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Nature, Convention, and Chemical Innovations



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Chemistry International

CHEMISTRY International

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

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Front Cover: The use of DDT is regulated by the Stockholm Convention and in many countries its use in agriculture has been banned completely. However, to control and avert malaria epidemics which is spread by mosquitos, DDT is still an acceptable pesticide in some regions of Africa and India. Mosquito control using additional ecological strategies such as eliminating mosquito breeding grounds by drainage or introducing fish to eat larvae is also advocated. Read more about the Stockholm Convention as a tool for the global regulation of persistent organic pollutants page 4.



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Back to France to Celebrate the Century-Old IUPAC

The 47th IUPAC World Chemistry Congress & 50th General Assembly

by Clément Sanchez, chair IUPAC-2019 and Jean-Pierre Vairon, coordinator IUPAC-2019

On behalf of the French Academy of Sciences and of its National Committee for Chemistry, the French National Adhering Organization to IUPAC, gathering the main academic and research institutions, learned societies, and industrial organizations relevant to Chemistry, we are very pleased and honoured to invite you to participate and contribute to the IUPAC 47th World Chemistry Congress to be held at the Palais des Congrès, Paris, France, 7-12 July 2019.

This IUPAC-2019 Congress (7-12 July) and the joint 50th General Assembly (5-12 July) will present a unique character as both will celebrate the Centenary of the Union. A Union conceived in Paris, elaborated in London and signed in Brussels between April and July 1919. Special events will be organized all week long, encompassing a Celebration plenary session organized together with the IUPAC100 Committee, a Celebratory evening organized by the Young Scientists at the Maison de la Chimie, a Celebration Gala Dinner, and an official Ceremony organized at the Sorbonne whereby France will celebrate the Century Old Union in presence of the high governmental and academic authorities, the IUPAC Council, the NAOs delegations, high level scientists, world chemical industry managers and invited honorary guests.

With the theme “**Frontiers in Chemistry: Let's create our Future! 100 years with IUPAC,**” the programme of such a general congress was built to merge the different fields of chemistry and to address today's most challenging issues relevant to human well-being, renewable energy resources, and sustainable development; as well as to cross themes highly connected to current real world problems. Yet it does remain broad enough to welcome every contribution whatever the domain of research or the academic/industrial origins of the Congress participants. The programme has been reviewed by a worldwide panel of recognized scientists. Furthermore, dedicated symposia will consider the educational, historical, gender, and other timely aspects together with the currently highly sensitive

question of the image of Chemistry and its perception by society, which will be considered in a special symposium involving a public panel discussion. A dense Young Scientists programme organized by the French YS network together with the International Younger Chemists Network (IYCN) is also planned throughout the week.

IUPAC Centenary is a unique opportunity to project the universal values of IUPAC and it is worth remembering that the Union welcomes both scientists from pure academic research as well as those involved in applied and industrial aspects. Particular attention has been paid to the participation of chemists from all continents (speakers from more than 30 countries have been invited) and all our sponsors. The major world chemical companies encouraged their researchers and engineers to communicate together with the academic scientists in the same symposia. We do expect a huge scientific contribution from industry.

Presidents or CEO of several internationally important chemical companies have already decided to attend part of the Congress and to participate in the Celebration events. We are planning a World Chemistry Leadership Meeting (WCLM) with a plenary panel discussion gathering six or seven of these high-level managers from all over the world.

Some 30 Symposia are offered, with multiple half-day sessions co-organized by teams of foreign and French scientists. About 900 oral presentations will be delivered, including about 250 invited lectures and 650 oral contributions open to regular attendees. Two (or three) sessions of 1000 posters each will be organized throughout the week. Eight Plenary Lectures (general) and 10 Thematic Honorary Lectures (specialized), covering all Congress topics, will be delivered by prestigious scientists.



Members of the IUPAC2019 organizing team: Stanislas Pommeret, Clémentine Vallet (PCO), Adrian Auger (PCO), Jean-Pierre Vairon, Clément Sanchez, Nicole Moreau, and Noël Baffier



XVth IUPAC Congress, Sorbonne, Paris, 1957

In July 1957, Paris welcomed IUPAC by hosting both the Congress at the Sorbonne University, and concurrently the 'Conférence internationale de la chimie', i.e. the equivalent of today's General Assembly at the Maison de la Chimie. During the Congress—attendance pictured above in the main auditorium of La Sorbonne—900 communications by authors of 36 countries were presented. The main sessions covered topics in physical chemistry (with 202 communications), inorganic chemistry (153), and organic chemistry (547). The inaugural lecture was presented by Giulio Natta, who six years later won a Nobel Prize in Chemistry (1963) with Karl Ziegler for their discoveries in the field on the chemistry and technology of high polymers. The Gala Dinner was hosted in The Orangerie in Versailles, followed a unique presentation of *L'Impromptu de Versailles*, a play by Molière. Also celebrated concurrently to the 16th IUPAC Congress in July 1957 was the centenary of the French Chemical Society. These celebrations included a plenary session at La Sorbonne with a plenary by Sir Cyril Norman Hinshelwood (Nobel Prize in Chemistry, 1956) and an interlude by the Symphonic Orchestra of the Republican Guard, and a reception in the Domaine de Chantilly par François Albert-Buisson, Chancelier of the Institut de France, Member of the Académie des sciences morales et politiques and Member of the Académie française.

The Year 2019 is a very unique year for Chemistry. Besides the IUPAC100 events all along 2019 and the IUPAC 47th WCC in July, the year has been declared by UN the International Year of the Periodic Table (IYPT2019), linked to the 150th anniversary of the Periodic Table, with an opening Ceremony at UNESCO headquarters, Paris this past January, a closing in Tokyo in December, and several important events like the 4th International Conference on the Periodic Table (Mendeleev 150) in Saint-Petersburg, 26-28 July 2019. Furthermore, the 51st International Chemistry Olympiads (IChO) will take place 21-30 July also in Paris.

The 2019 IUPAC General Assembly (GA) will be held, 5-12 July, both at the *Palais des Congrès*, porte Maillot, Paris, (Bureau, Divisions, Standing Committees) and at the neighbouring Hyatt Hotel (Council).

Again, we welcome all to Paris on the occasion of these unique IUPAC-2019 World Chemistry Congress and Union Centenary Events!

For those who could stay in Paris longer until the weekend of 13-14 July, we highly recommend enjoying our Bastille Day with its friendly atmosphere, fireworks, and festive events!

www.IUPAC2019.org

The Stockholm Convention

A Tool for the Global Regulation of Persistent Organic Pollutants

By Heidelore Fiedler, Roland Kallenborn, Jacob de Boer, and Leiv K. Sydnes

The aim of the Stockholm Convention on Persistent Organic Pollutants (POPs) is to eliminate persistent organic chemicals worldwide by either prohibiting their production and use or gradually reducing them. The Stockholm Convention was adopted in 2001 and entered into force in 2004, 90 days after receiving the 50th instrument of ratification. The Parties to the Convention have to regularly report progress in implementation of their measures taken to achieve the goals. The Convention has a mechanism to add more compounds; today 28 POPs are covered, 16 more than the initial ones.

The Stockholm Convention on POPs is a legally binding instrument for the protection of human health and the environment. Together with the Basel and Rotterdam Conventions, these three multi-lateral agreements are a unique framework for the life cycle management of hazardous chemicals and wastes. A "cradle-to-grave" approach is applied with interlinkages between their scopes of application:

- most POPs are covered by all three conventions;
- many pesticides are subject to the three conventions;
- as waste, all chemicals fall under the scope of the Basel Convention.

The three conventions are implemented by the Basel, Rotterdam and Stockholm Conventions (BRS) Secretariat, situated in Geneva, Switzerland, through (i) decisions by the Conference of the Parties (COPs); (ii) BRS-approved workplans; (iii) a resource-mobilization strategy; (iv) a communication strategy; and (v) a technical-assistance programme. Some facts about these conventions are summarized to the right.

History and Background

In 1995, the Governing Council of the United Nations Environment Programme (UNEP, now UN Environment) called for a global action on an initial list of 12

POPs. It was also requested that the Intergovernmental Forum on Chemical Safety (IFCS) should develop recommendations on international action for consideration no later than 1997 (www.pops.int). IFCS found that the scientific information on these POPs was sufficient to conclude that immediate international action was needed to protect human health and the environment. These conclusions and recommendations were approved by the UNEP Governing Council (GC) and the World Health Assembly and it was decided to begin negotiations of a global legally binding instrument by early 1998 within the framework of overarching objectives that were to be handled by an intergovernmental negotiating committee (INC) (Buccini, 2003). Over 120 countries participated in the negotiation



Basel Convention on the Control of Transboundary Movement of Hazardous Wastes and Their Disposal

Number of Signatories: 53

Number of Parties: 186

Date of adoption:
22 Mar 1989

Date of entry into force:
5 May 1992



Rotterdam Convention on Prior Informed Consent Procedures for Certain Hazardous Chemicals and Pesticides in International Trade

Number of Signatories: 72

Number of Parties: 160

Date of adoption:
10 Sep 1998

Date of entry into force:
24 Feb 2004



Stockholm Convention on Persistent Organic Pollutants

Number of Signatories: 152

Number of Parties: 182

Date of adoption:
22 May 2001

Date of entry into force:
17 May 2004



meetings until the final text was agreed upon. In May 2001 the final document, *The Stockholm Convention on Persistent Organic Pollutants*, was adopted and opened for signature in Stockholm, Sweden, and as of August 2018, there are 182 parties to the Convention, 181 states and the European Union, which adopted the Convention to EU legislation already in 2004. Among the countries that have not ratified the Stockholm Convention are Israel, Italy, Malaysia, and the United States of America (USA).

The objective of the Stockholm Convention is defined in article 1: “*Mindful of the precautionary approach, to protect human health and the environment from the harmful impacts of persistent organic pollutants.*” POPs are defined as chemicals that

- remain intact for exceptionally long periods of time (many years);
- become widely distributed throughout the environment as a result of natural processes involving soil, water and, most notably, air (mobility; long-range transport);
- accumulate in the fatty tissue of living organisms including humans, and are found at higher concentrations at higher levels in the food chain; and
- are toxic to both humans and wildlife.

In addition to being clearly identified (subparagraph (a) below), POPs have to fulfill a number of specific criteria as outlined in Annex D “Information requirements and screenings criteria”:

(a) Chemical identity:

- (i) Names, including trade name or names, commercial name or names and synonyms, Chemical Abstracts Service (CAS) Registry number, International Union of Pure and Applied Chemistry (IUPAC) name; and
- (ii) Structure, including specification of isomers, where applicable, and the structure of the chemical class;

(b) Persistence:

- (i) Evidence that the half-life of the chemical in water is greater than two months, or that its half-life in soil is greater than six months, or

that its half-life in sediment is greater than six months; or

- (ii) Evidence that the chemical is otherwise sufficiently persistent to justify its consideration within the scope of this Convention;

(c) Bio-accumulation:

- (i) Evidence that the bio-concentration factor or the bio-accumulation factor in aquatic species for the chemical is greater than 5000, or in the absence of such data, that the $\log K_{ow}$ is greater than 5;
- (ii) Evidence that a chemical presents other reasons for concern such as high bio-accumulation in other species, high toxicity or ecotoxicity; or
- (iii) Monitoring data in biota indicating that the bio-accumulation potential of the chemical is sufficient to justify its consideration within the scope of the Stockholm Convention;

(d) Potential for long range transport:

- (i) Measured levels of the chemical in locations distant from the sources of its release that are of potential concern;
- (ii) Monitoring data showing that long-range environmental transport of the chemical, with the potential for transfer to a receiving environment, may have occurred *via* air, water or migratory species; or
- (iii) Environmental fate properties and/or model results that demonstrate that the chemical has a potential for long-range environmental transport through air, water or migratory species, with the potential for transfer to a receiving environment in locations distant from the sources of its release. For a chemical that migrates significantly through the air, its half-life in air should be greater than two days; and

(e) Adverse effects:

- (i) Evidence of adverse effects to human health or to the environment that justifies consideration of the chemical within the scope of this Convention; or
- (ii) Toxicity or ecotoxicity data that indicate the potential for damage to human health or to the environment.

The Stockholm Convention

The POPs are listed in one or more of three annexes with different obligations; Annex A for elimination of production and use, Annex B for restriction of production and use, and Annex C for unintentionally generated and released substances. How the elimination and restriction are going to be carried out is described administratively and technologically (Articles 3 – 6, 11 and 12). The detailed implementation is up to the Parties to plan, present, update and execute (Article 7); specific actions are to be reported through Article 15.

The Stockholm Convention has proven to be a dynamic document and since 2009, 16 more POPs have been added. Whereas the 12 initial POPs were all chlorinated chemicals and had direct uses such as pesticides or industrial chemicals, many of the more recent POPs are integrated into articles or products such as flame retardants and water repellent chemicals.

The POPs presently listed in the Stockholm Convention are displayed in Table 1.

Chemicals in Annexes A and B

For the initial 12 POPs, all production and new uses ended in 2009, but time-limited exemptions exist for many of the newly listed POPs such as HBCD, PCP, PCNs, lindane, technical endosulfan and polybrominated diphenyl ethers. The register is publicly available (<http://chm.pops.int/Implementation/Exemptions/SpecificExemptions/ChemicalslistedinAnnexA/tabid/4643/Default.aspx>). PCB can remain in existing applications such as transformers or capacitors until 2025 for all Parties.

For the two POPs listed in annex B—DDT and PFOS—there are not yet safe and affordable alternatives available and therefore, they can still be produced or used for acceptable purposes. For DDT, the acceptable purpose is disease vector control but parties are required to notify the Secretariat of such production or use or the intention to do so. The Secretariat maintains a DDT Register which presently has 17 countries listed (Botswana, Eritrea, Ethiopia, India, Madagascar, Marshall Islands, Mauritius, Mozambique, Namibia, Senegal, South Africa, Swaziland, Uganda, Venezuela, Yemen, Zambia, Zimbabwe). Parties may withdraw from

Table 1: (at right) The chemicals targeted by the Stockholm Convention, including the 12 initial and 16 new POPs as listed in Annexes A (Elimination), B (Restriction) or C (Unintentional production), and their year of listing. Three types of chemicals as pesticide (green dot), industrial chemical orange triangle, or unintentional production (purple square) are identified.

POPs and their year of listing into the Convention:

Annex A (Elimination)

Initial POPs: Aldrin ●

Chlordane ●

Dieldrin ●

Endrin ●

Heptachlor ●

Hexachlorobenzene (HCB) ● ▲

Mirex ●

Polychlorinated biphenyls (PCB) ▲

Toxaphene ●

2009: Alpha hexachlorocyclohexane (α-HCH) ●

Beta hexachlorocyclohexane (β-HCH) ●

Chlordecone ●

Hexabromobiphenyl ▲

Hexabromodiphenyl ether and heptabromodiphenyl ether ▲

Lindane (γ-HCH) ●

Pentachlorobenzene (PeCB) ● ▲

Tetrabromodiphenyl ether and pentabromodiphenyl ether ▲

2011: Technical endosulfan and its related isomers ●

2013: Hexabromocyclododecane (HBCD) ▲

2015: Hexachlorobutadiene (HCBD) ▲

Pentachlorophenol (PCP) and its salts and esters ●

Polychlorinated naphthalenes (PCNs) ▲

2017: Decabromodiphenyl ether (commercial mixture c-decaBDE) ▲

Short-chain chlorinated paraffins (SCCPs) ▲

Annex B (Restriction)

Initial POP: DDT ●

2009: Perfluorooctane sulfonic acid (PFOS), its salts and perfluorooctane sulfonyl fluoride (PFOSF) ● ▲

Annex C (Unintentional Production)

Initial POPs: Polychlorinated dibenzo-*p*-dioxins (PCDD) ■

Polychlorinated dibenzofurans (PCDF) ■

Hexachlorobenzene (HCB) ■

Polychlorinated biphenyls (PCB) ■

2009: Pentachlorobenzene (PeCB) ■

2015: Polychlorinated naphthalenes (di- through octa; PCNs) ■

2017: Hexachlorobutadiene (HCBD) ■

● Pesticide

▲ Industrial Chemical

■ Unintentional Production

A Tool for the Global Regulation of POPs

Country	Year Start of production	Year End of production	Quantity (1 000 tonnes)
India	1955	Ongoing	239
Dem. People's Rep. Korea	1960	> 2010?	21
China	1952	2007	467
Mexico	1959	2004	> 93
Bangladesh	1966	1992	8
Indonesia	1986	1991	23
Brazil	1962	1982	76
Azerbaijan	1958	1980	481
Poland	1947	1980	79
United States of America	1944	1973	1383
Serbia	1947	1960	2
Total			2793

Table 2: Start, end, and total quantity of production of DDT by country.

the DDT register at any time, which three countries have done so far, namely People's Republic of China, Morocco, and Myanmar.

