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Progress and challenges towards the achievement of the 2020 goal of sound chemicals management: regional and sectoral achievements, strengths and challenges in the context of working towards the objectives of the Strategic Approach Overarching Policy Strategy

Submission from the International Union of Pure and Applied Chemistry

Note by the secretariat

The secretariat has the honour to circulate, for the information of participants, an information document submitted by the International Union of Pure and Applied Chemistry (see annex). The document is presented as received by the secretariat, without formal editing.

* SAICM/ICCM.4/1.

Annex



INTERNATIONAL UNION OF PURE AND APPLIED CHEMISTRY

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1. International Union of Pure and Applied Chemistry, IUPAC

IUPAC represents chemists and chemistry worldwide. Formed in 1919, it is a mature organisation with well developed processes to deliver science of the highest integrity and objectivity relating to the nomenclature, terminology, standards, and data for all the chemistry sub-disciplines and their relationships to the environment and health.

IUPAC actively promotes chemistry education world-wide in ways that are culturally sensitive and relevant to both global sustainability challenges and local needs for capacity building.

IUPAC's work is based on the contributions from leading chemists who work in academia, governments or in industry and who are elected by their peers solely on the basis of their science contribution. They serve for defined and limited periods of membership to ensure constant renewal.

IUPAC has an expansive body of work, in the form of conferences, publications, projects and recommendations in areas relevant to sustainable development, including green chemistry, toxicology, safety and security, medicinal chemistry, and environmental chemistry, a selection of which are itemised and annexed to this paper.

IUPAC has led the development of green chemistry for sustainability, through the inauguration of a major series of International Conferences on Green Chemistry, which bring together leading researchers to drive the innovative process forward. IUPAC has also produced vitally important special issues of its flagship journal Pure



and Applied Chemistry dealing with Green Chemistry, Naturally-Occurring Endocrine Disruptors, the Production of Chlorine, and currently Alternatives to the use of Chlorine. Through its Project System, where more than a thousand expert chemists are engaged in task groups, IUPAC contributes strongly to key issues relating to sustainability.

IUPAC is completely independent and beholden to no interests outside of chemical science.

2. IUPAC Strategic Plan.

The Strategic Plan has been recently updated and approved at the Council meeting in Busan during August 2015. Relevant extracts are shown below;

Vision. IUPAC is an indispensable worldwide resource for chemistry.

Mission. The International Union of Pure and Applied Chemistry is the global organization that provides objective scientific expertise and develops the essential tools for the application and communication of chemical knowledge for the benefit of humankind and the world.

IUPAC accomplishes its mission by fostering sustainable development, providing a common language for chemistry, and advocating the free exchange of scientific information.

Core values. IUPAC serve humankind by advancing chemistry worldwide.

- Scientific excellence and objectivity are the cornerstones of all IUPAC work.
- IUPAC value collaboration and communication among all its stakeholders.
- IUPAC strive for diversity and inclusiveness in all forms.
- IUPAC respect each other and the Union.
- IUPAC uphold the highest standards of transparent, responsible and ethical behavior.

Goals (short term and long term)

1. Provide scientific expertise to address critical world needs.
2. Provide the scientific community with critical resources.
3. Continue to advance chemistry worldwide.

3. Challenges for Science and Technology

A key challenge is the achievement of scientific and public understanding of the fundamental importance of chemical processes¹ in each of our planetary boundaries relating to biodiversity, the carbon cycle and in particular CO₂ and other key greenhouse gases, the nitrogen cycle, land use, freshwater, environmental pollution due to human activity, air quality and aerosols, ocean acidification, and the ozone layer².

