The current greenhouse gas concentration in the atmosphere is about 430 parts per million (ppm), up from 280 ppm in the pre-industrial years. If the present trend continues unchecked, the concentration could well cross 800 ppm by the end of the century. CO_2 is a long-lived greenhouse gas, difficult to capture and mitigate. The recent report of the Intergovernmental Panel on Climate Change (IPCC) has concluded that most of the observed

*V.S. Arunachalam and E.L. Fleischer, "Preface" *MRS Bulletin* Vol. 33, No. 4 (2008), p. 261. Reproduced with permission.

increase in globally averaged temperature since the mid-20th century is very likely (the emphasis is by the IPCC) due to the observed increase in greenhouse gas concentrations. If nothing is done to mitigate the CO_2 problem, the consequences could turn out to be catastrophic for human life and well-being. It is paradoxical that the people living in the developing countries, who consume far less energy and emit less CO_2 than the developed countries, will experience the more serious effects. Although one might argue at length about the nature and extent of environmental damage, it is also important for the scientific community to develop various options to contain CO_2 pollution.

Are there ways to control the greenhouse gas emissions without harming the environment? What are the energy technologies that emit no or minimal CO_2? Are there technologies and policies that help to minimize energy demand and consumption? These questions along with a few corollaries shape the theme for discussions on energy.

Many new energy-saving technologies are now emerging. Light-emitting diodes that can replace incandescent bulbs, electric cars and hybrids that substitute for petrol engines, and high-voltage direct-current transmission of electric power instead of alternating-current transmission are some of the energy-saving options. There are also concerns about the availability of more efficient energy storage systems. Storage is going to become increasingly important because some of the renewable resources generate power only intermittently.

We began this discussion by citing a list of energy-providing materials and their limitations. The criteria for their choice have been based on their availability, accessibility, and affordability. To this list, we must now add three other imperatives: The sources must be sustainable, they should emit a minimum of CO_2, and they should not pose dangers to global security. The "no CO_2" resources have to be made efficient, economical, and available.

There will be new materials and newer technologies, but these might not come quickly. After all, it took more than a century for electricity to become pervasive, and old materials and technologies will continue to serve until the new ones stabilize.

This special volume of *MRS Bulletin* on energy is the first of its kind in which the magazine addresses a major societal issue. This issue has contributions from energy experts from many countries and reflects not only the growing global concerns on energy but also the opportunities that materials researchers can tackle. Some of the new materials are already available, and many are or will be under development. Nuclear fusion might still be many decades away, but already, there are experiments with new materials to make fusion safe and viable. Hydrogen, as is often said, is not a fuel, but as a carrier of energy, perhaps it would make a difference when combined with fuel cells. Solar cells might turn out to be relevant in forms that we can now only imagine and work toward.

In a recent article in the *New York Review of Books*, physicist Freeman Dyson extolled biotechnologies that might in the future provide plants with solar photovoltaic "black " leaves that absorb every wavelength of light and are more efficient in transforming sunlight than natural leaves. We hesitate to go that far, but we do believe that materials research has the potential to provide some happy surprises in addressing what is now turning out to be the most critical problem for our society. Hence, this volume—free online access.

V.S. Arunachalam <vsa@cmu.edu> was chair of the organizing committee for this issue of MRS Bulletin. He is chair of the Center for Study of Science, Technology, and Policy (CSTEP), a Bangalore-based non-profit research corporation. Elizabeth L. Fleischer <fleischer@mrs.org> was project leader for the organizing committee. She has been with the Materials Research Society (MRS) since 1991, and she is now editor of MRS Bulletin.

www.mrs.org/bulletin_energy

The special expanded issue of *MRS Bulletin*, "Harnessing Materials for Energy," focuses on the most important materials research challenges that need to be addressed to move toward secure, affordable, and environmentally sustainable energy to meet the world's accelerating energy needs. The issue follows the full energy chain, including production, storage, distribution, use, and efficiency. The articles are designed to present an objective and global view of the energy challenges within each energy sector and the promising transformational materials research directions for meeting these challenges as far into the future as is scientifically feasible to consider (targeting 10-, 25-, and 50-year outlooks).

This issue was launched at the 2008 MRS Spring Meeting with an Energy Forum featuring presentations by leading experts in the field.