In an attempt to summarize production and use of DDT, the Chemicals Branch of the United Nations Environment Programme (UNEP) in collaboration with partners, has compiled available information regarding historic production and use (Table 2: Start, end, and total quantity of production of DDT by country.).

For PFOS, a list of acceptable purposes has been established; this includes photoimaging, aviation fluids, metal plating in closed loop systems, fire-fighting foams, and for control of leaf-cutting ants (<http://chm.pops.int/Implementation/Exemptions/AcceptablePurposes/tabid/793/Default.aspx>).

PCBs have received special attention for years. The Convention requires the parties to eliminate the use of PCB in equipment by 2025 and make determined efforts to environmentally-sound waste management by 2028. Reports on progress towards their elimination should have been provided every five years but information is scarce. In order to keep track of the situation, an inventory of historic PCB production has been developed (Table 3: Estimated total global production of PCB according to country and period.), and the progress towards the elimination of PCBs according to the 2025 and 2028 goals is under evaluation.

Chemicals in Annex C

Chemicals in Annex C are formed and released unintentionally during the production of other compounds or in thermal processes. To prevent formation of these POPs and reduce their unintentional releases, Parties

shall develop release inventories, apply best available techniques (BAT) and promote best environmental practices (BEP) and report progress every five years. Among the POPs listed in Annex C, the polychlorinated dibenzo-*p*-dioxins (PCDD) and dibenzofurans (PCDF) are the only ones that are exclusively listed in this annex and therefore serve as a model for the other POPs listed in the same annex. A guidance document has been prepared describing how to identify and quantify formation and release to five vectors—air, water, land, products, residues—that allows the development of complete and comparable inventories. Periodically, the inventories have been assessed and the latest assessments were published in 2016 (Fiedler, 2016; Wang *et al.*, 2016). Based on 86 national release inventories and other data, the global release of PCDD and PCDF



The Stockholm Convention

Country	Start of production (year)		End of production (year)		Amount of PCB produced (1000 t)	
	Earliest estimate	Latest estimate	Earliest estimate	Latest estimate	Lowest estimate	Highest estimate
China	1960	1965	1974	1983	7	10
Czechoslovakia	1959	1959	1984	1984	21	21
Democratic People's Republic of Korea	1960s	1960s	2006	> 2006	25	30
France	1930	1930	1980	1984	102	135
Italy	1958	1958	1983	1983	24	31
Japan	1952	1954	1972	1972	59	59
Poland	1966	1966	1977	1977	2	2
Soviet Union/ Russian Federation	1938	1939	1993	1993	180	180
Spain	1930	1955	1984	1986	25	29
United Kingdom	1951	1954	1965	1977	66	67
United States of America	1929	1930	1975	1977	476	700
West Germany	1930	1950	1983	1983	59	300
Total					1046	1512

Table 3: Estimated total global production of PCB according to country and period.

was estimated to be approximately 100 kg toxic equivalents *per year* (g TEQ/yr) (Table 4: Global estimate of PCDD/PCDF releases (TEQ per year)).

Stockpiles and wastes

According to the Convention, Parties shall manage stockpiles and wastes containing listed chemicals in a manner protective of human health and the environment. POPs in wastes are not allowed to be reused or recycled. In close cooperation with the parties to the Basel Convention, the maximum POPs content has been defined, for single POPs pesticides and PCB at 50 mg/kg and for new POPs that are incorporated into articles around 1000 mg/kg, and 15 µg TEQ/kg for PCDD and/or PCDF. Concentrations above these levels, waste consisting of, containing or contaminated with the listed POPs have to be treated using recommended destruction technologies.

Effectiveness evaluation and global monitoring plan

A mechanism to assess the success of the activities

undertaken worldwide to implement the Stockholm Convention is laid down in Article 16. These assessments are based on comparative analytical data on concentrations of POPs, national reports from the 182 Parties to the Convention (Article 15), and non-compliance information provided pursuant to established procedures (Article 17). To date, the Conference of the Parties could not agree on a compliance mechanism (according to Article 17). Presently, information gathering is underway for the fourth collection of national reports. Hopefully, the submission of the reports will be better than in the past; in 2007, 2011 and 2014 the numbers were as low as 45, 95 and 93, respectively (for overview and update, see <http://chm.pops.int/Countries/Reporting/ReportingDatabase/tabid/7477/>).

As to new POPs, parties have the possibility to opt out; *i.e.* not to ratify the listing of new POPs. (<http://chm.pops.int/Countries/StatusofRatifications/Amendmentstoannexes/tabid/3486/>). With 182 parties at present, none of the new POPs is legally binding for all Parties. For example, Australia, India, Slovenia, and Vanuatu have not accepted any of the new POPs.

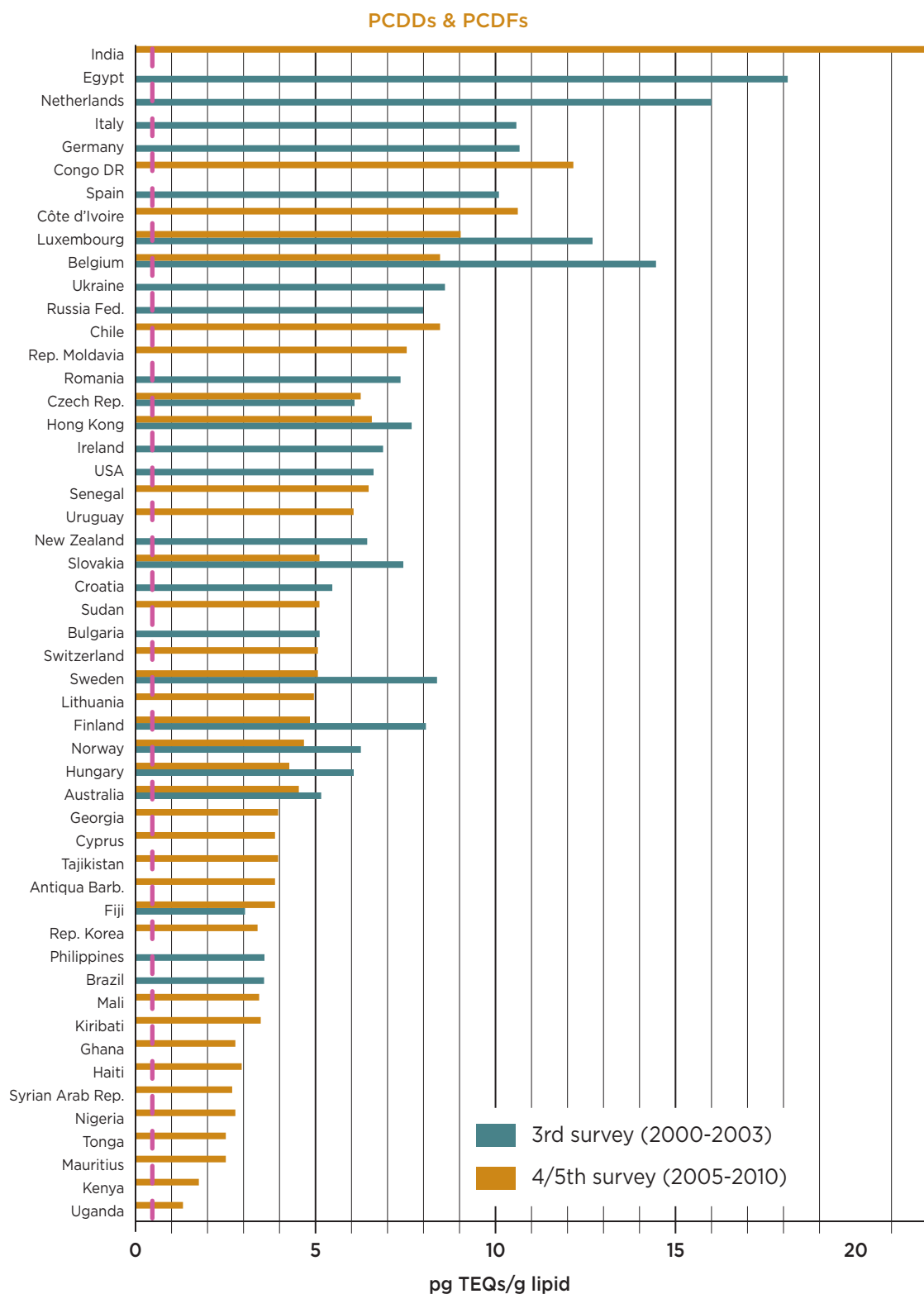


Figure 1. Results of the WHO/UNEP survey of PCDD and PCDF (pg TEQ/g lipid) in pooled human milk samples from selected countries. The dotted pink line represents the calculated safe level of these compounds for the breastfed infant. (Source: van der Berg et al., 2017, reproduced with permission) (That source ([www.doi.org/10.1007/s00204-016-1802-z](https://doi.org/10.1007/s00204-016-1802-z)) includes similar results representation for DL-PCBs, for the sum of the indicator PCBs, and for the sum of DDT-like compounds)

The Stockholm Convention

Region	Number of countries	Total (g TEQ/yr)	Area averaged (mg TEQ km ⁻²)	Population averaged (mg TEQ person ⁻¹)
Africa	52	29 596	0.98	34.2
Asia	58	47 101	0.98	12.1
Europe	44	9682	1.36	14.8
Oceania	2	1861	0.23	79.9
North America	26	43 341	0.19	8.79
South America	14	7851	0.45	11.1
All	196	100 424	0.75	16

Table 4: Global estimate of PCDD/PCDF releases (TEQ per year)

To assess changes of POP concentrations in the environment or in humans, a Global Monitoring Plan (GMP) for POPs has been set up. The GMP includes training of POP laboratories in developing countries and interlaboratory assessments on POPs with the aim that all laboratories that provide results to the GMP have successfully participated in these assessments. As core matrices, ambient air and human tissues (human milk or human blood) have been chosen for all POPs, and in addition, surface water for the hydrophilic chemicals (presently, only PFOS). Guidelines for sampling and analysis of the POPs have been established and are updated as more POPs are listed. The monitoring data presently addresses 23 of the 28 POPs and are broadly shared through the GMP data warehouse (<http://www.pops-gmp.org/>). Especially, the human milk monitoring activities—jointly performed with the World Health Organization (WHO)—have provided harmonized and comparable data of high quality, and these data are very useful when the impact of POPs on human health is being addressed. The results from monitoring of PCDD and PCDF (Figure 1) show for instance that their concentrations in human milk are still significantly above that considered toxicologically safe in all countries. On the other hand, the numerically highest concentrations for the sum of DDTs pose a lower risk for breastfed babies (van den Berg *et al.*, 2017). (When balancing potential adverse effects against positive health aspects for (breastfed) infants, the advantages of breastfeeding outweigh the possible disadvantages).

Financial Mechanism

In contrast to the Basel and Rotterdam Conventions, the Stockholm Convention has a financial mechanism, the Global Environment Facility (GEF), to help developing countries and countries with economies in transition to meet their convention obligations. Since the

adoption of the Convention over 4 billion USD in financial support has been granted.

Conclusions and Future

The Stockholm Convention has initiated many activities in the field of POP monitoring. Not only do countries contribute to the GMP, also third parties such as universities and research institutes have become more focused on POP research. The true effect of the Stockholm Convention is therefore much bigger than initially anticipated. Also, the capacity building part is very much welcomed by the developing countries and even reaches further than only POP analysis. On the other hand, still much has to be done to achieve the original goals of eliminating the production and use of POPs and gradually reduce spreading into the environment and causing harm to humans. A global treaty with so many countries involved is in a continuous challenge with procedures and political realities in countries, which hamper the achievement of perceived simple goals such as eliminating the use of PCB in 2025.

Nevertheless, the Stockholm Convention moves forward and in May 2019, two more POPs may be listed: the POPs Review Committee in September 2018 recommended to the Conference of the Parties that it consider listing dicofol in Annex A to the Convention without specific exemptions. Furthermore, the Committee recommended listing pentadecafluorooctanoic acid (PFOA), its salts and PFOA-related compounds in Annex A or B to the Convention with specific exemptions. 

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A Tool for the Global Regulation of POPs

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Ten Chemical Innovations That Will Change Our World

IUPAC identifies emerging technologies in Chemistry with potential to make our planet more sustainable

by *Fernando Gomollón-Bel*

2019 is a very special year in chemistry. 2019 marks two major anniversaries: the 100th anniversary of the founding of the International Union of Pure and Applied Chemistry (IUPAC), and the 150th anniversary of Dimitri Mendeleev's first publication on the Periodic Table of Elements [1]. IUPAC is the global organization that, among many other things, established a common language for chemistry—enabling scientific research, education, and trade. In a similar manner, Mendeleev's system classified all the elements that were known at the time, and even predicted the existence of elements that would only come to be discovered years later. These two anniversaries are closely entwined, as IUPAC has played a major role developing of the modern Periodic Table by ensuring that the most authoritative version of the table is accessible to everyone [2], establishing names and symbols for the newly discovered elements, and also constantly reviewing its accuracy through the IUPAC Commission on Isotopic Abundances and Atomic Weights.

These are two major scientific anniversaries. But we could celebrate many other things. Just over 100 years ago, Fritz Haber received his Nobel Prize [3]. This German chemist created cheap nitrogen fertilizers from nothing but air, a development that eventually detonated the huge population explosion in the 20th century. 2019 also marks the 230th anniversary of the original publication of Antoine Lavoisier's *Traité Élémentaire de Chimie*, considered by many to be the first modern chemistry textbook. Chemistry landmarks are ubiquitous because chemistry is everywhere—chemistry is the central science connecting the physical disciplines with life and applied sciences.

Finding landmarks in the history of science is not difficult. What is really challenging is identifying the discoveries that will eventually become the big chemical breakthroughs of the 21st century. Among the thousands of chemistry papers and patents that are published every day, which will really contribute to a more sustainable future?

For that reason, while celebrating the past, IUPAC is also looking into the future with this new initiative: “The

Top Ten Emerging Technologies in Chemistry” is an effort to more broadly promote the essential value of the chemical and related sciences and to identify discoveries that have the potential to change our world [4].

Experts recruited by IUPAC selected the “Top Ten Emerging Technologies in Chemistry” highlighted in this article from a pool of nominations submitted by chemists from around the globe. The following are emerging advances in the chemical sciences that hover between the embryonic ‘eureka’ moment at the lab and industrial application. Most certainly, in the near future, we will look back at these selections of innovative technologies and celebrate how they changed the world in which we live.

Nanopesticides

World population keeps growing. Some predictions suggest we will be almost 10 billion humans by 2050. Feeding that many people will require a huge increase in agricultural production, while keeping crops sustainable: minimizing the environmental impact in terms of land use, reducing the amount of water needed, and mitigating the contamination by agrochemicals such as fertilizers or pesticides. Unsurprisingly, nanotechnology is attracting quite a lot of attention beyond the pharma and health industries. Tailored nano-delivery systems could also become a great tool for farmers, as it would eventually allow them to tackle the main problems of conventional pesticides such as environmental contamination, bioaccumulation, and the huge increase in pest resistance. There are very few publications that carefully analyze the benefits—and risks—of so-called “nano-agrochemicals” against their conventional alternatives [5]. In most cases, the increase in efficacy is quite limited. However, in some cases researchers have observed



improvements by an order of magnitude under laboratory conditions. We still need a proper assessment of the efficacy of nanopesticides under field conditions. That is why some companies still investigate their potential, proving that there is still hope for this technology [6]. Canadian Vive Crop is possibly the best example, selling products that have demonstrated better absorption and less environmental impact than their non-nano commercial alternatives. Moreover, this company recently received the approval of the U.S. Environmental Protection Agency to commercialize various nano-encapsulated insecticides and fungicides. Nanotechnology may not be the only ingredient to a successful new, more sustainable agriculture, but it will certainly lead to more sophisticated agrochemicals with a lower impact on the environment and human health.