¹ Sala, S. and E. Saouter (2014). Planetary boundaries and chemical pollution: A Grail quest? *Chemistry International* 36(6):2-4, doi: 10.1515/ci-2014-0603

² Rockström, J. et al (2009). "A safe operating space for humanity." *Nature*, 461: 472-475; doi:10.1038/461472a



The challenges of sustainable development are large and multidisciplinary and new mechanisms will be needed to fund required research. The research, which will be carried out by the broad chemistry community, will need to focus on:

- New molecular transformations that are based on renewable feedstocks and that minimise waste – commonly referred to as green or sustainable chemistry,
- Reduced energy intensiveness of existing processes,
- Separation, sequestration and use of CO₂,
- New and improved routes to energy production from chemical bonds and from the nucleus,
- Toxicology and eco-toxicology to enable understanding of the fate and effects of chemicals introduced into the environment as a result of human activity.

Delivery of this research as meaningful innovation will require the development of new partnerships between the sciences, technologies, and industry and also new funding mechanisms for innovation in times of financial constraint e.g. the SusChem technology platform in Europe (EU, EuCheMS and Industry). Meaningful innovation is required for the profitable introduction of new business ideas, processes and products in sustainable ways.

IUPAC's role will be to provide the language and facilitation of the work of the world's chemists.

4. Specific Challenges for Chemistry

Achieving public recognition that chemistry is a crucial part of the solutions to living within safe operating spaces for human development is crucial. Chemists also have to work with all stakeholders to ensure technologies can be used in safe and sustainable ways. This has implications for the way chemistry is taught and communicated to society as a whole, and how chemistry research is structured and integrated within Universities³.

Chemistry can contribute in many ways to:

- Life Cycle Assessments of products and processes and objective quantification of the impacts of alternative technologies on planetary boundaries.
- increasing food production; through efficient agronomic practice, more efficient routes to fertilizers - replacing the Haber process, improved nutrient use by plants, effective pest control, reducing the impact of agricultural waste, understanding soil science and efficient water use.
- improved access to clean drinking water through low energy routes to water purification from poorer quality water resources.
- our urban living environments where:
 - most people live, often spending long periods indoors where a concern is the impact on air quality,
 - the population density poses major challenges for the provision of services, sanitation and the handling of waste.
 - where transport systems have an environmental impact.
 - where concentrated energy delivery and storage has an environmental impact,

³ Nature Vol 469 Page 21 January 6 2011



- Where construction systems and materials are needed to meet the demands for low cost housing and shelter, which in turn provide healthy indoor living environments.
- human health, where there is increasing demand for ever more effective diagnostics, drugs and therapies, infection control and, in many developed countries, improvements to the quality of extended life for the elderly. New faster and more economic ways are required to demonstrate the efficacy and safety of drugs. Better understanding of the ultimate fate and environmental impact of drug metabolites and additives used in animal feedstocks is also required.
- lifestyle and recreation; where chemistry becomes a cultural enterprise enriching peoples lives through its impacts on art, fashion, information technology, sports goods and other recreational pursuits.
- raw materials and feed-stocks, as pressure increases to conserve scarce resources, to find sustainable alternatives and to ensure effective recycle through innovative design across the product life cycle.
- energy, to power the new world managing a progressive transition away from a dependence on fossil fuels to more sustainable and climate neutral sources, sources with the highest energy output per kilogram and improved energy storage and energy conservation.

The chemical science that will enable many of the new technologies that will be needed to maintain the planet is either known or can be identified as a focus for basic research. Chemistry has a key role in delivering green economies that meet the challenges of sustainable development and poverty eradication. Innovative chemistry research can contribute to practical developments if suitable partnerships are facilitated and supported by appropriate governmental policy frameworks.

IUPAC has existing networks of chemists who already work collaboratively as can be seen in the Appendix. This skill can be used to facilitate the cooperation needed to accomplish the work outlined above.

5. The Position of IUPAC

Chemistry will have a key enabling role both in understanding the impact of human development on our future and the development of sustainable solutions for this future. IUPAC has limited secretariat resources along with a large volunteer chemist community.