Agrochemicals Protecting Crop, Health, and Natural Environment

by N.A. Shakil and Jitendra Kumar

Dr. S.A. Patil (left) and Dr. N.A. Shakil (right) responding to reporters questions during an interview with Indian television.

Today, there is an urgent need to apply advances made in crop production research and formulate strategies to achieve the ultimate goal of more food, nutrition, higher income, and employment. New concepts in crop protection systems and augmentation in green chemistry, biotechnology, and related sciences are likely to boost agricultural productivity. Further, environmental challenges posed by pest resurgence and toxic pesticides need to be resolved using eco-friendly and economically viable technologies.

The **First International Conference on Agrochemicals Protecting Crop, Health, and Natural Environment** was held 8–11 January 2008 at the Indian Agricultural Research Institute, in New Delhi, India. The conference centered around several major topics, including agricultural production, introduction of better and improved crop varieties, and the use of biotechnology and nanotechnology for the betterment of crop health and the environment. The National Organizing Committee was chaired by S.A. Patil, director of the Indian Agricultural Research Institute, New Delhi. The conference attracted scientists from all over the world, teachers, research scholars, and students, who showed tremendous enthusiasm toward the subject matter.

The conference, which was IUPAC sponsored, was attended by 468 scientists from 30 countries. The participation of a large group of young scientists and students was a welcome sign. The scientific program consisted of 26 technical sessions consisting of 17 plenary lectures, 33 invited lectures, 48 oral presentations, and 208 poster presentations. Among the many topics covered in the conference program were New Generation Synthetic and Natural Agrochemicals; Agrochemicals Delivery Systems towards Occupational and Environmental Safety; Organic Approaches to Pest Management; and Agrochemical Detection, Analysis, and Quantification. The following plenary lectures give a sense of the overall quality of the conference.

The opening session began with a talk by Shri Kanti Lal Bhuria, minister of State for Agriculture, Consumer Affairs, Food and Public Distribution in India. He relayed his genuine interest in pursuing economically viable pest management strategies with minimal reliance on synthetic pesticides.

The first plenary lecture was delivered by Kenneth D. Racke. He spoke about Good Agricultural Practice (GAP), which results in minimum residues on harvested food, and about the Maximum Residue Limit (MRL) as a regulatory standard that reflects GAP and allows control of pesticide use and residues in food. Racke explained how the world Trade Organization, through a 1995 agreement on the application of Sanitary and Phytosanitary Measures, identified Codex MRLs as the official reference for food safety issues that affect international food trade. Racke pointed out that a number of countries now actively applies Codex MRLs for regulation of pesticide residues in imported foods. Some food associations and traders have adopted private standards and food policies to avoid disharmony between major food-exporting and food-importing regions, but these policies may undermine science-based approaches. In the end, he said, creative approaches must be adopted to develop a more harmonized international approach towards regulation of pesticide residues in food if the benefits of global free trade are to be realized.

Plenary lecturer A.M.R. Gatehouse, of the school of Biology, Institute for Research on Environment and Sustainability, UK, emphasized the role of biotechnology in crop protection to achieve increased crop yields in a sustainable and cost-effective way. Her lecture dealt with the role of recombinant DNA technology in crop protection, with an emphasis on the use of insect-resistant transgenic crops.

Martin Gibson, stewardship director of Croplife Asia, Bangkok, Thailand, enriched attendees' understandings about crop protection product safety and associated benefits. His plenary lecture identified the “drivers for change” and the stakeholders who are contributing to changing how food is produced. A crucial element in protecting crops from the effects of disease, insects, and weeds in modern agriculture is the use of hi-tech crop protection products. He talked about the principles of integrated pest management, including intervention only to avoid unacceptable economic losses.

Chief Guest Shri Kanti Lal Bhuria, Minister of State for Agriculture, Consumer Affairs, Food and Public Distribution in India, is shown lighting one of the ceremonial candles to inaugurate the conference.

The topic of Denis Hamilton’s plenary lecture was “The JMPS Process for Setting Pesticide Specifications.” As he explained, the Joint Meeting on Pesticide Specification has issued new specifications for agricultural pesticides. The new procedure for evaluating pesticides deals with all the relevant data on the physico-chemical and hazardous properties of pure active ingredients and technical material and comparative assessment of the impurities and toxicological profile. The summary of relevant data and the data evaluation are now published as an integral document for each pesticide, available at <www.fao.org/ag/AGP/AGPP/pesticid/> and <www.who.int/whopes/quality/newspecif/en>.