Enantio-selective organocatalysis

Chemists have always been inspired by nature. A few years back, researchers dreamt of a new kind of catalysts that, like most natural enzymes, would not require the use of expensive metals. “Organocatalysis” was born in the late 1990s and it has not stopped growing ever since. According to Paolo Melchiorre, one of the leading experts in the field, organocatalysis was successful because “[It] was quite democratic, everyone could have access to it without needing expensive reagents or a glovebox, which allowed many young researchers to start their independent careers, and quickly assembled a community of international experts that become a great incubator of ideas for catalysis without metals,” he explains.

Initially, some chemists criticized organocatalysis for not being as green as it claimed to be—it needed high catalyst loads and, moreover, it was hard to recover the catalyst after the reaction, which seem to go against the very definition of catalysis. However, Melchiorre points out how researchers have overcome most of these problems. He says that the original focus of organocatalysis was “to develop new methods rather than decreasing the catalyst loads.”

Nevertheless, because chemists understood the industrial implications that lowering the catalyst amount could have, they crafted ways of creating chiral carbon-carbon bonds using just part per millions of organocatalysts. “This is still not comparable to metals, but the cost is significantly cheaper,” he adds.

Chemists have also developed solutions to better recover the catalysts—Ben List immobilizes them on solid substrates like nylon [7], which is just one of the

many possible answers. Melchiorre highlights how organocatalysis has seeded the chemical landscape and eventually sprung other fields, especially photoredox catalysis, which allows new types of transformations: “[David] MacMillan created the link between the two fields. Light activation enabled reactions such as the alkylation of aldehydes with enamines, which couldn’t be done with classic organocatalytic methods.” Many other fields have emerged from organocatalysis, and now industries have scaled-up asymmetric organocatalytic protocols to synthesise fine chemicals and drugs.

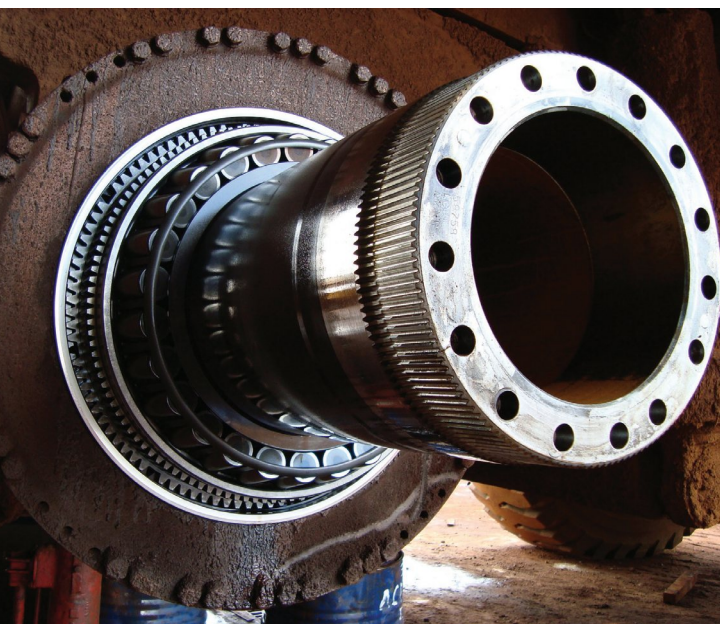
Solid-state batteries

Solid-state batteries were already envisioned in the 19th century by pioneer chemist Michael Faraday. However, their development never become a reality until quite recently. Now, important industries from a variety of sectors such as Bosch, Dyson, Toyota, and Intel are investing billions of dollars in this technology. John Goodenough, co-inventor of the now omnipresent lithium-ion batteries, recently unveiled a battery that uses glass as the electrolyte—proving that solid-state batteries are closer to market than ever. Compared to lithium-ion batteries that power our smartphones, tablets, and laptops, solid-state batteries are lighter, allow higher energy storage, and perform well at high temperatures. Moreover, unlike the electrolytes used in lithium-ion technology, solid-state electrolytes are not flammable, which could potentially avoid spontaneous fires and explosions, like the flames that darkened the launch of Samsung Galaxy Note 7 a few years back. However, the new technology is still very expensive.

As for many other applications, polymers may be the best and most economical solution. French transportation company Bolloré is already fabricating and commercializing polymer-based solid-state batteries, which they use mostly for network connected sensors.

According to polymer expert Tanja Junkers, “charge transporting polymers [are] truly fascinating—we have just yet seen the very beginning of what will be possible in [the] future.” There is still a lot of research to be done, especially because solid-state battery components are so closely bound together that it is quite complicated to understand how each of them behaves.

Academics and industrial researchers are closely working together to develop better non-destructive, operando technologies—electron microscopy and nuclear magnetic resonance—to understand how solid-state batteries perform. For most uses, the technology will still need a few more years of development [8].



Flow chemistry

Chemistry is key in achieving some of the United Nation's Sustainable Development Goals (SDGs), a blueprint to attain a better and more sustainable future for all by the year 2030. Among them, flow chemistry, where reactions are run in a continuously flowing stream rather than in batch, is particularly critical for tackling SDG12: responsible consumption and production. Flow chemistry processes eventually minimize the risk of handling hazardous substances and increase productivity, both preventing harm and lowering the environmental impact. Although some people consider flow chemistry to be on a very early, small-scale laboratory stage, efficient industrial applications are increasingly common.

Back in 2015, chemists at MIT demonstrated the potential of flow chemistry to create tailored polymers that would be unattainable by classical batch techniques. According to the experts in the field, the flow process is quicker and simpler, yet more reliable, which is quite in line with the SDG goals.

More recent examples have even shown the potential of flow chemistry to withstand hazardous reagents such as organolithium compounds. Merck chemists achieved a 100kg-scale synthesis of a precursor for verubecestat, a phase III candidate to treat Alzheimer's disease. Other recent examples include the flow synthesis of ciprofloxacin, an essential antibiotic, and an automated flow system developed by Pfizer capable of analyzing up to 1500 reaction conditions a day, speeding up the discovery of optimal synthetic routes for both new and existing drugs.

Reactive extrusion

Along with flow chemistry comes reactive extrusion, a technique that allows chemical reactions to happen completely solvent-free. The elimination of potentially toxic solvents makes this process environmentally friendly. It creates however many engineering challenges as it would require a complete redesign of the industrial processes that are now in place. Although extrusion processes have been widely-used and investigated by polymer and material experts, it is only now that other chemists are starting to dig into their possibilities in the preparation of organic compounds. Classic extrusion methods involve grinding reagents in a ball mill, but more advanced extrusion technologies using screws could even allow these solvent-free reactions to operate in flow setups. Once again, the downside lays on effectively adapting the systems and scaling them up. In their labs, chemists have used ball mills to prepare several attractive products—amino acids, hydrazones, nitrones, and peptides—and have achieved some very classic organic reactions—Suzuki coupling, click chemistry—but the examples in reactive extrusion conditions beyond polymers remain quite elusive [9]. However, the scarce exceptions show great promise [10]. Biotech company Amgen reported the optimized synthesis of co-crystals with potential use in the treatment of chronic pain, which was also the first example of mechanochemical synthesis scaled-up to several hundred grams. Furthermore, scientists in the UK have used reactive extrusion to efficiently prepare deep eutectic solvents [11]—a class of ionic liquids that could become the new generation of green, non-flammable solvents. Both previous examples involve the formation of intramolecular interactions, but not the creation of new covalent bonds. However, chemists have recently reported the formation of metal organic frameworks (MOFs) [12] and discrete metal complexes by screw extrusion, opening the door to new possibilities towards a cleaner and more sustainable solvent-free chemistry.

MOFs and porous materials for water harvesting

According to the United Nations (UN), water scarcity affects more than 40 % of the global population and is projected to rise. On top of that, three in ten people lack access to safely-managed drinking water services. Chemistry could bring a solution to this problem identified as SDG 6 [13] “to change our world” using porous materials, particularly metal organic frameworks (MOFs). Porous materials like MOFs have a

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sponge-like chemical structure with microscopic spaces that can selectively trap molecules, from gases—hydrogen, methane, carbon dioxide, water—to more complex substances, such as drugs and enzymes. While some researchers were focusing on the uses of MOFs in drug delivery and gas purification, Omar Yaghi accidentally discovered their great potential in capturing water from the atmosphere. “When we were studying the trapping of post-combustion gases uptake into MOFs, we noticed that some MOFs exhibited a unique interaction with water molecules,” explains Yaghi. Then, they wondered whether the same material “[could] be used to trap water from the atmosphere in arid climates, and then be released easily for collection.” This technology is unique, because “it can harvest drinkable amounts of pure water from the dry desert air with no energy required other than the natural sunlight,” says Yaghi. Just one kilogram of MOF could harvest 2.8 litres of water a day at a humidity level as low as 20 %. While working on higher capacity, potentially cheaper versions of the water-harvesting materials, Yaghi is “already partnering with companies to test their MOF water harvesters on an industrial scale.” There are other porous materials with similar abilities such as silica-based and inorganic porous solids, and the recently-reported biomimetic porous surfaces that mimic the structure of cactus spines [14]. Most of them, Yaghi argues, are not as productive as MOFs in taking up water from low humidity air. Nevertheless, further research may of course explore all possibilities to find the best solution, not only for harvesting water, but also for purifying it, guaranteeing the achievement of one of the most important UN goals—achieving access to adequate and equitable sanitation and hygiene for all.

Directed evolution of selective enzymes

Directed evolution of enzymes received the 2018 Nobel Prize in Chemistry. Enzymes produced through directed evolution are used to manufacture everything from biofuels to pharmaceuticals. According to the Nobel committee, chemists such as 2018 Laureate Frances H. Arnold “have taken control of evolution and used it for purposes that bring the greatest benefit to humankind.”

“Directed evolution requires the experimental testing of tens of thousands of variants, but [at the end] provides highly active enzymes,” explains Silvia Osuna, who investigates enzymes through advanced computational methods. She believes that the most active

enzymes created through rational design “still perform quite poorly in comparison with the natural enzymes and enzymes artificially evolved in the lab.” According to Osuna, the most interesting fact about directed evolution is how “mutations [that are] remote from the enzyme active site have a tremendous effect on the enzyme catalytic activity.”

It is only through analyzing artificially evolved enzymes that we have come to learn this. Her field, studying enzymes through computation, could be the key to identifying similar trends, thus better understand directed evolution. “Computation is one of the many tools, together with protein engineering advances, gene synthesis, sequence analysis, and bioinformatics, that will help us chemists make more focused [enzyme] libraries,” she concludes.

The limits of directed evolution are yet to be discovered. In her most recent paper [15], Arnold “hacked” plant enzyme cytochrome P450 using directed evolution. Now, they can easily catalyze the transformation carbon-hydrogen bonds into the more complicated asymmetric carbon-carbon bonds.

From plastics to monomers

“Circular economy is certainly the goal,” says Tanja Junkers. Once again, chemists should be inspired by nature. There, “everything is reused, and we should do the same with our synthetic materials.” This strategy will kill two birds with one stone, “it will solve the problem of recyclability in the long term, and the [need of] finding suitable sources for the main [polymer] building blocks.”

Some polymers, like polylactic acid (PLA), can be easily recycled into their monomers just by using heat.



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Others, such as polyethylene-terephthalate (PET), can be similarly broken down into their most basic units. First, the polymer is treated with ethylene glycol, which breaks the long polymer chains down into oligomers. These smaller fragments melt at lower temperatures and therefore can be filtered to remove any impurities. Then, once the material has been purified, it's completely broken down into the monomers, which are then purified again by distillation.

Beyond classic chemistry, and much like Arnold's approach to enzymatic transformations noted earlier, some bacteria have evolved such that they can also break down PET into pieces. Sometimes plastic is the only source of carbon around and you need to adapt if you want to survive. At least one species of *Nocardia* possesses an esterase that can break the ester bonds in PET [16] and, more recently, Japanese researchers discovered *Ideonella sakaiensis*, a bacterium that can disintegrate a PET plastic film in about six weeks thanks to two different enzymes [17]. Yet, recycling is expensive, and "the world of plastics works on so small margins that every cent matters," says Junkers. Chemists are looking into cheaper options towards a circular economy. Moreover, the price of plastic will slowly rise as oil becomes less abundant. But, beyond that, we have to raise awareness that cleaner plastic may be more expensive, but worth it. "Society must be willing to pay a [higher] price for more sustainable options," concludes Junkers.

Reversible-deactivation of radical polymerization

"Reversible-deactivation of radical polymerizations (RDRP) was invented more than twenty years ago and revolutionized the world of polymers," explains Junkers. "These methods all rely on mechanisms that impose control over otherwise almost uncontrollable chain reactions, allowing us to design polymers with an accuracy that comes close to what nature is doing," she says. RDRP polymers have found uses in a myriad of sectors: construction, printing, energy, automotive, aerospace, and biomedical devices are just some examples. "Most of the time, we are using these polymers without realizing it," says Junkers. RDRP has become a very powerful and useful tool for industrial chemists.

But there is still plenty of room for further innovation, especially towards finding more environmentally-friendly polymerization solutions. There are now many methods to control RDRP processes using only light, even without the need of using metals [18]. In recent years, chemists have also developed RDRP

methods that work in flow systems, which will allow them to move towards greener synthesis of polymers and plastics [19].

Finally, chemists have also mastered polymerization processes that work in aqueous media, avoiding the use of volatile or hazardous solvents. The most recent advances allow them to obtain ultra-high-molecular-weight polymers in water in just a few minutes [20], while keeping an exquisite control of the polymer branching. Some of these processes can work with a very low-energy light source, even just sunlight in some cases. Despite being a well-established technique, we can be certain that RDRP methods will continue to innovate, yielding an even broader commercial success [21].

3D-bioprinting

Bioprinting is one of today's most promising technologies. Using 3D printers and inks made out of living cells and also biomaterials and growth factors, chemists and biologists have managed to fabricate artificial tissues and organs almost indistinguishable from their natural versions. 3D-bioprinting could revolutionize both diagnostics and treatments, as artificial tissues and organs could be easily used for drug screening and toxicology research. This technology could even lead to the creation of tissues and organs for ideal transplants that would not require a donor. Currently, scientists can already 3D-print tubular tissues (heart, urethra, blood vessels), viscous organs (pancreas) and solid systems (bones) [22]. Recently, Cambridge researchers even managed to 3D-print a retina, carefully depositing layers of different types of living cells to generate a construct that architecturally resembles the native eye tissue [23].

Chemistry plays a central role in all the steps of this very complex process. First, organs and tissues need to be "scanned" in order to have a computational model. This is done using imaging techniques like computerized tomography (CT) scans and magnetic resonance imaging (MRI), both of which usually require chemical contrast agents such as gadolinium dyes. Then, bioprinting itself requires a myriad of chemicals to stabilize the bio-inks, trigger the assembly of the cells, or act as a scaffold for the printed tissue.

And finally, the 3D-bioprinted object needs to maintain its structure and form over time, a process for which both physical and chemical stimuli are required. Moreover, much like in any transplant or surgery, there is always the risk of the body rejecting the printed tissues. Understanding the chemistry of cell-cell

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recognition, mostly ruled by sugars that coat the membrane in the form of glycolipids and glycoproteins, is key to minimize rejection. Chemistry, in the center of all the crossing disciplines behind the highly-complex 3D-bioprinting, will be key in the further development of this fringe technique that, according to some experts, could even build new organs that are better than the existing biological ones [24].