Therefore IUPAC is committed, within its resource structure;

- To providing leadership to the chemistry community to address the challenges of sustainable development.
- To working with UNEP, CEFIC, ICCA and other organizations toward meaningful contributions to global policy developed during the all ICCMs, Rio +20 and others. In particular, IUPAC is willing to provide feedback on the material of the official decisions, which were made at meetings.
- To promoting IUPAC projects in relation to the challenges of sustainable development for chemistry and for chemistry education.
- To working with other global agencies to support the chemistry basis of their work.
- To engaging chemists in the debate about the suitability of current chemistry education and academic research designed to meet the challenges of sustainable development.



- To working with the global chemistry community, chemistry using industries and governments to promote the development of more sustainable technologies, including the metrics used to establish this.

The areas of potential IUPAC activity that align with the SAICM secretariat are provision of scientific information, cooperation and capacity building. This is a core activity. IUPAC has the wealth of data, expertise, educational material and active capacity building activities useful for SAICM and for other organizations. As a beginning IUPAC could follow the model that it has for interaction with OPCW, which is organizing a state of science conference ahead of the regular OPCW reviews of the convention

The IUPAC science community within its resources could:

- take responsibility for establishing a scientific community that would organize purely scientific meetings to initiate, develop, and monitor collaboration with the SAICM process;
- be accountable for ensuring the scientific integrity of the process;
- provide peer review and publish the proceedings.

Putting issues into perspective is essential to proper management of chemicals for the following reasons:

- Perceptions of issues of concern may or may not be founded on the best available knowledge. Science can bring new insights, understanding, and a sense of proportion when emerging issues are identified, thereby providing the ability to judge priorities for action.
- Scientists, and in this case chemists and environmental toxicologists, will often have an appreciation of potential issues before they reach the public and political domain, thereby providing early warning.
- Scientists are well placed to develop both an understanding about possible risks to human and environmental health and the possible mitigation of these risks, including practical measures to minimize exposure.



ANEX. IUPAC Activities Related to Chemical Management

In 2010, IUPAC undertook a preliminary scoping project to assess a potential science contribution and outline the following potential contributions of the science community to developing policy⁴:

- ensuring a firm scientific basis for policy development
- reinforcing education and capacity building in relation to chemistry and its safe and -responsible application
- identifying and mitigating emerging issues of concern to health and the environment as early as possible
- providing a balanced scientific perspective when considering new or emerging issues.

For the purposes of highlighting the work of the IUPAC as a non-governmental scientists organization to SAICM, implementation projects and initiatives listed under the action plan are grouped according to how they relate to the five SAICM core objectives.

1) Risk Reduction

Global Framework for Implementing Consistent Ecological Risk Assessment of Pesticides for Sustainable Agriculture (project 2010-056-1-600). This project was: (i) Identify and prioritize key issues related to pesticide ecological risk assessment in scientifically emerging regions. (ii) Develop an integrated framework and guidance document for the application of ecological risk assessment (ERA) methodologies that can be applied to the pesticide regulatory process. (iii) Develop training materials and plan for two workshops in order to transfer this approach to selected areas; and (iv) Facilitate workshops in scientifically emerging countries (Brazil and China) to promote the documents developed as described above, based on state-of-the-art-science and past IUPAC projects.

Global Framework for Implementing Consistent Ecological Risk Assessment of Pesticides for Sustainable Agriculture: Workshop in Chile (project 2014-038-2-600).

Risk Assessment of Effects of Cadmium on Human Health (project 2009-034-2-700). Under this project, the task group members were compiled and evaluate all relevant literature and focus on health risks related to cadmium exposure at low-level exposures. Reference was to existing risk assessment documents from WHO/IPCS, WHO/FAO/JECFA, ATSDR, USEPA, EU-RAR, EFSA and others.

Evaluation of food and feed safety implications of (altered) residues of pesticides applied on transgenic (GM) crops (project 2006-015-3-600) The primary objectives of this project are: (i) Update of past and future trends in GM Crops Production, (ii) Definition/determination of the characteristics of specific agrochemical residues, (iii) Evaluation of the health impact of (altered) agrochemical residues in edible crops, and (iv) Assessment of regulatory measures and food and feed safety requirements.