Ronald Parker, senior environmental engineer in the U.S. Environmental Protection Agency’s Office of Pesticide Programs, Washington D.C., USA, gave a plenary lecture on ”Practical Tools and Methods for Evaluating Ecological Impact of Pesticides.” He described a pesticide risk assessment and training module that is being developed by the Joint FAO/IAEA Pesticide Program with assistance from IUPAC. The module is designed to provide “one step shopping” for conducting an evaluation of ecological risk from pesticide use.

V.S. Parmar, head of the Department of Chemistry, University of Delhi, India, delivered a lecture on “Biocatalytic Synthesis of Novel Pharmaceutically and Agriculturally Important Nanomaterials.” He pointed out that biocatalytic reactions in synthetic sequence provide unique advantages of efficacy, economy, and environmental friendliness. A few highly novel amphiphilic polymers based on PEGs having a broad range of chemical functionality have been prepared that aggregate in aqueous medium to form a nanosphere, which is found to be useful in encapsulation of small hydrophobic drugs.

Pam Marrone, Marrone Organic Innovations, delivered her plenary lecture on the topic “Discovery, Development, and Marketing of Pesticidal Natural Product.” She provided an overview of the market for biopesticides, described biopesticide discovery screening and development, outlined some examples of successful biopesticides in the market, and discussed barriers to adoption.

Ronald J. Nachman, Areawide Pest Management Research Unit, Southern Plains Agricultural Research Center, U.S. Department of Agriculture, lectured on “Stereochemical Aspects of the Interaction of Neuropeptide Agonists/Antagonists with Arthropod Receptors and Mimetic Analog Development for Pest Control.” He addressed the stereochemical and conformational aspects critical for the successful interaction of the two classes of arthropod neuropeptides with their respective receptors, using either expressed receptor cell lines or bioassays. This information is then used to design and develop mimetic analogs of these insect neuropeptide classes with enhanced biostability, bioavailability, and selectivity. The effects of a selected number of mimetic analogs on physiology of insects are also discussed.

During the closing ceremony, the following recommendations were formally adopted:

1. Role of Agrochemicals: It was resolved that the use of agrochemicals, whether of natural or synthetic origin, is indispensable for protecting crop health and natural environment and to feed the

burgeoning population of the world. Therefore, innovative efforts to discover, develop, and formulate conventional or novel molecules to yield ecologically benign products need to be vigorously pursued and promoted to meet the needs of the future.

2. Introduction of New Technology: Approaches such as biotechnology, nanotechnology, and the like need to be carefully introduced for agricultural applications after careful evaluation of the benefits and risks, and identification of stewardship practices to accompany practical implementation.
3. Biopesticides: The simple assumption that biopesticides must be inherently safe for humans and the environment due to their natural origin is not correct. As for any crop protection product, biopesticides should be subject to evaluation and scrutiny for safety based on applicable data requirements.
4. Harmonization: International standards and guidelines for pesticide quality, safety, and environmental testing, and limits for residues in food are being developed under the auspices of such advisory bodies as FAO, WHO, CODEX, and OECD. Based on the increasing globalization of trade for both agrochemicals and food, it is recommended that national authorities and industry cooperate to the greatest extent possible in supporting and adopting such harmonized approaches. International advisory bodies should in turn monitor closely the emergence of new technologies and commodities and develop appropriate standards in a timely fashion to meet changing needs.
5. Sustainability: Sustainable agriculture requires the adoption of good agriculture practice, product stewardship, and integrated pest management on a widespread scale. Theory and methods are in place and pilot projects have demonstrated the feasibility of such approaches. It is recommended that governments, academia, and industry develop intense co-operation so as to implement these practices on a much broader basis and with a high sense of priority.

N.A. Shakil <iamshakil@gmail.com> and Jitendra Kumar are senior scientists in the Division of Agricultural Chemicals, Indian Agricultural Research Institute, New Delhi, India; they were conveners of the conference.

Improving Chemical Education in the Philippines

by Fortunato B. Sevilla III

A two-day conference on **Improving Chemical Education in the Philippines** was held at the University of Santo Tomas in Manila, Philippines, from 17–18 April 2008. The conference was a project of the IUPAC Flying Chemists Program and was organized by the Commission on Higher Education (CHED), the government body covering higher education institutions in the Philippines, in cooperation with the Kapisanang Kimika ng Pilipinas (Chemical Society of the Philippines) and the University of Santo Tomas.