With the “Top Ten Emerging Technologies in Chemistry” initiative, IUPAC not only celebrates its last 100 years, but also glances into the future of Chemistry. Each of these advances holds an enormous potential to ensure the well-being of our society and the sustainability of our planet Earth. Thus, IUPAC will continue to showcase these emerging technologies in chemistry, materials, and engineering in future editions of *Chemistry International*. The goal is to promote and highlight the ubiquitous contributions of Chemistry in our daily lives, and to inspire the new generation of young scientists to fearlessly embrace the challenges we face, empowering them to find solutions through research, entrepreneurship, and creativity.

Chemistry innovation will drive the change towards achieving the Sustainable Development Goals and, ultimately, to accomplish the mission of IUPAC—to apply and communicate chemical knowledge for the greatest benefit of humankind and the world. 🏆

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50th International Chemistry Olympiad: Back to Where It All Began

by *Henrieta Stankovičová, Petr Holzhauser, and Martin Putala*

In July 2018, the International Chemistry Olympiad returned to celebrate its golden jubilee in its birthplace, Slovakia and the Czech Republic, which this year also commemorated the 100th anniversary of the constitution of Czechoslovakia.

The International Chemistry Olympiad (IChO) is a worldwide competition for talented high school students who compete in chemistry skills and competencies to solve challenging problems in two parts: theory and laboratory practice. Students qualify for IChO based on the results of the national Chemistry Olympiads and/or selection competitions.

IChO is organized annually in July. Individual countries are approved by the International Jury. The organizer of IChO is usually a prestigious university from the organizing country. Each participating country sends a delegation to the competition which consists of four competitors, two mentors and up to two scientific observers. Mentors form an International Jury, approve competition problems, translate them from English into a national language, and—for objective evaluation—mark the solutions of their competitors independently of the authors of the tasks. The IChO program is balanced according to the needs of organizers and competitors and consists of an opening ceremony, practical part, theoretical part, evaluation and closing ceremony, as well as social, cultural, sport and relaxation programs.

The 50th IChO was organized for the first time by two countries, Slovakia and the Czech Republic and by the Comenius University in Bratislava (Slovakia) and the University of Chemistry and Technology in Prague (Czech Republic), under the auspices of the Ministries of Education of both countries. The idea to hold the golden jubilee of IChO in co-operation between Czechs and Slovaks was established about seven years ago and officially announced at the 46th IChO in Hanoi, Vietnam. After two years of intensive work, a large community of people around the Czech and Slovak national teams of the Olympiad fulfilled their dream—the IChO returned to the place where it was born. The opening ceremony and the competition itself were held in Bratislava, the jury was working in Prague, where the closing ceremony was held and medals were awarded. This prestigious event was attended by 300 competing high school students from 76 countries, attended by 256 members of the International Jury, scientific observers, and guests from 82 countries on 5 continents.



Figure 1. Presidents of 50th IChO: M. Putala (first left), P. Holzhauser (far right)

The Olympiad lasted from 19–29 July 2018 and it may surprise that it was not possible to make it shorter. Every day had purpose. For example, during competitions, it is necessary to prepare translations of competition problems from English into national languages. It's not an easy task for mentors who must translate about 25 000 characters (approximately 50 pages) of booklets for both the practical and theoretical part with just a single day available for each one.

IChO history

IChO began writing its history in Prague in 1968 with only 3 participating countries (Czechoslovakia, Hungary, Poland) and 18 competitors. This competition took place every year, except 1971. Since its inception, the Olympiad has observed many historical milestones: the introduction of preparatory tasks (1972), the beginning of arbitrations that ensure a fair evaluation of all participants (1975), awarding medals (1977), English as an official language (1984), creation of the Olympic Flag (1985), more than 100 participants (1987), issuing a magazine during a competition (1992), first Asian organizer (1995), first delegation from Africa (2002), the largest number of theoretical tasks—35 (2003), and emergency change of the organizer (2016).

The symbolism of IChO

When you hear the word “Olympiad,” everyone immediately imagines medals and Olympic circles. This symbolism has gradually emerged in IChO since 1968. IChO now has its own flag, and each year it has its own logo and slogan. Just like with sports, medals are awarded.

As a symbol of IChO, the flag was first presented at the 17th IChO in Bratislava, Czechoslovakia, in 1985.



At the end of the competition, it was given as a pledge to the organizers of the following years Olympiad. Thus, a new, unwritten tradition emerged that endures to this day. At the occasion of the 40th IChO in Budapest, Hungary, the organizers created a new flag that fulfilled its purpose for the following ten years. On the latest IChO flag, the third in order, introduced at the Opening Ceremony of the 50th IChO, there is an acronym "IChO" and the five Olympic flames, calling to mind the Olympic rings and symbolizing the characteristic colours of the flame-tests compounds of thallium (green), calcium (orange), sodium (yellow), copper (blue-green) and strontium (red). A closer look will also reveal a burner, a timeless symbol of lab work of alchemists and chemists. The older flags are stored in the archive of the IChO International Information Centre in Bratislava, Slovakia.

Through the years, the main themes of the logos were different molecules, flasks, or national symbols. The logo of the 50th IChO, the head of young chemist, protected by goggles, with turquoise hair in the shape of flame represents the fact that IChO is not just about flasks and molecules, but especially about young chemists. These young chemists are full of passion for chemistry and knowledge. Their inner flame is pictured in another of the symbols used, the Olympic flame.

This year's slogan "*Back to where it all began,*" certainly requires no explanations.

The medal of the jubilee carries the logo of the competition, the head of the young chemist burning by the passion for knowledge; the reverse depicts a linden leaf, the national tree for both Czechs and Slovaks, commemorating the 100th anniversary of the constitution of independent Czechoslovakia.

Specifics of the golden jubilee

This year's Slovak-Czech Olympiad was exceptional in many ways. For the first time, the competition was organized by more than one sovereign state, and for the first time the IChO had two presidents—Martin Putala (for Slovakia) and Petr Holzhauser (for the Czech Republic) (Figure 1). For the first time three hundred contestants competed. The new IChO flag was introduced, and for the first time IChO had mascots: "Copperheads." The reunion party was first opened to the general public through a music and cultural festival at Prague's Victory Square. On the occasion of the IChO golden jubilee, the Slovak Post issued a postal stamp at a nominal value of 1.25 €. (see *Chem Int* Jan 2019)



The Competition

The competition problems were prepared by an experienced team of authors (Scientific Committee) under the auspices of national chemical societies. Martin Putala from the Faculty of Natural Sciences of the Comenius University in Bratislava (Slovakia) supervised the practical part and Petra Ménová from the University of Chemistry and Technology in Prague (Czech Republic) oversaw the theoretical section. Many of the 30 authors are former IChO participants, and have won a combined 20 IChO medals.

Within the five-hour practical part of the competition,

students were solving three problems (Figure 2). They could verify their skills in organic synthesis, product extraction, and subsequent analysis of its purity by thin-layer chromatography. Fans



Figure 2. Students show their skills with pipettes, thermometers and other laboratory equipment in the practical part of the competition.

50th International Chemistry Olympiad



*Figure 3. (above) Students work through the problems of the theoretical part of the competition.
Figure 4. (below) Mentors translate tasks.*

of physical chemistry have been given the opportunity to exhibit their deep knowledge in chemical kinetics while working hard with pipettes, stopwatches, thermometers, and calculators. The third practical task was to identify an unknown sample of mineral water originating from the amazing nature of Slovakia.

The theoretical part of the competition, which also lasted five hours, consisted of a set of eight multi-layered problems with several sub-questions covering all areas of chemistry (Figure 3). This test verified the ability of competitors to creatively approach the problems. Students tested their ability to solve palindromic DNA sequences, to calculate thermodynamic constants, and determine protein ratios in the human body based on knowledge of chemical equilibria and reaction kinetics. Problems related to electromobility also emerged; students calculated combustion enthalpies and electromotive forces. The efficiency of separation of metal ions by ion exchange chromatography was investigated and the color and the crystal structure of the Czech garnet was also solved. Organic chemists had an opportunity to show their knowledge by solving the total synthesis of coprine (toxin from *Coprinopsis inkisia*), cidofovir (antiviral agent against HIV), and caryophyllene (a terpenoid from linden tree).

The IChO is not just about chemistry

Besides the scientific program, a rich accompanying social and leisure program was ensured for all participants. The IChO began with an Opening Ceremony at the Old Market Hall in Bratislava in the presence of hosts from Slovakia and the Czech Republic and ambassadors of the participating countries. Besides the introduction of all the competitors, the ceremony featured the presentation of a new flag, postage



stamp, and the culture of Slovakia. The joint program of mentors, observers, hosts, and students continued with a gala reception at the Červený Kameň Castle. Students then separated and acquainted themselves with the history of mining in Banská Štiavnica, one of the most important mining towns in the world, especially regarding the historical and mine-technical aspects. They tried to find minerals, visited Bratislava, tasted the mineral waters of Slovakia, and relaxed at sport events.

After the competition, they traveled to Prague by a special IChO train and met their mentors at reunion party. Besides the historical center of Prague, they visited Solvay's quarries and the historical waste water treatment plant in Bubeneč. In Bubeneč they enjoyed barbecue and a lecture of Peter Wothers from the University of Cambridge concerning the origin of chemical elements revived by chemical experiments.

50th International Chemistry Olympiad

While the students competed, their mentors did not rest. In addition to meetings of the International Jury lasting deep in the night, translations of competition tasks into the mother language of the competitors (Figure 4) and marking them, they visited Bratislava, Prague and Kutná Hora.

Evaluation, closing ceremony and feedback from participants

In the very heart of Prague, in Rudolfinum, the world's top young chemists gathered for the closing ceremony gala. All participants were ranked based on their individual scores and no official team scores are given. Gold medals were awarded to 35 students, silver medals were awarded to the next 65 students, bronze medals were awarded to 95 students, and honorable mentions were awarded to 10 participants. Absolute winners of IChO (Figure 5) were Qingyu Chen (China), Aleksei Konoplev (Russian Federation) and Raymond Eugene Bahng (South Korea). Competitors from China also took prizes for the best theoretical part (Yichen Nie) and practical part (Qingyu Chen). At the very end of the Closing Ceremony both presidents of IChO 2018 met Anne Szymczak from France, Chair of IChO 2019, on the stage and passed the IChO flag (Figure 6). With this, the relay baton was passed to IChO 2019 organizer.

The highlight of the last IChO evening was the Farewell Party and the festive fireworks over the Vltava river.

The entire 50th IChO would not have been possible without the financial support from sponsors and

partners of IChO, enthusiastic and hard work of the organizing committee and about 200 assistants from the staff, PhD students and students of both organizing universities, of the Faculty of Science of Charles University in Prague and of Chemical and Food Technology of the Slovak Technical University in Bratislava, as well as many former Slovak and Czech IChO participants. Under the supervision of Henrieta Stankovičová (for Slovakia) and Dana Poláchová (from Czechia), they did a great deal of honest work as laboratory assistants, assistants, guides, team members for the daily magazine *Catalyzer*, and many other helpers, for which we are very grateful.

When we look back on July 2018, we can ask ourselves: What was the golden jubilee anniversary of IChO? It looks like the 50th IChO has been a great success thanks to a smooth course, rich program, imaginative and creative tasks, and friendly and cordial atmosphere. At least that is the result of numerous statements at the end of the event and from emails from members of the IChO Steering Committee, mentors and competing students.

We select just a few of them:

I-Jy Chang (Chair of the Steering Committee for IChO 2018, Chinese Taipei): Congratulations on a wonderful and successful IChO. I got commends from many mentors that if this is not the best one, they can't think of others. I felt the same. It is definitely the best IChO I have attended. Thank you very much for years of time and efforts.

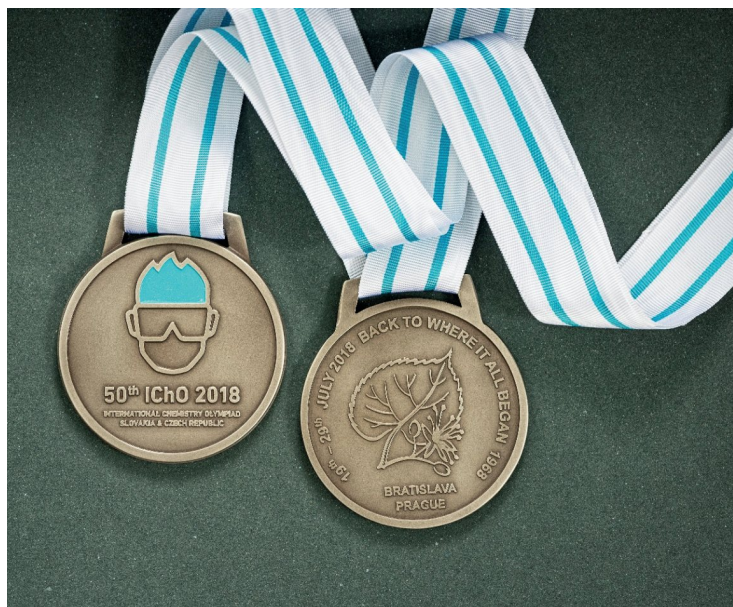


Figure 5. (left) Qingyu Chen, Aleksei Konoplev and Raymond Eugene Bahng were the absolute winners of the competition. Figure 6 (right) is the silver medal of the 50th IChO.

50th International Chemistry Olympiad

Sarika Subramanian (United Arab Emirates): It was a fantastic, flawless IChO 50th event. Cannot really find words to thank each one of you involved to make it just awesome. All I can say is a big thank you from the bottom of my heart.

Gábor Magyarfalvi (Chair of the Steering Committee for IChO 2019, Hungary): I was also trying very hard to find the appropriate words to express our thanks to every organizer and contributor. It was a great olympiad, exceptional for all the right reasons. I hope the organizers will enjoy their well-deserved rest soon. Let me remind them that there are years open in the near future—no one will oppose if they wish to repeat the experience.

Carlos Castro-Acuna (Mexico): There are not enough words to thank Martin, Petr and all people involved in the organization of the 50th IChO. It will be remembered as one of the best, for sure. It was perfect to celebrate the 50th Anniversary. Besides, the opportunity to meet good friends from past olympiads, was just incredible. 🏆

<https://50icho.eu/>

www.facebook.com/InternationalChemistryOlympiad, #icho2018

Martin Putala (martin.putala@uniba.sk) was the President of the 50th IChO for Slovakia. He is a chair of Slovak Chemistry Olympiad Committee and professor of organic chemistry at Faculty of Natural Sciences, Comenius University in Bratislava, Slovakia.

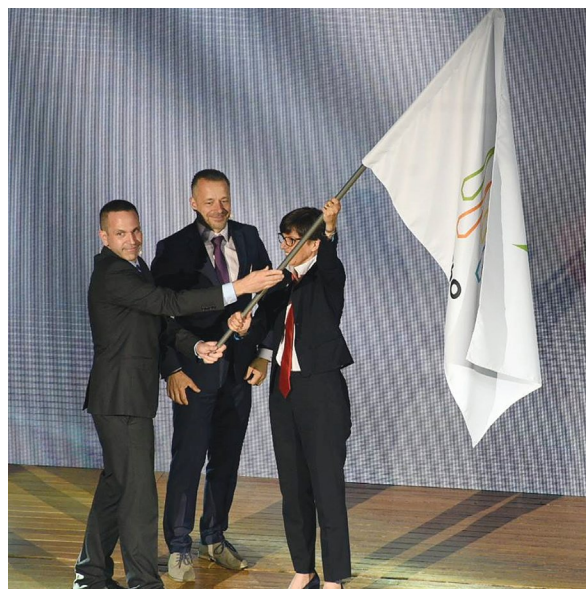


Figure 6. Passing the IChO flag to the next organizing country, France

Petr Holzauser (petr.holzauser@vscht.cz) was the President of the 50th IChO for the Czech Republic. He is a chair of the Czech Chemistry Olympiad Committee and a senior lecturer at University of Chemistry and Technology in Prague, Czech Republic in the field of inorganic chemistry and chemistry education.

Henrieta Stankovičová was the Head of the Organizing Committee of the 50th IChO for Slovakia. She is Senior Researcher at Faculty of Natural Sciences, Comenius University in Bratislava, Slovakia.