2) Knowledge and Information.

IUPAC aims to have this goal achieved by enabling:

⁴ http://iupac.org/publications/ci/2010/3202/2_humphris.html



- the publication of scientific books, articles and other texts in fields of chemicals safety;
- the creation of a glossary of terms (the glossary is published as IUPAC Recommendations) in fields of chemicals safety;
- the compilation of present knowledge and collecting data;
- the organizing of conferences and other meetings.

THE PUBLICATION OF SCIENTIFIC BOOKS, ARTICLES AND OTHER TEXTS:

Chlorine-free Synthesis for Green chemistry. A Special Issue of Pure and Applied Chemistry was issued in February 2012 (project 2008-016-1-300). This PAC issue deals with the following topics: chlorine-free reagents, chlorine-free catalysts, phosgene replacement, chlorine-free solvents, thionyl chloride substitution, and metrics for chlorine-free reactions.

Waste: A Guide to the Chemistry, Recycling and Management of Waste (project 2008-039-2-600). The objective of the book is to highlight the problems related to all types of waste and to focus on recycling solutions. "Waste - A Handbook for Management" Edited by Trevor Letcher, published by Elsevier, 2011 [ISBN 978-0-12-381475-3].

Analogue-based Drug Discovery (project 2011-011-1-700). These are reference books for medicinal chemists that afford an easily usable overview on drugs, drug classification and analogue types. The 3rd volume is under preparation. The first 2 volumes are Fischer, J. & Ganellin, C.R. (Eds.) Analogue-based Drug Discovery, Wiley-VCH, 2006 and 2011.

Climate and global change: observed impacts on planet earth (project 2007-050-2-600). The objective of this book was to have an overview in one volume of the scientific arguments and evidence relating to 'climate and global change'. "Climate Change - Observed Impacts on Planet Earth" Edited by Trevor Letcher, published by Elsevier, 2009 [ISBN: 044453301X; ISBN 13: 9780444533012].

Stand-Alone Drugs (project 2005-032-1-700). The project is a study of drugs having no structural and pharmacological analogues. In several cases it is not possible to improve an existing drug with the help of analogues. The project resulted in a review article published as a book chapter also published online and free access: <http://onlinelibrary.wiley.com/doi/10.1002/9783527630035.ch2/summary>

Chemistry Beyond Chlorine (project 2013-057-3-300). The perception of the role of chemistry in issues of general interest will take advantage by the publication of book "Chemistry Beyond Chlorine". The project is not committed in any way against chlorine; conversely, it will be useful to seek alternative pathways beyond chlorine chemistry

THE CREATION OF A GLOSSARY OF TERMS:

Glossary of terms used in toxicology and Explanatory Dictionary of Terms in Toxicology (project 2006-020-1-700). Toxicology is a subject area dependent on good chemistry and itself influences chemistry through its impact on legislation for chemical safety. IUPAC has long recognized this fact and the latest Glossary is published as IUPAC Recommendations in Pure Appl. Chem. 79: 1153-1344 (2007). A 'complementary' Explanatory Dictionary has been also recently updated and enhanced to include an additional 20 terms used in toxicokinetics with full explanations of the meaning and underlying concepts. See Pure Appl. Chem. 82:



679-751 (2010). See also "Concepts in Toxicology", Duffus, J.H., Templeton, D.M. & Nordberg, M., Royal Society of Chemistry, Cambridge, U.K, 2009. 179 pp.

Glossary of terms used in ecotoxicology (project 2005-047-1-700). This glossary gives definitions of terms used in ecotoxicology; it also includes terms related to chemical speciation in the environment, sampling, monitoring and environmental analysis, adverse ecological effects of chemicals, ecological biomarkers, and environmental distribution of chemicals. Outcome published as Pure Appl. Chem. 81: 829-970 (2009).