This conference is a follow-up activity to the revision carried out by the CHED Technical Committee for Chemistry of the curriculum for the B.S. program for chemistry. It aimed to upgrade the course delivery methods employed by chemistry teachers in the Philippines. The project was inspired by the write-ups featured in *Chemistry International* on the Indian and Sri Lanka projects of the Flying Chemists Program <www.iupac.org/standing/cce/FCP.html>.

Participation in the conference, a total of 324 tertiary-level chemistry teachers, was beyond expectations. Attendees came from all the regions of the country and represented 89 different institutions of higher education in the Philippines. Among the partici-

Peter Mahaffy (red shirt), chair of the IUPAC Committee on Chemistry Education, and others listen to a lecture.

pants were 12 young chemistry teachers who received travel grants through the IUPAC Program on Financial Support of Conferences.

Five lectures were presented during the conference by IUPAC affiliated experts:

- "The Role of Visualization" by Peter Atkins of Oxford University, UK
- "New Technologies and New Tools for Chemistry Education" by Peter Mahaffy of King's University College, Canada
- "Microscale Chemistry" by Jorge G. Ibañez of the Universidad Ibero-Americana, Mexico
- "Evaluation of an Integrated Chemistry Laboratory Program at the Undergraduate Level in Taiwan" by Mei-Hung Chiu of the National Taiwan Normal University, Taiwan
- "Low-Cost Instrumentation for Chemical Education" by Fortunato Sevilla III of the University of Santo Tomas, Philippines

The five IUPAC lecturers, from left : Fortunato Sevilla, Peter Mahaffy, Jorge Ibañez, Peter Atkins, and Mei-Hung Chiu.

Peter Atkins demonstrated how pictures can help with simple introductory chemistry issues, such as stoichiometry and electrochemistry. Peter Mahaffy presented approaches that he has found valuable in introductory university chemistry, and gave examples of new tools for helping students to visualize the molecular world. Jorge Ibanez proved that the majority of the laboratory experiences in chemistry can be substituted using small-scale techniques without decreasing the educational gain. Fortunato Sevilla III discussed instrumentation that can be fabricated at low cost and that can be used for microscale experiments. Mei-Hung Chiu reported on the impact of a integrated laboratory program for students at the National Taiwan University. The program uses a scaffolding structure to integrate different skills for conducting chemistry experiments needed for developing chemistry literacy.

Three workshops were conducted concurrently in two sessions of the conference. The topics of the workshops were "Visualizing Chemistry," "Low-Cost Instrumentation," and "Microscale Chemistry," which were facilitated by Peter Mahaffy, Fortunato Sevilla, and Jorge Ibañez, respectively. These workshops provided the participants with a hands-on and up-close experience with the teaching and learning resources described in the lectures. An industry-academe forum was also held, involving three presentors.

The conference opened with welcoming remarks from Fortunato Sevilla III, chair of the CHED Technical Committee for Chemistry and dean of the UST College of Science; Saturnino Ocampo Jr., CHED commissioner; and Peter Mahaffy, chair of the IUPAC Committee for Chemistry Education.

The culmination of the conference was the presentation of the output of the parallel group discussions, wherein the participants evaluated the applicability of the approaches or strategies presented in the five lectures. The participants affirmed that visualization, microscale laboratory experiments, low-cost instrumentation, and integrated laboratory courses can be implemented in various courses in the B.S. chemistry program offered by colleges and universities in the country. They expressed enthusiasm in carrying out the newly learned approaches and adopting newly learned technologies to improve the teaching and the learning of chemistry.

The output of these discussions provided the basis for the actions that will be taken to improve chemistry education. The outcome of these actions will be reported during the 2009 Philippine Chemistry Congress, wherein several sessions will focus on chemistry education. The participants agreed to present papers during the congress on their endeavors to apply the tools and strategies expounded by the IUPAC speakers. Indeed, the IUPAC "flying chemists" have become partners of the Philippine chemistry teachers in their goal to upgrade chemical education in the Philippines.

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Polymeric Materials

24–26 September 2008
Halle- Wittenberg, Germany

Polymeric Materials 2008 (P2008) will take place from 24–26 September 2008 at the Martin Luther University, Halle-Wittenberg. As with previous meetings in this series, this event is a essential feature in the calendars for all those interested in polymer science and engineering.