A vintage blue typewriter sits on a rustic wooden surface. To its left is a small green plant with white flowers. To its right is a decorative card with a white floral pattern on a brown background. Overlaid on the image is the text: "Feature Articles Wanted", "Contact the editor for more information", and "at <edit.ci@iupac.org>".

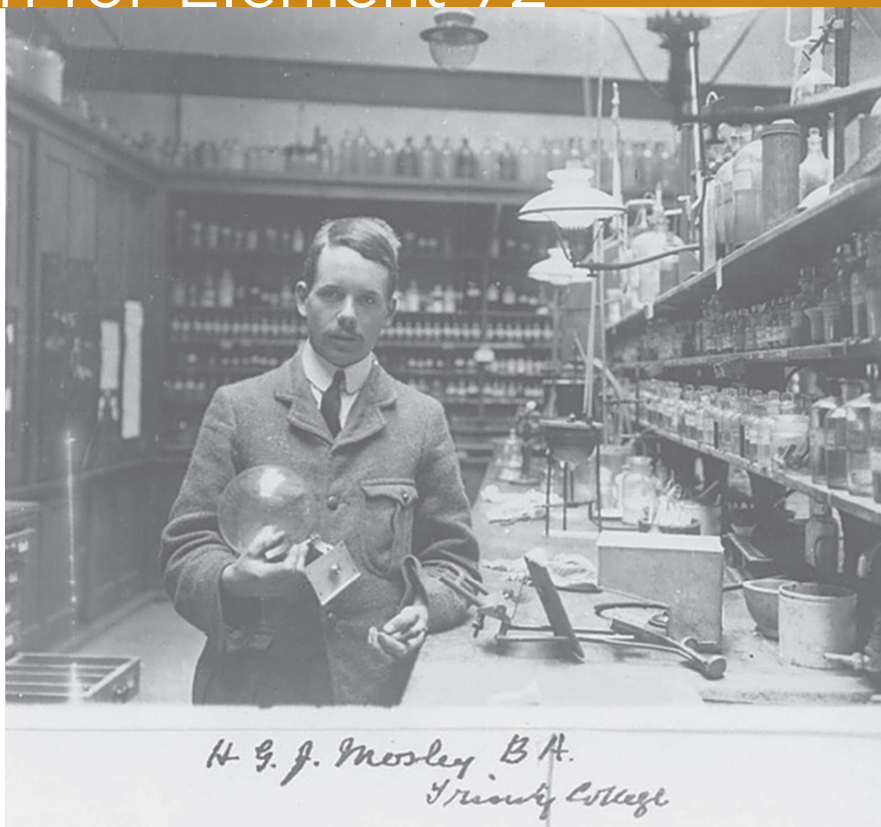
Feature Articles Wanted
Contact the editor for more information
at <edit.ci@iupac.org>.

Henry Moseley and the Search for Element 72

by K. M. Frederick-Frost

“Unfortunately the new element for the examination of which he came over, proves shy and will not disclose itself. I cannot imagine what it can be, and seriously doubt its existence. This is disappointing and leaves one more gap in the list of the known elements.”

When Henry Moseley penned this statement to his sister on 7 June 1914, he was not in a celebratory mood. It was less than a week after an experiment in which he collaborated with the famous rare earth chemist, George Urbain. Together they hoped to show that Urbain’s preparation “celtium” was the missing element with atomic number 72. The data only delivered disappointment. After putting the scientific community on its head and the elements in their place with two papers on the “High-Frequency Spectra of the Elements,” this null result failed to excite Moseley. But it should excite us. He not only used X-ray spectroscopy to identify gaps in the list of known elements, he used it to rule out a candidate for one of those gaps. In this International



Source: History of Science Museum, University of Oxford

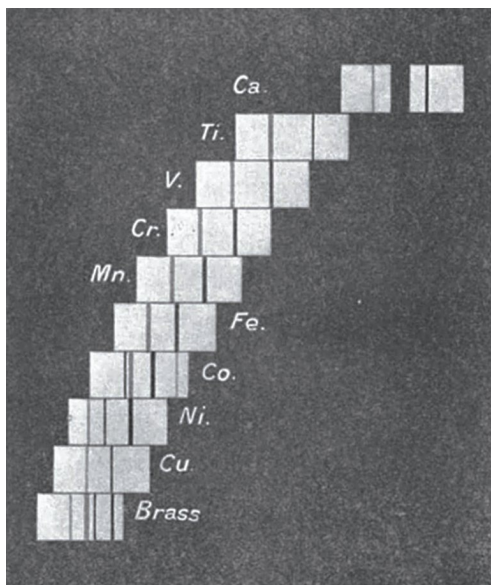


Fig. 1. X-ray spectra aligned according to the angle of reflection. Source: H. G. J. Moseley, “The High-Frequency Spectra of the Elements,” *Philosophical Magazine* 26 (1913): PI XXIII.

Year of the Periodic Table, let’s consider element 72, before it was called hafnium, when the possibility of its discovery brought together chemists and physicists in a new way. Let’s consider Moseley’s research.

Henry Gwyn Jeffreys Moseley (1887-1915) might have begun his education at Eton and the University of Oxford, but his time as a demonstrator and researcher at the University of Manchester under Ernest Rutherford (1871-1937) is what provided him with access to the ideas, people, and infrastructure needed to support the scientific research that would earn him fame. Moseley was in the right place at the right time, but he was ultimately drawn to the wrong kind of ionizing radiation. Rutherford was more at home with radioactivity, so it was arranged for Moseley to learn about experimenting with X-rays from another famous scientist, W. H. Bragg (1862-1942), at Leeds University. W. H. Bragg, with his son, W. L. Bragg (1890-1971), would share the 1915 Nobel Prize for their work analyzing crystals with X-rays.

When Moseley returned to Manchester, he partnered with another young scientist drawn to Rutherford’s group, C. G. Darwin (1887-1962), and, much like the Braggs, they started looking closely at the intensity and angular distribution of X-rays reflected from a crystal. Moseley and Darwin found five peaks with specific wavelengths that stood out from a background

Henry Moseley and the search for element 72

of heterogeneous reflected radiation. These characteristic X-rays were associated with the platinum target in their X-ray tube. Moseley next set his sights on investigating the characteristic radiation of a series of elements in the periodic table, which was largely organized by increasing atomic weight and shared chemical properties. He was sure to include two misfits in his study—Co and Ni—whose atomic weight did not fit the overall pattern. The question he set out to answer: Would the atomic weight or the element's order in the periodic system determine the X-ray spectra?

For his first foray in to the “High-Frequency Spectra of the Elements,” Moseley used a customized X-ray tube with a trolley of interchangeable elemental targets that he could pull under the tube's cathode in relatively quick succession. Unlike his first study of X-rays, where he used an ionization detector to measure the intensity of the radiation as a function of the angle of reflection, he imaged the spectra with photographic plates. This captured the strongest two emission lines, but that was enough to create a powerful visual when all the images were arranged according to the angle of reflection (Fig. 1). The X-ray data, unlike the atomic weight, were decisive in placing Ni between Co and Cu.

Right in the middle of this famous research, Moseley gave up his fellowship at Manchester and moved to the University of Oxford to work as an unpaid researcher in the Electrical Laboratory. He was angling for a new position. Compared with the frenzy of activity under Rutherford, the Electrical Laboratory moved at a slower pace and had less support staff to assist with the construction and repair of his apparatus, which is why Moseley still contracted with the Manchester instrument maker to provide some of the equipment needed for the next phase of his study. Part II, which he published in April 1914, expanded his dataset from 12 elements to 45.

Moseley derived the relationship between the square root of the frequency of characteristic X-rays and an element's atomic number in his first paper, but the graph in his second paper makes Moseley's Law manifest. (Fig. 2) The data were grouped into the two flavors of characteristic radiation he studied, K and L rays (bottom and top set of lines respectively). Because this radiation was related to the structure of the atom, so, too, was the atomic number. Far from just a serial number in the periodic system, Moseley concluded, “there is every reason to suppose that the integer which controls the X-ray spectrum is the same as the number of electrical units in the nucleus,” which supported a hypothesis proposed by a Dutch solicitor-turned-scientist, Antonius van den Broek (1870-1926).

While the gaps in the dataset for known elements didn't detract from Moseley's overall accomplishment, the gaps in the dataset for *unknown* elements added to it. He declared that “known elements correspond with all the numbers between 13 and 79 except three. There are here three possible elements still undiscovered.” Not only did his research provide experimental evidence that the atomic number was a physical property of the nucleus of an atom, it made the hunt for new elements specific and finite. However, he was wrong about the number of elements yet to be discovered.

Moseley's original hand-drawn plot hangs in Oxford's Clarendon Laboratory. A close look at the y-axis reveals corrections made post-publication and his original confusion about elements 66-72 (Fig. 3). It was shortly after publication that he realized that there were actually four unknown elements (43, 61, 72, and

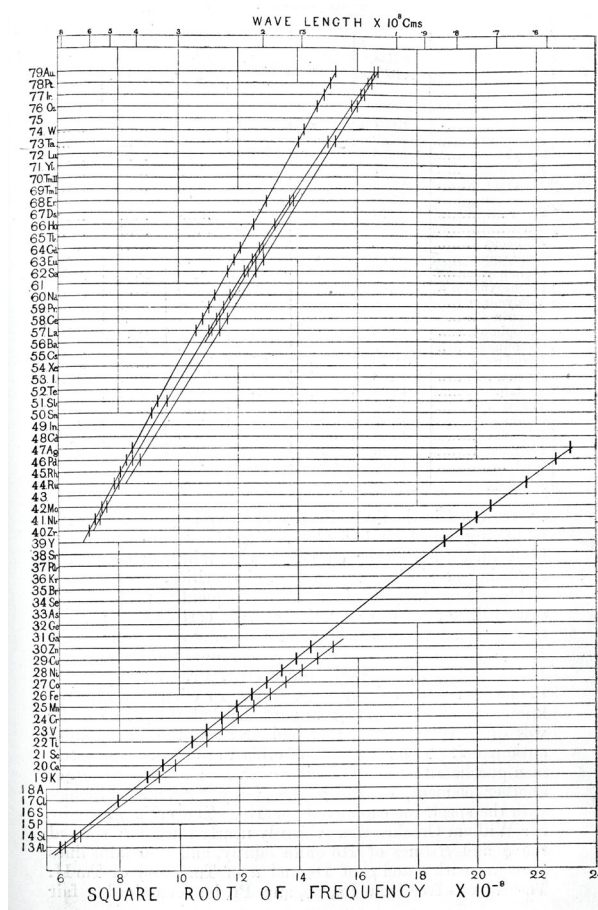


Fig. 2. Plot of X-ray data (square root of frequency vs atomic number). Source: H. G. J. Moseley, “The High-Frequency Spectra of the Elements, Part II,” *Philosophical Magazine* 27 (1914): 709.

Henry Moseley and the search for element 72

75) yet to be discovered. The one he overlooked was the only one he would have an opportunity to hunt—element 72.

“As the X-ray spectra of these elements can be confidently predicted, they should not be difficult to find.” Not too long after publishing this statement in his second paper on the “High-Frequency Spectra of the Elements,” Moseley was about to get an education for just how hard it could be. A possible hiding spot for number 72 was in the rare earths, which were famously hard to separate and therefore held the promise of new discoveries. For example, both George Urbain (1872-1938) and Carl Auer von Welsbach (1858-1929) claimed to separate ytterbia into two different elements in 1907. The two researchers locked horns over priority, and Urbain won out. They were both a natural choice for Moseley to approach if he wanted samples to examine that would enable him to fill the holes in his plot between 69-72. Moseley asked George

von Hevesy (1885-1966) to approach Auer for samples of the rare earths, but Moseley was especially interested in getting a crack at a new element Urbain reported discovering in 1911: celtium.

Urbain was also keen to collaborate with Moseley, and in June 1914, he traveled to Oxford with several samples, celtium included. Moseley agreed that celtium had a “very definite” visible spectrum, but the absence of a handful of X-ray emission lines with frequencies expected for element 72 was conclusive. The lines he did measure were more consistent with Lu and Ny

(Yb). Figure 4 shows some of his data for celtium, with the relative percentage concentrations for Lu and Ny (Yb) in the rightmost column.

The two researchers not only spoke different languages but they came from different scientific traditions. Urbain had a successful career utilizing visible spectra and magnetic susceptibility measurements to analyze elements. His explanation for the missing lines in the X-ray spectra was that they were just too faint to see. In fact, he would later note, “the negative result given by Moseley’s method in the case of celtium was due only to the insensitiveness of the method.” He believed he ultimately achieved success finding those faint lines with physicist Alexandre Dauvillier (1892-1976) in 1922 using the same sample that Moseley examined in 1914.

Despite Moseley’s failure to find X-ray data to support celtium as element 72, Urbain still wanted him to publish his endorsement of this idea. Instead, Moseley reported that celtium was a mixture of previously discovered elements at the 1914 meeting of the British Association for the Advancement of Science in Australia. Moseley’s involvement in the war effort and subsequent death is largely cited as the reason why these results were never published. He went off to the front disappointed about never submitting his paper, writing to Rutherford on 4 April 1915, “One thing lies heavy on my conscience, and that is my Sydney B. Ass paper, for I have never published it. I must make time to get ready an abstract for the Phil Mag, before I leave, as to chemists the reality and order of the rare earth elements is of much importance.” Urbain and Dauvillier’s claim to the discovery of 72 was not long lived. Physicist Niels Bohr (1885-1962) would wrest the search for 72 from the rare earths altogether while pursuing his new atomic model. We could conclude that the success of Moseley’s spectroscopy in ruling out celtium as a new element was an example of how in science the “truth will out.” But, that isn’t very satisfying.

The story gets interesting when we consider the possible reasons why Moseley’s work was never published—both while he lived and after he died. He knew the data were valuable. He even planned for their future should he not return from the war, instructing his mother, Amabel Sollas (1855-1928), to give his notes, spectra, and calculations to Rutherford. She did so within a month after learning of the loss of her son. According to a note written by Moseley’s sister on 12 June 1933, both she and her mother were shocked when Rutherford failed to find anything worth publishing. Since their close relationship with Moseley provided unique insight as to the nature and value of his

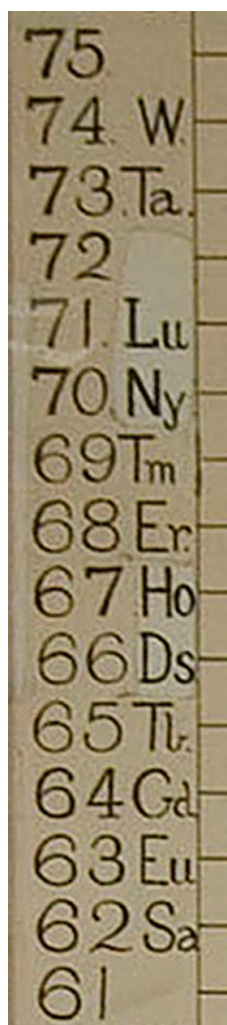


Fig. 3. Corrected hand-drawn version of Moseley’s 1914 plot shown in Fig 2. Originally, he labeled number 72 as Lu, 71 as Yb, 70 and 69 as TmII and TmI, and swapped the order of Ho and Ds. Close inspection shows places where sections excised. Source: History of Science Museum, University of Oxford, by courtesy of the Clarendon Laboratory, University of Oxford).

Henry Moseley and the search for element 72

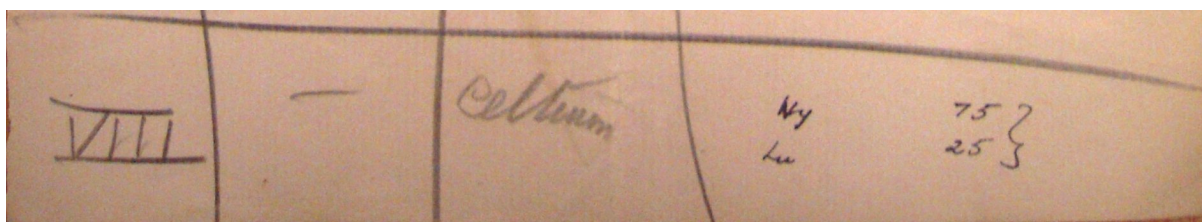


Fig. 4. Excerpt from page of Moseley's notes showing data for celtium. Percentage concentration measured from X-ray line intensity shown in rightmost column. Source: History of Science Museum, University of Oxford.