Glossary of Terms Used in Immunotoxicology (project 2007-053-1-700). Immunotoxicology of both organic and inorganic substances is presently of great interest in occupational and environmental health. In parallel to this glossary, a project has been ongoing to explore the Immunochemistry of Metals (project 1999-047-1-700).

Update of Glossary of Terms used in Computational Drug Design (project 2010-057-3-700). The aim is to provide a useful glossary for medicinal chemists and computational chemists in research in industry and academia as well as for teaching. The glossary is providing intellectual support for conversations between laboratory and computational chemists and for the interpretation of calculations that a bench chemist or student might perform.

Glossary of Terms in Pharmaceutical Technology (project 2001-049-2-700). A first set of recommendations titled 'Glossary of Terms Related to Pharmaceutics' is published in Pure Appl. Chem. 81: 971-999 (2009). The second part -Glossary of Terms in Pharmaceutical Process Chemistry- is being finalized.

THE COMPILATION OF PRESENT KNOWLEDGE AND COLLECTING DATA:

Advances in Immunochemistry and Applications to Human Health (project 2010-051-1-700). The objective of this project is to compile present knowledge of the molecular basis of immunochemical interactions, to summarize the rapidly expanding applications in many health-related areas, and to critically discuss the upcoming research needs.

Latin American Plants as Sources for Nutraceuticals (project 2005-031-2-700). The project objectives were to collect data in Latin American countries, identify plants, especially those which are natives of the continent, which are used in Latin American societies as Nutraceuticals, estimate clinical security, related to the consumption of Nutraceuticals used in Latin America as well as for exportation, and consider the possibility of patents and industrialization of Nutraceuticals that are native of the Latin American countries. A report titled 'Traditional plants as source of functional foods: a review/ Plantas tradicionales como fuente de alimentos funcionales: una revisioacuten' is published in CyTA - Journal of Food, Volume 8, Issue 2 August 2010, pp. 159-167.

THE ORGANIZING OF CONFERENCES AND OTHER MEETINGS:

International Conferences on Green Chemistry Every two years (beginning from 2006) the International Union of Pure and Applied Chemistry (IUPAC) holds the International Conference on Green Chemistry (International IUPAC Conference on Green Chemistry, ICGC) in different cities around the world. ICGC involves 200 - 400 leading world specialists in the field of green chemistry. Previously the conference was held in Dresden (Germany), Ottawa (Canada), Foz do Iguacu (Brazil) and Durban (South Africa). The next conferences will be held in Venice (Italy) and Moscow (Russia).



Environmental Chemistry, Green and Sustainable Chemistry (project 2012-034-1-600). The project aim is to coordinate and organize three symposia to be included in the "T-6 Environmental Chemistry, Green and Sustainable Chemistry" theme in the 44th IUPAC Congress - Clean Energy Through Chemistry, 2013, Istanbul. The symposia proposed were:

- Analytical and Risk Considerations for Nanomaterials and Emerging Environmental Contaminants
- Marine Pollution and Sustainable Management of Coastal environment.
- Bioavailability of Metals, Metalloids and Organic Contaminants in the Environment

A special issue of PAC was published based on papers from these symposia.

CHEMRAWN XVII - Greenhouse Gases: Mitigation and Utilization (project 2006-031-1-021) CHEMRAWN (Chemical Research Applied to World Needs) and the International Conferences on Carbon Dioxide Utilization (ICCDU) held in 2007 a combined conference in Kingston on science and policy related to mitigation and utilization of CO₂ and other greenhouse gases. CHEMRAWN XVII Perspectives have been edited by Erwin Buncl and published (ISBN-10: 1-55339-345-7 ISBN-13: 978-1-55339-345-0).

CHEMRAWN XII –The Role of Chemistry in Sustainable Agriculture and Human Well Being in Africa held in Stellenbosch, South Africa from 2-5 December 2007. Published in Pure Appl. Chem. 81(1), 85 -151 (2009).