The technical program will include symposia with main (key) lectures and short contributions as well as poster sessions to the following topics:

- structure and morphology
- polymer characterization and testing
- synthesis and properties
- nanostructured and functional polymers
- polymer applications
- modification and processing
- polymers for biomedical applications
- simulation and modeling and structures and properties

www.physik.uni-halle.de/P2008

Molecular Modeling and Drug Design

10–14 September 2008, Istanbul, Turkey

A **Summer School on Molecular Modeling and Drug Design** will be held in Istanbul, Turkey, on 10–14 September 2008. This school is organized by Yeditepe University, Faculty of Pharmacy, and supported by the Turkish Association of Pharmaceutical and Medicinal Chemistry.

The organizers invite Ph.D. students, diploma/master students, as well as young scientist at the beginning of their careers in academic or industrial drug research to participate in this summer school. Leading scientists from universities and pharmaceutical companies will present innovative ideas, modern methods and strategies, and best practices, as well as case studies in the field of drug design. The main topics are as follows:

- target identification and drug discovery process
- modern strategies for lead finding and optimization
- computer-assisted methods:
  - — virtual screening,
  - — structure-based design,
  - — 3D QSAR,
  - — neuronal networks
- in silico ADME—tox and metabolism
- cheminformatics/bioinformatics and synthetic feasibility
- plant protection and biocatalysis research

Confirmed key lecturers

- Hugo Kubinyi (Germany)
- Thierry Langer (University of Innsbruck, Austria)
- Wolfgang Sippl (University of Halle, Germany)
- Stefano Moro (University of Padova, Italy)
- Gerhard F. Ecker (University of Wien, Austria)
- UÃur Sezerman (Sabanci University, Turkey)
- Klaus-Juergen Schleifer (BASF, Germany)
- Maurizio Botta (University of Siena, Italy)
- Serdar Kuyucak (University of Sydney, Australia)

Additionally, the participants are invited to present their scientific results on posters. The language of the meeting is English.

For more information, contact Mine Yarim <myarim@summerschoolmmdd2008.org>.

www.summerschoolmmdd2008.org

Mark Your Calendar

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

2008 (later than 1 August)

IUPAC poster prizes to be awarded

3–8 August 2008 • Chemical Education • Pointe aux Piments, Mauritius
20th International Conference on Chemical Education: Chemistry in the Information & Communications Technologies Age, (20th ICCE)
Dr. Ponnadurai Ramasami, Department of Chemistry, University of Mauritius, Reduit, Mauritius, E-mail: p.ramasami@uom.ac.mu

3–8 August 2008 • Chemical Thermodynamics • Warsaw, Poland
20th International Conference on Chemical Thermodynamics
Questions should be addressed to E-mail: info@icct2008.org. Comments, concerns, proposals, etc., should be addressed to E-mail: secretariat@icct2008.org.

7–11 September 2008 • Macromolecular Chemistry • Düsseldorf, Germany
Macro- and Supra-Molecular Architectures and Materials
Prof. Dr. D. H. Ritter, Institute of Organic Chemistry & Macromolecular Chemistry, Universität Düsseldorf, Universitätsstrasse 1, D-40225 Düsseldorf, Germany, Phone: + [49] 211 811 4760, Fax: + [49] 211 811 4788, E-mail: mam08@uni-duesseldorf.de

8–11 September 2008 • Macromolecules & Materials • Kruger National Park, Mpumalanga, South Africa
10th Annual UNESCO/IUPAC Conference on Macromolecules & Materials
Prof. Ronald D. Sanderson, Department of Chemistry & Polymer Science, University of Stellenbosch, Stellenbosch 7602, South Africa, Tel.: +27 (21) 808-3172, Fax: +27 (21) 808-4967, E-mail: rds@sun.ac.za

14–20 September 2008 • Green Chemistry • Moscow, Russia
2nd IUPAC Conference on Green Chemistry
Prof. Valery V. Lunin, Chairman Russia Chemistry Department, M.V. Lomonosov Moscow State University, Leninskiye Gory 1, build. 3, 119992 Moscow Russia, Tel.: +7-495-9394575, Fax +7-495-9394575, E-mail: vvlunin@kge.msu.ru