Fig. 5. Excerpt from page of Moseley's notes showing wavelength calculations for Lu, Ny (Yb), Tm, Er. Source: History of Science Museum, University of Oxford

	λ_3	7510	4771	$\lambda \times 10^8$
Lu	$16^\circ 46'$	4601	2111	1626
Ny	$17^\circ 19'$	4737	2247	1678
Tm	$17^\circ 53\frac{1}{2}'$	4874	2384	1732
Er	$18^\circ 34'$	5019	2529	1790

work and results, their disappointment in the lack of a posthumous publication should not be discounted.

A rare page of Moseley's notes at the History of Science Museum, University of Oxford related to his rare earth research with Urbain shows that, despite the disappointment with celtium, several new data points for Tm, Ny (Yb) and Lu were ready for incorporation into his famous plot. (Fig. 5) Interestingly, Moseley didn't even prepare a short publication stating these numbers. One possible stumbling block was that the samples that provided the data for these elements were shown to be mixtures. X-ray spectra of samples labeled "Lu" and "Ny" (Yb) were actually combinations of the two elements. This wouldn't be a problem on its own, after all several of the data associated with rare earth elements he previously investigated were from impure samples (The sample of Pr that he obtained from the chemical supply Dr. Schuchardt of Görlitz contained 50 % La, 35 % Ce, 15 % Pr.) It was likely more awkward to point out impurities when Urbain claimed both success and priority in isolating Lu and Ny (Yb). The decision to go public with this information was more fraught than the addition of a few new data points. For all his success, Moseley was a junior researcher. Publishing information that countered Urbain's claims—or at least muddled the waters—would have been a bold step.

As a Nobel laureate and senior researcher, Rutherford held more authority in the scientific community. However, once he reviewed Moseley's rare earth data, he also held his hand, stating in the 1917 Proceedings of the Royal Society that "no record of his [Moseley's]

definite conclusions on this question has been found." There are several possible reasons why Rutherford didn't publish any of the materials. They range from Moseley's sister's accusation of negligence with the data he was given to not having the time in the middle of his own research and war work to devote himself to the completion of Moseley's unfinished paper.

Analysis of the archival documents related to Moseley's rare earth research point to another set of difficulties. His notes, spectra, calculations, experimental setup, and conclusions were all entangled. The data points shown in Fig. 5 required corrections that were different than were described in his two publications on "The High-Frequency Spectra of the Elements." This might have something to do with the fact that he often varied the location and arrangement of various components of his X-ray spectrometer to wrestle the characteristic lines from the background radiation. Like many experimentalists, he readily modified his setup to suit his purposes. However, if he changed the way the data were collected, he could change the way the data were reduced, and that might change more than a few irrelevant decimal places. Talented as Rutherford was, he might not have been able to derive the same level of certainty, if not the same conclusions, as Moseley.

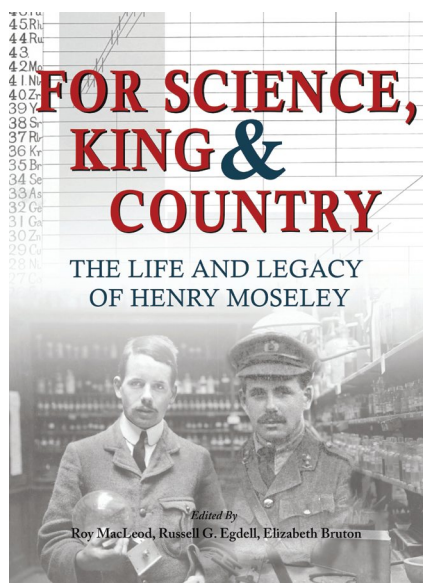
Because Urbain's celtium discovery and the purity of his other elements might have been called into question, the stakes were high. The reward for publishing someone else's work was low. Rutherford remained in the thick of the work to identify element 72, not as an active participant in the hunt, but as a powerful referee. In 1922, when Urbain and Dauvillier announced

Henry Moseley and the search for element 72

that celtium was the missing element 72, Rutherford included a note of support before the English translation of Urbain's article in *Nature*. A few months later, Bohr privately wrote to Rutherford about "the reliability of Dauvillier's result," because it went counter to his new theory of the atom and to the X-ray absorption data that he and Dirk Coster (1889-1950) were compiling and investigating. This work indicated that 72 belonged in the group with zirconium.

With that opening, George von Hevesy was able to collaborate with Coster and find what we know as hafnium just in time for Bohr to announce it at the acceptance of his Nobel Prize in December 1922. This was also the start of another priority dispute involving Urbain, but unlike Lu and Yb, it wouldn't be decided in his favor. Henry Moseley's results might therefore seem prophetic, but it is more interesting to use his work as a case study of the kind of support and context data need to generate new knowledge. Moseley died young. His data and work on celtium might not have died with him—they just couldn't live without him. 🏴󠁧󠁢󠁥󠁮󠁧󠁿

K. M. Frederick-Frost <frederickfrostk@si.edu> is curator of Modern Science for the National Museum of American History of the Smithsonian Institution, in Washington, DC



Do you want to learn more? A new collection of essays by scientists and historians, *For Science, King & Country: The Life and Legacy of Henry Moseley*, was recently compiled by Roy MacLeod, Russel G. Egdell, and Elizabeth Bruton (eds.). John Heilbron's *H. G. J. Moseley: The Life and Letters of and English Physicist, 1887-1915* is an excellent biography and collection of transcribed letters. To learn more about Moseley's unpublished work with Urbain, see K. M. Frederick-Frost, "For the Love of a Mother—Henry Moseley's Rare Earth Research," *Historical Studies in the Natural Sciences* 47 (2017): 529-567.

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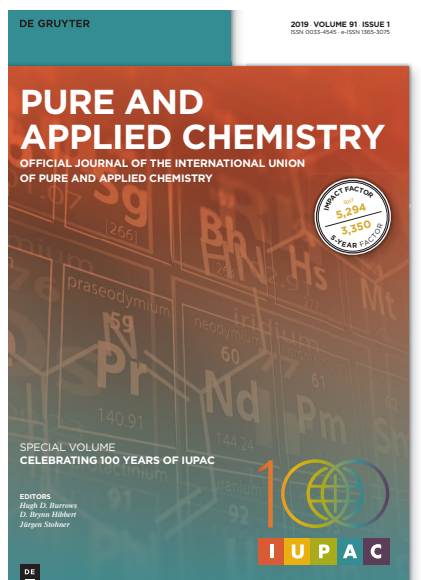
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Since 1960, the International Union of Pure and Applied Chemistry (IUPAC) has made available to chemists everywhere a large amount of important chemical information published in the journal *Pure and Applied Chemistry*.

Pure and Applied Chemistry is the official monthly Journal of IUPAC, with responsibility for publishing works arising from those international scientific events and projects that are sponsored and undertaken by the Union. The policy is to publish highly topical and credible works at the forefront of all aspects of pure and applied chemistry, and the attendant goal is to promote widespread acceptance of the Journal as an authoritative and indispensable holding in academic and institutional libraries.

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Awardees of the IUPAC 2019 Distinguished Women In Chemistry or Chemical Engineering

To celebrate International Day of Women and Girls in Science this February 11, IUPAC announced the awardees of the IUPAC 2019 Distinguished Women in Chemistry or Chemical Engineering:

- **Professor Kim Baldridge**, School Pharmaceutical Science and Technology, Tianjin, China
- **Professor Donna Blackmond**, The Scripps Research Institute, La Jolla, CA, USA
- **Professor Susan Bourne**, University of Cape Town, Rondebosch, South Africa
- **Professor Janine Cossy**, ESPCI, Paris, France
- **Professor Vicki Grassian**, University of California San Diego, La Jolla, CA, USA
- **Professor Otilia Mó Romero**, Univ Autonoma Madrid, Madrid, Spain
- **Professor Elizabeth Ann Nalley**, Cameron University, Lawton, OK, USA
- **Professor Carol Vivien Robinson**, University of Oxford, Oxford, United Kingdom
- **Professor Molly Shoichet**, University of Toronto, Toronto, Canada
- **Professor Luisa Torsi**, University of Bari Aldo Moro, Bari, Italy
- **Professor Chris Willis**, School of Chemistry, Bristol, United Kingdom
- **Professor Pernilla Wittung-Stafshede**, Chalmers University, Gothenburg, Sweden

The awards program, initiated as part of the 2011 International Year of Chemistry celebrations, was created to acknowledge and promote the work of women chemists/chemical engineers worldwide. (See also *imPACT*, p. 35) These 12 awardees have been selected based on excellence in basic or applied research, distinguished accomplishments in teaching or education, or demonstrated leadership or managerial excellence in the chemical sciences. The Awards Committee has been particularly interested in nominees with a history of leadership and/or community service during their careers.

An award ceremony will take place during the IUPAC World Chemistry Congress in Paris, France, coinciding with the special symposium on Women in Chemistry and reception in honor of the recipients. See www.iupac2019.org for details.

Dr. Carolyn Ribes, chair of the IUPAC committee on Chemistry and Industry and co-chair of the special



symposium, remarked: "We are pleased with this year's awardees and eager to recognize their contribution in a special session organized for the 2019 IUPAC Congress. Each year since 2011, the award has gained more attention in the community. During this year's Congress and with the help of IUPAC leadership, we plan to continue this trend."

The International Day of Women and Girls in Science is a global day celebrating achievement and promoting full and equal access to and participation in science for women and girls. The day also marks a call to action for further achieve gender equality and the empowerment of women and girls.

<https://iupac.org/iupac-2019-distinguished-women/>

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IUPAC-Zhejiang NHU International Award for Advancements in Green Chemistry

IUPAC and Zhejiang NHU have established a new collaborative award in Green Chemistry encouraging young and experienced chemists, and emphasizing the importance of advancements in Green Chemistry and the value of sciences to human progress. This newly established award covers all the topics of Green Chemistry, such as Green and Renewable Feedstocks, Green Synthetic Routes, Green Solvents, Green Catalysis, Green products, Green Energy, and as broadly defined by OECD as Sustainable Chemistry.

The objective of this award is to encourage young professional chemists and experienced chemists of the importance of advancements in Green Chemistry and the value of experimental sciences to human progress. IUPAC- Zhejiang NHU International Award includes several awards.

Three prizes will be awarded to three early career chemists, 2,000 US\$ each, who have received their Ph.D. (or equivalent) degree, or completed all Ph.D. requirements including successful defense of their doctoral thesis within the last 3 years (2016-2018). Qualified

PhD chemists will be evaluated based on the quality of their theses work. Application requires submission of a completed entry form, including an essay submitted by the entrant that describes his or her research work and places it in perspective relative to current research in Sustainable Chemistry. The essay must be written in English by the entrant and may not exceed 1000 words.

One prize will be awarded to an experience chemist (10,000 US\$) who should have made significant contribution to green/sustainable chemistry throughout their career.

The Awards will be presented every two years and will highlight the work of the winners in progressing Green Chemistry in their applications and will disseminate it to the attention of a wider global audience. All scientists are eligible irrespective of gender and nationality. Winners of this award will be expected to submit a review article for publication in *Pure and Applied Chemistry* in the year following their award.

The first awards will be presented at the 2019 IUPAC World Chemistry Congress to be held in Paris, France, 7-12 July 2019.

Complete applications must be received via the submission form no later than **30 April 2019**.

<https://iupac.org/iupac-zhejiang-nhu-international-award/>

IUPAC Provisional Recommendations

Provisional Recommendations are preliminary drafts of IUPAC recommendations on terminology, nomenclature, and symbols, made widely available to allow interested parties to comment before the recommendations are finalized and published in IUPAC's journal *Pure and Applied Chemistry (PAC)*. Full text is available online.

Recommendations and Terminology for Lactic Acid-Based Polymers

Lactic acid enantiomers and cyclic lactic acid dimers, the latter referred to as lactides, are sources of degradable aliphatic polymers that are composed of chiral constitutional repeating units. The different synthesis routes and the various combinations of chiral units result in a multitude of chiral structures and of corresponding properties. Distinctive structural identification is often crucial, especially for applications as degradable polymers. This document provides recommendations for the nomenclature, abbreviations, and terminology related to lactic acid-based polymers in order to allow consistent comparison between polymers of different origins and between data collected within

different disciplines.

Comments by 31 May 2019

Corresponding Author: Michel Vert / michel.vert@umontpellier.fr

Definition of the Chalcogen Bond

This recommendation proposes a definition for the term "chalcogen bond"; it is recommended the term is used to designate the specific subset of inter- and intramolecular interactions formed by chalcogen atoms wherein the Group 16 element is the electrophilic site.

Comments by 31 May 2019

Corresponding Author: Giuseppe Resnati / giuseppe.resnati@polimi.it

Project Place

Building Broader and Deeper Links Between OPCW and IUPAC

by Richard M. Hartshorn and Jonathan Forman

The Organisation for the Prohibition of Chemical Weapons (OPCW) and the International Union of Pure and Applied Chemistry (IUPAC) have recently signed a Memorandum of Understanding (MoU) wherein they have agreed to cooperate towards achieving their common goals, particularly in promoting chemistry for peaceful purposes and facilitating the exchange of scientific and technical information in support of their work (see <https://iupac.org/iupac-opcw-take-partnership-new-level/>). It was our belief that the cooperation outlined in the MoU between OPCW and IUPAC will be significantly advanced if more people in our organisations know more about how the other one operates and about the institutional frameworks, and detailed priorities, that affect their work. We have therefore initiated a project

with this object in mind (<https://iupac.org/project/2018-022-3-020>). This article outlines the detail of the project, and reports on progress from the first stage.