Global Chemistry Experiment for the International Year of Chemistry (project 2010-011-1-050). The project was the first phase in establishing a multi-stakeholder partnership including IUPAC, UNESCO, chemical industry, NGOs, and countless national and local partners to organize a global chemistry experiment focused on the context of water as a major contribution to global activities to be carried out during the International Year of Chemistry in 2011. The global experiment was developed to appeal to students from primary school to senior high school. The activities that made up the experiment are intended to help students appreciate the role of chemistry in issues of water quality and purification. At the same time, students contributed to an online global map, reporting on their investigations of water quality and water treatment. The central theme of the experiment was Water: A Chemical Solution, and it provided an outstanding educational opportunity to learn about water and the challenge of meeting the Millenium Development Goal of greatly improving access to safe drinking water before 2015.

3) Capacity Building and Technical Assistance

Evaluated Kinetic Data for Atmospheric Chemistry (project 2009-031-1-100). This project supports the continuous updating of the web-based database on atmospheric reactions located at the Centre for Atmospheric Science in the Department of Chemistry, University of Cambridge, UK, (www.iupac-kinetic.ch.cam.ac.uk) which is visited up to 1000 times each week. The website contains approximately 1000 data sheets covering gas phase reactions, photolysis reactions and heterogeneous reactions on liquids and on solids and is the backbone of predictive numerical simulations of the global climate.

A Survey of Research into New Drugs for Neglected Diseases in Latin America (project 2009-033-1-700). This project aims to identify chemistry researchers and testing laboratories, and their equipment and facilities, in Latin America who are currently working to discover new drugs to treat NTD's. One intent



is to stimulate other medicinal chemists in Latin America to conduct research in this area, and to develop a network of practitioners and testing laboratories.

The environmental and health challenges of e-waste and its management: an emerging 21st century global concern (project 2014-031-3-600). This project aims to bring together global expertise to a) examine current research on the chemical nature of e-waste and its global distribution; b) evaluate its environmental and health impact of e-waste and related risk management tools and models; c) identify shortcomings in present regulations and management strategies as well as future challenges; and d) develop a set of specific recommendations for management approaches that are science-based and globally informed.

Visualizing and Understanding the Science of Climate Change (project 2008-043-1-050). This project has developed a set of interactive, web-based materials for global dissemination to help students visualize and understand the underlying science of climate change. Target audiences are (a) teachers at the secondary and first year tertiary levels, (b) students at those same levels, and (c) chemistry professionals. Visualizations emphasize the fundamental chemistry of climate processes. The project is carried out in partnership with the Royal Society of Chemistry, the American Chemical Society, and UNESCO.

Responsible Application of Chemistry - Responsible Care Case Study (project 2011-020-1-022). The goal of the RC project is to build knowledge and capacity about the bases, methodology, and goals of Responsible Care targeting specific audiences. The results of this initiative are increase the awareness and the application of the ethics of Responsible Care in the institutions related to chemistry around the world, ultimately resulting in safer and environmentally improved ways of developing, making and using chemical products.

Safety Training Program (project 2011-004-2-022; 2013-011-2-22; 2015-005-1-022). The IUPAC Safety Training Program provides scientists from developing countries with a 2-3 week training course provided by a chemical company with a strong environmental, health, and safety culture. The Fellows learn about the components of a successful safety program and critical aspects to incorporate in their local programs. As a result of the training, Fellows have driven improvements in industry and academia in their home country. Every two years, fellows of the Program are invited to report back during a special workshop organized during the IUPAC World Congress.

Enhancing the capacity to provide quality chemistry education at secondary and tertiary levels in Ethiopia (project 2010-025-1-050). This project was the 2011 leg of the Flying Chemists Program, a program coordinated by the IUPAC Committee on Chemistry Education. The goal of the project is to empower Ethiopian chemists and teachers to modernize chemistry education at secondary and tertiary levels. Specifically, the project aims at the following: (i) introducing innovative and cost-effective laboratory instruction in chemistry education, (ii) empowering chemistry instructors in designing and implementing contextualized and learner-centered chemistry education, (iii) promoting innovative ways of training quality chemistry teachers. In similar and earlier projects, the Flying Chemists Program addressed education issues in India (2005), in Sri Lanka (2006), and the Philippines (2008).