14–20 September 2008 • Humic Substances • Moscow, Russia
14th Meeting of the International Humic Substances Society (IHSS-14)
Prof. Irina V. Perminova, Department of Chemistry, Moscow State University, 119992 Moscow, Russia, E-mail: iperm@org.chem.msu.ru, Tel: +7 495 939 5546, Fax: +7 495 932 8846

Summer School on Green Chemistry, 10th Event

12–18 October 2008, Venice, Italy

The **Summer School on Green Chemistry** is an annual event, which has run over the last nine years. This unique school aims to bring together a large number of experts in the field of green chemistry and young researchers: the synergy of competences will certainly be a valuable occasion to promote diffusion of the knowledge in this emerging field. The number of participants is limited to 60 post-graduate students and post-doctoral researchers from EU countries, and hopefully 6–10 from Asia, Balkan, and Eastern Europe countries.

The 10th school will be dedicated to two main topics:

- Safer and Innovative Solvents, in collaboration with SOLVSAFE, an European Integrated Project, funded within the 6th Framework Programme
- Renewable-Based Chemicals and Products

The program will include 15 plenary lectures and a poster session.

It is expected that in this environment, students and instructors will find an informal and relaxed atmosphere, which will stimulate discussions, questions, a profitable exchange of ideas and the beginning of new scientific collaborations.

www.incaweb.org/education/summer_school_on_green_chemistry_2008

12–17 October 2008 • Biotechnology • Dalian, China

13th International Biotechnology Symposium (ISB 2008): "Biotechnology for the Sustainability of Human Society"

Prof. Fengwu Bai, Dept. of Bioscience & Bioengineering, Dalian University of Technology, 2 Linggong road, Dalian 116023, China, Tel.:+86 411 84706329, Fax:+86 411 84708083, E-mail: fwbai@dlut.edu.cn

15–18 October 2008 • Novel Materials and Synthesis • Zhenjiang, China

International Symposium on Novel Materials and their Synthesis (NMS-IV)

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

26–30 November 2008 • Soil Science • Pucon, Chile

International Symposium of Interactions of Soil Minerals with Organic Components and Microorganisms

Dra. Maria de La Luz Mora, Universidad de La Frontera, Ciencias de Recursos Naturales, Temuco, Chile, Tel: +56 45 325479, Fax: +56 45 325053, E-mail: mariluz@ufro.cl

2009

IUPAC poster prizes to be awarded

15-17 February 2009 • Radical Polymerization • Melbourne, Australia

Materials of the Future-Science of Today: Radical Polymerization

Dr. Graeme Moad, CSIRO Molecular Science, Bag 10, Clayton South, Victoria, 3787, Australia

Tel.: +61 3 9545 2509, Fax: +61 3 9545 2446, E-mail: graeme.moad@csiro.aul

1–3 April 2009 • Trace Elements in Food • Rome, Italy

3rd International Symposium on Trace Elements in Food (TEF-3)

Dr. Francesco Cubadda, National Centre for Food Quality and Risk Assessment, Istituto Superiore di Sanità, Viale Regina Elena 299, I-00161 Rome, Italy

Tel.: +39 06 4990 3643, Fax: +39 06 4990 2540, E-mail: francesco.cubadda@iss.it

16–17 April 2009 • Clinical Laboratory Diagnostics • Barcelona, Spain

5th European Symposium on Clinical Laboratory and Diagnostic Industry: Standardization and Tumor Markers

Dr. Xavier Filella, Hospital Clínic, Department of Biochemistry & Molecular Genetics, C/ Villarroel 170, E-08036 Barcelona, Spain, Tel: +34 93 227 54 00 x 3141, Fax: +34 93 337 93 76, E-mail: xfilella@clinic.ub.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: wskene@umontreal.ca

Visas

It is a condition of sponsorships that organizers of meetings under the auspices of IUPAC, in considering the locations of such meetings, should take all possible steps to ensure the freedom of all bona fide chemists from throughout the world to attend irrespective of race, religion, or political philosophy. IUPAC sponsorship implies that entry visas will be granted to all bona fide chemists provided application is made not less than three months in advance. If a visa is not granted one month before the meeting, the IUPAC Secretariat should be notified without delay by the applicant.

How to Apply for IUPAC Sponsorship

Conference organizers are invited to complete an Application for IUPAC Sponsorship (AIS) preferably 2 years and at least 12 months before the conference. Further information on granting sponsorship is included in the AIS and is available upon request from the IUPAC Secretariat or online.

www.iupac.org/symposia/application.html