OPCW is a relatively young organisation (established in 1997) which serves as the implementing body of the Chemical Weapons Convention; an international disarmament and non-proliferation treaty. This treaty is intended to achieve a world that is free of chemical weapons and of the threat of their use; its ultimate aim is the complete elimination of chemical weapons. Through implementation of this treaty, the OPCW contributes to international security and stability, and promotes a world in which cooperation in chemistry for peaceful purposes is fostered for all. OPCW oversees and verifies the destruction of chemical weapon stockpiles; performs inspections of chemical facilities within the territories of the Member States of the treaty to verify compliance; investigates and collects information related to accusations of use of chemical weapon; and facilitates the provision of assistance protection from

Periodic Table of States Parties to the Chemical Weapons Convention

In Honour of the International Year of the Periodic Table of Chemical Elements 2019

In Honour of the International Year of the Periodic Table of Chemical Elements 2019

1 SE
Sweden
17/06/1995

2 NO
Norway
07/04/1994

3 AU
Australia
06/05/1994

4 ES
España
03/08/1994

11 HR
Hrvatska
23/05/1995

12 MC
Monaco
01/06/1995

19 NA
Namibia
24/11/1995

20 IT
Italia
08/12/1995

21 CI
Côte d'Ivoire
18/12/1995

37 ML
Mali
28/04/1997

38 MT
Malta
28/04/1997

39 FJ
Fijini
20/01/1999

55 SV
El Salvador
30/10/1999

56 GE
Georgia
27/11/1999

57 CZ
Čechy
06/03/1999

87 SR
Suriname
28/04/1997

88 CU
Cuba
29/04/1997

89 TR
Türkiye
12/11/1999

119 PA
Panama
07/10/1998

120 UA
Ukraina
14/10/1998

121 ID
Indonesia
12/11/1999

151 AD
Andorra
27/07/2003

152 TL
Timor Leste
07/05/2003

153 TO
Tonga
29/05/2003

183 CG
Congo
04/12/2007

184 GW
Guinea-Bissau
20/05/2008

185 LB
Libanon
20/11/2008

1 H
Hydrogen
1/1/1999

2 He
Helium
1/1/1999

3 Li
Lithium
1/1/1999

4 Be
Beryllium
1/1/1999

5 B
Bor
1/1/1999

6 C
Carbon
1/1/1999

7 N
Nitrogen
1/1/1999

8 O
Oxygen
1/1/1999

9 F
Fluor
1/1/1999

10 Ne
Neon
1/1/1999

11 Na
Natrium
1/1/1999

12 Mg
Magnesium
1/1/1999

13 Al
Aluminium
1/1/1999

14 Si
Silicium
1/1/1999

15 P
Phosphor
1/1/1999

16 S
Sulfur
1/1/1999

17 Cl
Chlor
1/1/1999

18 Ar
Argon
1/1/1999

19 K
Kalium
1/1/1999

20 Ca
Calcium
1/1/1999

21 Sc
Scandium
1/1/1999

22 Ti
Titanium
1/1/1999

23 V
Vanadium
1/1/1999

24 Cr
Chrom
1/1/1999

25 Mn
Mangan
1/1/1999

26 Fe
Eisen
1/1/1999

27 Co
Cobalt
1/1/1999

28 Ni
Nickel
1/1/1999

29 Cu
Kupfer
1/1/1999

30 Zn
Zink
1/1/1999

31 Ga
Gallium
1/1/1999

32 Ge
Germanium
1/1/1999

33 As
Arsen
1/1/1999

34 Se
Selen
1/1/1999

35 Br
Brom
1/1/1999

36 Kr
Krypton
1/1/1999

37 Rb
Rubidium
1/1/1999

38 Sr
Strontium
1/1/1999

39 Y
Yttrium
1/1/1999

40 Zr
Zirkon
1/1/1999

41 Nb
Niobium
1/1/1999

42 Mo
Molybdän
1/1/1999

43 Tc
Technetium
1/1/1999

44 Ru
Ruthenium
1/1/1999

45 Rh
Rhodium
1/1/1999

46 Pd
Palladium
1/1/1999

47 Ag
Silber
1/1/1999

48 Cd
Cadmium
1/1/1999

49 In
Indium
1/1/1999

50 Sn
Zinn
1/1/1999

51 Sb
Antimon
1/1/1999

52 Te
Tellur
1/1/1999

53 I
Jod
1/1/1999

54 Xe
Xenon
1/1/1999

55 Ba
Barium
1/1/1999

56 La
Lanthan
1/1/1999

57 Ce
Cer
1/1/1999

58 Pr
Praseodym
1/1/1999

59 Nd
Neodym
1/1/1999

60 Pm
Promethium
1/1/1999

61 Sm
Samarium
1/1/1999

62 Eu
Europ
1/1/1999

63 Gd
Gadolinium
1/1/1999

64 Tb
Terbium
1/1/1999

65 Dy
Dysprosium
1/1/1999

66 Ho
Holm
1/1/1999

67 Er
Erbium
1/1/1999

68 Tm
Thulium
1/1/1999

69 Yb
Ytterbium
1/1/1999

70 Lu
Lutetium
1/1/1999

71 Hf
Hafnium
1/1/1999

72 Ta
Tantalum
1/1/1999

73 W
Wolfram
1/1/1999

74 Re
Rhenium
1/1/1999

75 Os
Osmium
1/1/1999

76 Ir
Iridium
1/1/1999

77 Pt
Platin
1/1/1999

78 Au
Gold
1/1/1999

79 Hg
Quecksilber
1/1/1999

80 Tl
Thallium
1/1/1999

81 Pb
Blei
1/1/1999

82 Bi
Bismut
1/1/1999

83 Po
Polonium
1/1/1999

84 At
Astatin
1/1/1999

85 Rn
Radon
1/1/1999

86 Fr
Francium
1/1/1999

87 Ra
Radium
1/1/1999

88 Ac
Actinium
1/1/1999

89 Th
Thorium
1/1/1999

90 Pa
Protaktinium
1/1/1999

91 U
Uran
1/1/1999

92 Np
Neptunium
1/1/1999

93 Pu
Plutonium
1/1/1999

94 Am
Americium
1/1/1999

95 Cm
Curium
1/1/1999

96 Bk
Berkelium
1/1/1999

97 Cf
Californium
1/1/1999

98 Es
Einsteinium
1/1/1999

99 Fm
Fermium
1/1/1999

100 Md
Mendelevium
1/1/1999

101 No
Nobelium
1/1/1999

102 Lr
Lawrencium
1/1/1999

103 Rf
Rutherfordium
1/1/1999

104 Db
Dubnium
1/1/1999

105 Sg
Seaborgium
1/1/1999

106 Bh
Bohrium
1/1/1999

107 Hs
Hassium
1/1/1999

108 Mt
Meitnerium
1/1/1999

109 Ds
Darmstadtium
1/1/1999

110 Cn
Copernicium
1/1/1999

111 Nh
Nihonium
1/1/1999

112 Fl
Flerovium
1/1/1999

113 Ts
Tennessium
1/1/1999

114 Og
Oganesson
1/1/1999

Western Europe and Other States (WEOG)

Eastern Europe

Africa

Latin America and the Caribbean (GRULAC)

Asia

Order of Entry into Force

Country Element

Country Symbol

Date of Deposit

LEGEND

OPCW

United Nations

International Year of the Periodic Table of Chemical Elements

1999

2019

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Dr Robert Mathews (University of Melbourne, a former Chair of the OPCW Scientific Advisory Board) highlights the October 2018 OPCW themed issue of *Pure and Applied Chemistry*, for which he was a contributing author, to diplomats at the Fourth Review Conference of the Chemical Weapons Convention in The Hague, The Netherlands on 22 November 2018. Photo courtesy of OPCW.



the effects of chemical weapons at the request of Member States. OPCW also encourages international cooperation in peaceful uses of chemistry, and facilitates a number of programmes to assist scientists in Member States (see www.opcw.org/resources/capacity-building). In order to achieve these goals, OPCW seeks to secure universal membership, and is close to achieving this, as its roster of 193 States Parties leaves only four of the world's internationally recognized States outside of the Chemical Weapons Convention.

IUPAC is a nongovernmental, nonprofit global organisation that provides objective scientific expertise and develops the essential tools for the application and communication of chemical knowledge for the benefit of humankind. IUPAC seeks to foster sustainable development, provide a common language for chemistry, and advocates for the free exchange of scientific information, and values scientific excellence, objectivity, and the highest standards of transparent, responsible, and ethical behavior. Indeed, IUPAC and OPCW have collaborated on such issues long before the MoU was signed, with projects on a code of conduct for chemistry in 2005 (see *Pure Appl. Chem.*, **2006**, 78(11), 2169-2192, DOI: 10.1351/pac200678112169), and the drafting of the Hague Ethical Guidelines in 2015 (see www.opcw.org/hague-ethical-guidelines).

In a recent editorial, Richard M. Hartshorn examined the question of whether IUPAC, a much older organisation (established in 1919), was a large or small organization (*Chem Int*, July 2018, 40(3), pp. 2-3. DOI:10.1515/ci-2018-0301). In terms of formal membership, IUPAC is far smaller than OPCW (IUPAC currently has 55 full country members, so-called National Adhering Organizations), and it has only five paid staff. However, the real strength of IUPAC lies in the large group of expert scientist volunteers (over 2000) who are actively involved in the governance of IUPAC and in running its scientific projects—which also includes volunteers from countries that are not formal members of IUPAC. This contrasts significantly with OPCW,

which has approximately 500 staff, and a governance system which is largely based in the world of diplomats (of whom only relatively few have scientific training). OPCW has an associated scientific community as well; this is manifested through its 25 member Scientific Advisory Board which is comprised of scientists from 25 Member States, and a network of 26 international “Designated Laboratories” located across 19 of OPCW’s Member States that provide chemical analysis support for the work of the OPCW (see *Pure Appl. Chem.*, **2018**, 90(10), 1507-1525. DOI: 10.1515/pac-2018-0902).

The complementary nature of the two organisations offers the prospect of significant and productive collaboration, and this has indeed been underway. There has been significant collaborative work between the two organizations since the founding of the OPCW, this includes the ethical issues previously mentioned; the pursuit of the UN Sustainable Development Goals (see, for example: <https://www.opcw.org/media-centre/news/2018/12/experts-increase-cooperation-green-and-sustainable-chemistry-strengthen>); and, in collaboration with the OPCW Scientific Advisory Board, IUPAC has organized workshops for the Review Conferences of the Chemical Weapons Convention that take place every five years, starting from the first Review Conference in 2003. (See *Chem. Int.* July **2013**, 35(4), pp. 4-8. DOI: 10.1515/ci.2013.35.4.4 and ref therein) The outcomes of these workshops have been published in the IUPAC journal, (*Pure Appl. Chem.*, **2002**, 74(12), 2323-2352; **2008**, 80(1), 175-200; **2013**, 85(4), 851-881; 2018, 90(10), 1501-1506 and 1527-1557). These workshops have provided the basis for reports and recommendations to the Review Conferences from OPCW’s Scientific Advisory Board.

The OPCW Director-General addressed the World Chemistry Congress in 2017, OPCW staff members have participated in IUPAC conferences, and have been appointed to the IUPAC Committee on Chemistry Education (*ex-officio* member) and to send an observer to meetings of the Interdivisional Committee on Green

Project Place

Chemistry for Sustainable Development. The IUPAC President has delivered remarks to the States Parties of the Chemical Weapons Convention at the yearly Conference of States Parties since 2014, and a IUPAC representative has served as a permanent observer and contributor on the OPCW Advisory Board on Education and Outreach since its inception in 2016.

With this background we identified that, while there were connections, and previous collaborative activities between the two organisations, they were very dependent on the cross-memberships and in particular the individuals occupying those positions. This has additional significance in the context of the term-limits that exist in both organisations—OPCW's professional staff have a tenure limit of seven years, OPCW Scientific Advisory Board members serve for up to six years, and many IUPAC committees also have limits on total time served. A key way to mitigate this kind of situation is to ensure that more people have in-depth knowledge of the other organisation and the opportunity to meet and engage with staff in equivalent roles.

In this project we provided the opportunity for a full delegation of IUPAC scientists to attend the Fourth Review Conference of the Chemical Weapons Convention (held in November 2018 in The Hague), and in so doing to find out more about the staff structure of OPCW and the way that it operates. The delegation was made up of representatives from most IUPAC Divisions and Committees, and they had the opportunity to provide an outline of their areas of activity and expertise at a side-event of the Review Conference. The side-event was very well attended by diplomats from across many of the 193 States Parties (including

Qifeng Zhou	President
Richard Hartshorn	Secretary General
Ron Weir	Div I
Jan Reedijk	Div II
Nikolay Nifantiev	Div III
Marloes Peeters	Div IV
Hemda Garelick	Div VI
Vladimir Gubala	Div VII
Ed Constable	Div VIII
Jan Apotheker	CCE
Pietro Tundo	ICGCSD
Anna Makarova	COCI
Leiv Sydnes	ChemRAWN

IUPAC representatives having attended the Fourth Review Conference of the Chemical Weapons Convention and side events in The Hague in November 2018

Ambassadors Member Nations of the OPCW to the Netherlands) and OPCW staff (it was a standing room only event). The presentation, co-organized with OPCW staff can be accessed from the OPCW website or via <https://iupac.org/project/2018-022-3-020>.

As a result of interactions at the OPCW meetings, numerous additional connections have been made between the two organisations. For example, OPCW scientists will make connections with experts from Division VIII (Chemical Nomenclature and Structure Representation) to define and improve the names used for relevant chemicals, and the International Chemical Identifier (InChI) may find use in linking database entries and similar records. Similar issues were identified



IUPAC representatives speak at the Chemical Weapons Convention.
From left to right: Richard Hartshorn, Nikolay Nifantiev, and Ron Weir.





Clockwise from top left: Qifeng Zhou, Jan Reedijk, Hemda Garelick, Jonathan Forman, Pietro Tundo and Marloes Peeters.

in relation to polymers, and polymer science may find applications in sensors and wearable technology. It is clear also that there is potential for collaborations involving the OPCW Verification Division and the IUPAC Div III (Organic and Biomolecular Chemistry) in characterising and identifying metabolites (including bio-adducts) of toxic chemical exposure. This latter work might include involvement of scientists from OPCW Designated Laboratories.

As mentioned above, there are already OPCW-IUPAC links in the area of chemical education. As a result of this visit there was an opportunity for IUPAC volunteers to review and offer advice on a series of short videos that OPCW has prepared as part of a youth outreach project. The series “OPCW UpClose” can be found at: <https://www.opcw.org/opcw-upclose>, and aims to inspire young people with the possibilities of careers with OPCW and in other international organisations—while at the same time providing insights into the work of OPCW.

The second stage of the project will take place at the IUPAC Centenary General Assembly (GA), which will be held in Paris, in July 2019 and where the IUPAC Divisions and Standing Committees meet to review progress and identify new initiatives. OPCW observers will be present at these meetings and this will provide an opportunity to contribute new ideas and develop further collaborative projects. Just as being at the OPCW meetings provided the IUPAC delegation with insights into the structure and operation of OPCW, similar insights into IUPAC activities will be gained by the OPCW delegates attending the IUPAC GA. Furthermore, the GA is co-located with the IUPAC World

Chemistry Congress, and the OPCW delegation will also have the opportunity to engage with and contribute to the scientific programme of the Congress.

OPCW and IYPT2019

In honour of the International Year of the Periodic Table, OPCW has even given their own twist to this iconic symbol of chemistry, as a way to record the order in which the 193 States Parties joined the Chemical Weapons Convention in the “Periodic Table of the States Parties of the Chemical Weapons Convention.” Each “element” represents a State Party with “atomic numbers” that signify the order in which the Convention entered into force in the territories of the State. The dates signify when the signed treaty was deposited with the United Nations by each State. If you are looking for the Democratic people’s republic of Korea, Egypt, Israel or South Sudan, you will not find them in this table as these are the four States that have yet to join the OPCW (Israel has signed the Convention but it has not been ratified, the others have neither signed nor ratified).

Jonathan Forman <jonathan.forman@opcw.org> is Science Policy Adviser and Secretary to the Scientific Advisory Board in the Office of Strategy and Policy of the Organisation for the Prohibition of Chemical Weapons, The Hague, The Netherlands

Richard Hartshorn <rhartshorn@iupac.org> is Secretary General of the International Union of Pure and Applied Chemistry and a Professor of Chemistry in the School of Physical and Chemical Sciences of the University of Canterbury, Christchurch, New Zealand.

For more information, see www.iupac.org/project/2018-022-3-020

Chemical and Biochemical Thermodynamics Reunification

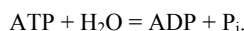
by A. Sabatini, M. Borsari, L.M. Raff, W.R. Cannon, and S. Iotti

Chemical equations are written in terms of specific ionic and elemental species and balance elements and charge, whereas biochemical equations are written in terms of reactants that often consist of species in equilibrium with each other and do not balance elements that are assumed fixed, such as hydrogen and magnesium at constant pH and pMg. When pH and pMg are specified, the conditional equilibrium constant K' for a biochemical reaction is written in terms of sums of species and can be used to calculate a standard Gibbs energy of reaction $\Delta_r G'^0$. A chemical equation, as an example, is:



$$K = \frac{[\text{MgADP}^-][\text{HPO}_4^{2-}][\text{H}^+]}{[\text{MgATP}^{2-}]}$$

whereas the biochemical equation is



$$K' = \frac{[\text{ADP}][\text{P}_i]}{[\text{ATP}]}$$

In the “Recommendations for nomenclature and tables in biochemical thermodynamics” the IUPAC-IUBMB Joint Commission on Biochemical Nomenclature (JCBN) [1] states: “When pH and pMg are specified, a whole new set of transformed thermodynamic properties come into play. These properties are different from the usual Gibbs energy G , enthalpy H , and entropy S and they are referred to as the transformed Gibbs energy G' , transformed enthalpy H' , transformed entropy S' .” As a consequence, two categories of thermodynamics based on different concepts and different formalisms have been established: *i*) chemical thermodynamics that employs conventional thermodynamic quantities to deal with chemical reactions; *ii*) biochemical thermodynamics that employs transformed thermodynamic quantities to deal with biochemical reactions.