Green Chemistry – creation and implementation of international cooperation in teaching and investigations (project 2008-017-4-300). This project is to provide a platform for chemists from developed and developing countries historically linked through THE GREAT SILK WAY to find collaborators for fruitful



development of interdisciplinary green chemistry projects, both in science and in education, including public enlightenment, through establishing the network centred in Russia; to improve quality and to widen green chemistry collaboration from the West to the East.

The Social Responsibility of Chemists: Responsible Stewardship (project 2006-043-3-050). This project contributed to the dissemination of new educational means in the field of the chemistry education for sustainable development and education for responsible stewardship, and promotes all aspects of chemistry, not just among the members of the profession, but increasingly to the worldwide community. iupac.org/publications/ci/2008/3002/pp6_2006-043-3-050.html

Sustainable Education and Environmental Development (SEED) in Latin America (project 2009-014-2-300). This project seeks to introduce and disseminate the seeds of Sustainable Education and Environmental Development (SEED) in Latin America, in the field of Green Chemistry, and to improve quality and to extend green chemistry collaboration from the Europe to Latin American. The SEED network is also responsible for the organization of the 4th International IUPAC Conference on Green Chemistry (4th ICGC).

Harmonized Protocol for the Proficiency Testing of sampling of environmental matrices (project 2009-010-3-500). Equivalence and/or analogies between reference materials (routinely distributed among the laboratories within chemical Proficiency Testing schemes) and references used for sampling (soil reference sampling, reference sampling target, etc.) have been even debated in the past years. Moreover, these aspects involve also the requirements that such references must have to be properly used in sampling PTs. Starting from the experience on soil sampling intercomparison exercise, the project output a general guidance for carrying out proficiency testing on sampling, integrating the protocols already published on proficiency testing for chemical analyses; and include simple example of application (where possible).

Methods of measurement and evaluation of natural antioxidant capacity/activity (project 2008-031-1-500). The chemical diversity of natural antioxidants makes it difficult to separate, detect and quantify individual antioxidants from the complex matrix. This project bring in terms of definitions or definition-like characterization and classification the chemical and biochemical methods of antioxidant assays as well as related antioxidants chemistry and provide analytical, food chemical, biomedical/clinical and environmental communities with critical evaluation on this topic.

Metrological traceability of measurement results in chemistry (project 2001-010-3-500). This project is aimed to develop a concept for traceability of chemical measurements underpinned with examples (various scenarios) for establishing traceability in chemical measurement and to provide clarification related to the term traceability and to smooth its proper practical application in chemical measurement. A Technical Report has been published in *Pure Appl. Chem.* 2011, Vol. 83, No. 10, pp. 1873-1935 doi:10.1351/PAC-REP-07-09-39.

Solubility Data Series. The IUPAC-NIST Solubility Data Series (SDS) is long-standing IUPAC project for the exhaustive compilation and critical evaluation of experimental data on solubility of chemically defined systems. This task is approached by considering systems of two or more well-defined components and producing printed volumes of compilations and critical evaluations of chemically-related systems. Subsets address solubility data related to industrial processes, solubility data of compounds relevant to human health, or solubility data of



compounds relevant to mobility of metals in the environment. Project 2008-008-1-500 provides a guide to preparation and use of compilations and evaluations; *Pure Appl. Chem.*, 2010, Vol. 82, No. 5, pp. 1137-1159 (doi:10.1351/PAC-REP-09-10-33) <http://www.iupac.org/publications/sds/volumes.html>

4) Governance

Chemistry as a Cultural Enterprise (project 2010-031-2-050). To raise students' curiosity for other cultures, this IYC project asked students 12-17 year old to design a national stamp that reflects chemical developments important to their lives, in order to foster better understanding and appreciation of chemistry as a human and cultural enterprise. They must present their stamps with an explanation (in English) electronically on a platform that allows peer review.

World Crop Protection Chemistry Institute: Developing Global Leaders for Research, Regulation and Stewardship in the 21st Century (project 2013-019-4-600). The purpose of this project is to bring together global crop protection chemistry leadership from academia, industry, government and NGO's to a) examine the current state of affairs with respect to research and regulatory leadership development, b) discuss unmet needs and future changes in crop protection chemistry that challenge current approaches, and c) develop a set of specific recommendations for ensuring that tomorrow's crop protection chemistry leaders have a well-rounded, science-based and globally informed approach.

Inventory of developments in the field of RNAi-based pesticides and potential needs for international harmonization of regulatory safety requirements (project 2013-029-2-600). The project makes an overview of the progress of RNA-based approaches, their chemistries and mode of action, as well methods for their delivery to the target. Moreover the regulatory environment for these bio pesticides in various legislative environments (e.g. US EPA, APVMA in Australia) was explored and reviewed, particularly with a view on whether their distinct characteristics also have led to specific regulations and safety requirements. Potential gaps for international harmonization was identified and highlighted.

Options for IUPAC engagement in SAICM implementation (project 2008-012-1-022) and **IUPAC Support to SAICM Implementation** (project 2009-003-2-020) Report *Chem. Int.* March- April 2010. pp 8-11

5) Illegal International Traffic

Impact of scientific developments on the Chemical Weapons Convention (IUPAC Technical Report) This report summarizes the findings and recommendations of an international workshop that was organized jointly by IUPAC and the Organisation for the Prohibition of Chemical Weapons (OPCW), and held in Zagreb, Croatia, from the 22nd to the 25th of April 2007. It was held to assist with the preparation for the Second Review Conference of the Chemical Weapons Convention (CWC), which commenced in April 2008. *Pure and Applied Chemistry* 80 (1), 175 - 200 (2008).

IUPAC and OPCW have a relationship that extends back over 15 years now. In 2002 OPCW asked IUPAC to host a workshop on trends in science and technology relevant to the Chemical Weapons Convention (CWC) to provide input to the OPCW's Science Advisory Board (SAB). The idea was to highlight developments that had occurred over the past five years and anticipated developments in the next five years. The information from this event was used to draft documents provided to the National Authorities (signatory countries) in support of the 1st Review



Conference. At that review conference, national authorities went through the CWC and considered whether any modifications needed to be made. This review conference occurs every five years. The S&T workshop was successful enough that IUPAC was asked to hold similar meetings in 2007 and 2012 in anticipation of the 2nd and 3rd review conferences. Conversations are currently underway to begin planning for the next event to be held in the 2016 -2016 timeframe.

In addition to this work, OPCW has worked with IUPAC's Committee on Chemical Education (CCE) to develop materials to provide education about multiple use chemicals. These materials are designed to support education and training of chemists to increase their awareness of the potential risks and need for security related to multiple use chemicals.

Finally, OPCW has been involved in an effort to develop a code of ethics/conduct related to chemicals of concern for chemists, and they have been holding meetings in support of that activity.

Nomenclature and Terminology

Standard approaches to nomenclature and terminology are vital to any attempt to engage different groups of people in meaningful debate on important issues. These are a major thrust of IUPAC activity and provide an important foundation to debate and progress in relation to sustainability.

Quantities, Units and Symbols in Physical Chemistry . The Green Book, 3rd edition (project 110/2/81) Cohen, E.R., Cvita, T., Frey, J.G., Holmström, B., Kuchitsu, K., Marquardt, R., Mills, I., Pavese, F., Quack, M., Stohner, J., Strauss, H.L., Takami, M. and Thor, A.J., RSC Publishing, Cambridge 2007 [ISBN 0 85404 433 7; ISBN-13 978 0 85404 433 7]

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