In his works, Alberty [2,3] has shown how to obtain the transformed thermodynamic quantities $\Delta_r G'^0$, $\Delta_r H'^0$, and $\Delta_r S'^0$ from $\Delta_r G^0$, $\Delta_r H^0$, and $\Delta_r S^0$, and of the specific chemical species. According to Alberty $\Delta_r G$ and $\Delta_r G'$ provide Gibbs energy of reaction of chemical and biochemical reaction, respectively. In literature numerous



The task group met in Florence, Italy on 23 May 2018; from left: William Cannon, Antonio Sabatini, Marco Borsari, Stefano Iotti, Raff Lionel.

papers treating the thermodynamics of a variety of biochemical reactions assert that the two quantities are not the same. However, it has been shown that $\Delta_r G = \Delta_r G'$ regardless of the reaction involved [4]. This fact has not been sufficiently divulged, and it is still not generally understood by the scientific community. It must be underlined that this equality is restricted to Gibbs energy changes and does not apply to enthalpy or entropy changes.

Moreover, it has been subsequently shown [5] that the “transformed” thermodynamic quantities can be obtained without performing any “transformation” simply balancing a chemical reaction whose reactants and products are the specific species involved in the biochemical reaction.

In a document prepared by the task group including A. Sabatini, M. Borsari, L.M. Raff, W.R. Cannon, and S. Iotti, and available online from the project webpage, the two different methods are analyzed in details. Ultimately, through this IUPAC project 2017-021-2-100, the task group plans to show that the use of these methods allows the two worlds of chemical and biochemical thermodynamics, which so far have been treated separately, can be reunified within the same thermodynamic framework.

References:

1. R. A. Alberty, *Pure Appl. Chem.*, 66, 1641-1666 (1994).
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For more information and comments, contact Task Group Chair, Stefano Iotti <stefano.iotti@unibo.it>.

www.iupac.org/project/2017-021-2-100

International Standard for viscosity at temperatures up to 473 K and pressures below 200 MPa (IUPAC Technical Report)

Josefa Fernandez, Marc J. Assael, Robert M. Enick, and J.P. Martin Trusler
Pure and Applied Chemistry, 2019
Volume 91, Issue 1, pp. 161-172

This paper presents the results of an investigation into possible liquid viscosity standards to meet an industrial requirement for a liquid with a nominal viscosity of 20 mPa s at a temperature of 473 K and pressure of 200 MPa with a relative expanded uncertainty of less than 5 %. There are no commercially available certified viscosity reference liquids that meet this requirement. Four candidate fluids were examined: squalane, Krytox GPL102, tris(2-ethylhexyl) trimellitate (TOTM), and dipentaerythritol hexa(3,5,5-trimethylhexanoate) (DiPEiC₉). Although none of these fluids satisfies all of the criteria, two fluids were identified as being suitable as International Standards for viscosity at temperatures up to 473 K and pressures below 200 MPa. These fluids are squalane and tris(2-ethylhexyl) trimellitate (TOTM), which at $T = 473.15$ K and $p = 200$ MPa present viscosity values of 5 mPa s and 10 mPa s, respectively.

<https://doi.org/10.1515/pac-2018-0202>

IUPAC Distinguished Women in Chemistry: Contributions to Science and Careers*

Pure and Applied Chemistry, Feb 2019 – Special Issue

Through the years, there have been countless contributions of women to chemistry. In this International Year of the Periodic Table, it is important to recognize the contributions that women have made in the field. Historically, most notable are the distinct roles that women have played in the development of the Periodic Table—Marie Curie (discovery of radium (Ra) and polonium (Po)) received two Nobel Prizes for her work on radiation, and became the namesake of curium (Cm); Berta Karlik (astatine (At)); Lise Meitner (isotope of protactinium (Pa), discovered nuclear fission, namesake of meitnerium (Mt); Ida Noddack (rhenium (Re); nominated three times for a Nobel Prize); Marguerite Perey (francium (Fr)).

Here, in this special issue of *Pure and Applied Chemistry*, in celebration of the International Year of the Periodic Table and the 100th anniversary of IUPAC, we recognize a number of the women who received the IUPAC Distinguished Women in Chemistry or Chemical Engineering Award. They have provided short technical reviews for this special issue, or have provided career advice and insight for future scientists and engineering, or have provided examples of how they have navigated the many challenges and opportunities they have encountered in their own careers.

So, how have these women become IUPAC Distinguished Women in Chemistry or Chemical Engineering? To provide context for this special issue, for the International Year of Chemistry in 2011, a project, “Are Women still Underrepresented in Science?” was initiated to celebrate the 100th anniversary of the Nobel Prize in Chemistry awarded to Marie Curie. The project, first sponsored by the American Chemical Society, and initially led by Ingrid Montes and Janet Bryant, included the first international award dedicated to the recognition of distinguished women chemists and chemical engineers across the globe, and acknowledgement and promotion of their work worldwide. 23 women were recognized with the first “IUPAC Distinguished Women in Chemistry or Chemical Engineering,” and the awards were presented at the IUPAC General Assembly and World Chemistry Congress held in San Juan, Puerto Rico, meetings hosted by the Colegio de Químicos de Puerto Rico and under the leadership IUPAC President Nicole J. Moreau (France). Women were recognized for their distinction and excellence in chemistry and chemical engineering, whether in research, leadership, teaching, management, industry, government, academia, or whatever work sector in which the women are engaged. Among the women honored by the first award were Nobel Laureate Ada Yonath and Princess Chulabhorn (Somdet Phrachao Luk Thoe Chaofa Chulabhorn Walailak Agrarajakmurai) of Thailand, who has been a remarkable advocate for chemistry.

The celebration and recognition of women in chemistry that was begun in 2011 continues, and has continued at each biennial IUPAC General Assembly and World Chemistry Congress since then. In addition to an awards program that is held at each meeting to present the awards, a symposium is also held to discuss the status of women in chemistry across the globe. Challenges that women can encounter in their careers and routes to navigate challenges have been addressed by the distinguished awardees. The presentations have been motivational, and have been very helpful to women who are newer in the field, to help them understand



Pictured are a number of the awardees and organizers of the 2011 program, with Susan M. Frontczak, (center, in black) who enacted Marie Curie in a play performed in honor of the International Year of Chemistry.

that everyone faces challenges in their careers, and, that those challenges are not unsurmountable.

To date, four groups of scientists have now been recognized with the IUPAC Distinguished Women in Chemistry or Chemical Engineering Award. On 2 August 2011, in San Juan, Puerto Rico, 23 women were recognized with the very first IUPAC Distinguished Women in Chemistry or Chemical Engineering Award. The awardees were:

- Nouria A. Al-Awadi (Kuwait)
- Faizah Mohammed Abdel Mohsin Al-Kharafi (Kuwait)
- Ayse Aroguz (Turkey)
- Vanderlan Bolzani (Brazil)
- Novella Bridges (USA)
- Luisa De Cola (Germany)
- Joanna Fowler (USA)
- Véronique Gouverneur (UK)
- Magdolna Hargittai (Hungary)
- Nancy B. Jackson (USA)
- Susan M. Kauzlarich (USA)
- Katharina Kohse-Höinghaus (Germany)
- H.R.H. Princess Chulabhorn Mahidol (Thailand)
- Nicole J. Moreau (France)
- Linda F. Nazar (Canada)
- Izabela Nowak (Poland)
- Carolyn Ribes (Netherlands)
- Sara Snogerup Linse (Sweden)
- Yoshie Souma (Japan)
- Natalia Tarasova (Russia)
- Klára Tóth (Hungary)
- Lesley J. Yellowlees (UK)
- Ada E. Yonath (Israel)

More details about the 2011 recognition program are provided at the following websites: http://iupac.org/publications/ci/2011/3306/5_montes.html, www.chemistry2011.org/participate/activities/show?id=1156 or <http://imageevent.com>

[/pnwalumnaeconnection/wccalbums/iupacworldchemistrycongress2011](http://pnwalumnaeconnection/wccalbums/iupacworldchemistrycongress2011)

In 2013, the awards program was held at the 47th IUPAC General Assembly and 44th World Chemistry Congress; meetings that occurred under the leadership of IUPAC President Kazuyuki Tatsumi (Japan) and the organization of the Turkish Chemical Society. The awards program was held in a garden ceremony at the Istanbul Lutfi Kirdar Convention and Exhibition Center. The continuation of the recognition program beyond the International Year of Chemistry was supported by both IUPAC (<https://iupac.org/project/2013-002-2-022>) and ICSU (renamed in 2018 as ISC, the International Science Council).

The 2013 honorees were:

- Irina P. Beletskaya (Russia)
- Annette Doherty (UK)
- Mary Garson (Australia)
- Evamarie Hey-Hawkins (Germany)
- Kazue Kurihara (Japan)
- Liliana Mammino (South Africa)
- Elsa Reichmanis (USA)
- Concepcio Rovira (Spain)
- Maria Vallet-Regi (Spain)
- Angela Wilson (USA)
- Yi Xie (China)

A symposium was held where the awardees described their careers, support, and challenges they encountered, and shared advice and recommendation for younger scientists. An additional discussion was held about the status of women in chemistry across the globe.

For the 2015 IUPAC project, <https://iupac.org/project/2015-007-1-020>, and recognition program, the award ceremony took place during the IUPAC 48th General Assembly and 45th World Chemistry Congress at the Busan Exhibition and Conference Center

(Bexco) in Busan, Korea, which was hosted by the Korean Chemical Society under the leadership of IUPAC President Mark Cesa (USA).

The awardees of the IUPAC 2015 Distinguished Women in Chemistry or Chemical Engineering recognition are as follows:

- Lucia Banci (Italy)
- Margaret Brimble (New Zealand)
- Ewa Bulska (Poland)
- Karen Gleason (USA)
- Janet Hering (Switzerland)
- Nadia G. Kandile (Egypt)
- Maki Kawai (Japan)
- Hyunjoo Lee (South Korea)
- Carmen Najera (Spain)
- Helga Rübsamen-Schaeff (Germany)
- Roberta Sessoli (Italy)
- Livia Simon Sarkadi (Hungary)

The ceremony coincided with a symposium entitled “Women in Chemistry: Gaining Momentum” and a reception, which were both held in honor of the recipients. At the symposium, award recipients shared their stories, describing their personal career highlights, and provided their insight about how women can best achieve success in chemistry.

The fourth recognition of women chemists and chemical engineers took place during the opening ceremony of the 46th IUPAC World Chemistry Congress, held at the WTC Center in São Paulo, Brazil and hosted by the Brazilian Chemical Society under the leadership of IUPAC President Natalia Tarasova (Russia). A symposium was held, and the awardees participated in a panel discussion about their career pathways, challenges they encountered, and advice to younger chemists.

The 2017 awardees were:

- Misako Aida (Japan)
- Lifeng Chi (China)
- M. Concepción Gimeno (Spain)
- Jaqueline Kiplinger (USA)
- Zafra Lerman (USA)
- Thisbe K. Lindhorst (Germany)
- Ekaterina Lokteva (Russia)
- Yvonne Mascarenhas (Brazil)
- Veronika Ruth Meyer (Switzerland)
- Ingrid Montes-González (Puerto Rico)
- Frances Separovic (Australia)
- Jihon Yu (China)

The program will continue to recognize outstanding women, and we look forward to recognizing them and including them among this distinguished group of women scientists.

We hope that you enjoy the manuscripts in this special issue as much as we have and find them insightful.

And, finally, we recognize several individuals. The initial and ongoing support of this IUPAC awards program would not have been possible without the support of the IUPAC Presidents through the years. We recognize the following former and current IUPAC Presidents: Nicole Moreau, Kazuyuki Tatsumi, Mark Cesa, Natalia Tarasova, and Qi-Feng Zhou. And, for this special issue, we especially thank Hugh Burrows, Editor of *Pure and Applied Chemistry*, not only for his willingness to enable this special issue, but also the significant work that he has put into this issue. This issue would not have been possible without him.

Fabienne Meyers
Carolyn Ribes
Angela K. Wilson

*Preface of the February 2019 Special issue, reproduced from *Pure and Applied Chemistry* 2019, 91(2), pp. 175-180, <https://doi.org/10.1515/pac-2019-2920>

Read about the Awardees of the IUPAC 2019 Distinguished Women In Chemistry or Chemical Engineering - page 28 and plan to meet them at the IUPAC World Chemistry Congress in Paris, where an award ceremony and a special symposium are being organized. See www.iupac2019.org for details.

Erratum

In the article entitled “Standard reporting of Electrical Energy per Order (E_{EO}) for UV/H₂O₂ reactors (IUPAC Technical Report),” *Chem Int.* **2018**(4) pp 35, the chemical structure for sucralose is incorrect. It was written C₁₂H₁₉C₁₃O₈. The correct formula is C₁₂H₁₉Cl₃O₈.

Conference Call

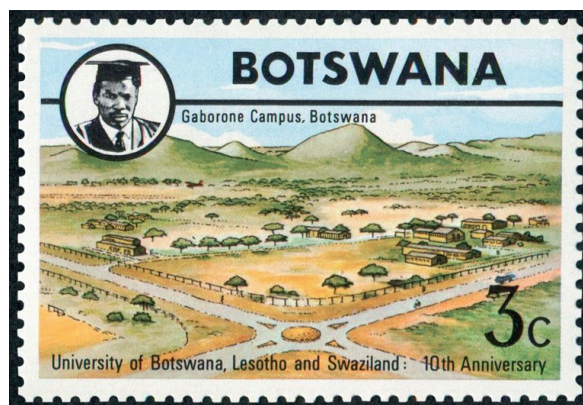
Bringing IUPAC to Southern Africa Division II promotes IUPAC in Africa by meeting in Botswana and co-sponsoring the 2nd Symposium on Organic and Inorganic Chemistry, Southern Africa.

by Lars Öhrström and Ishmael Masesane

Scientists seldom meet outside the high-income countries without an explicit purpose to promote development or solve problems in low- and middle-income countries. While such meetings may serve a good purpose, the very format and objective do not create a platform where all scientists can connect and discuss as equals. Moreover, this geographical restraint of the regular conference circuit also means that low- and middle-income countries to a large extent, and especially in Africa, often miss out on this both formal and informal scientific exchange of ideas and information.

Decisions on where to hold conferences and symposia are largely up to individual groups of researchers and seldom guided by any overall policy aimed at a geographical diversity. This is therefore an arena where individuals, or groups of individuals, can make a difference and promote a truly global scientific culture [1].

IUPAC's technical divisions meet every second year under the larger IUPAC umbrella of the General



*This stamp was issued in 1974 for the 10th anniversary of the University of Botswana, Lesotho and Swaziland.
(Thanks to Daniel Rabinovich)*

Assembly during the World Chemical Congress, and in the intervening year an “off-year” meeting is organized by the divisions themselves. The Inorganic Chemistry Division had for some years discussed whether it would be feasible to hold one of these “off-year” meetings somewhere in Africa, and the right conditions materialized in 2018.

Hosted by the University of Botswana (UB) in the capital Gaborone, the Division first assembled for an informal evening meeting with the Head of the Chemistry Department, Prof Ishmael Masesane, followed by the regular off-year meeting from 2-3 October, including a visit to the chemistry department facilities, and lunch with faculty members.

As the division meeting was concluding, with some matters postponed to a break-out session with participation from potential new IUPAC-membership countries Botswana, Namibia and Zimbabwe, the speakers of the following days upcoming symposium started to arrive. Consequently, an informal get-together session with the speakers and the local organizing committee was held in the evening and the guests were welcomed by the conference co-chairs Ishmael Masesane and Lars Öhrström.

Then, early morning the next day (because that is how to organize things in a semi-arid hot climate) the 2nd Symposium on Organic and Inorganic Chemistry, Southern Africa was inaugurated in the new conference center just beside University of Botswana's main campus in the center of Gaborone. The importance with which the local UB community regarded this event was emphasized in the inaugural speech delivered by the acting Deputy Vice Chancellor of Academic Affairs Dr. Oathokwa Nkomazana. She had to step in at the very last minute for the Vice Chancellor, but

2nd Symposium on Organic and Inorganic Chemistry, Southern Africa

Organizing bodies: University of Botswana, IUPAC Division II, Swedish Research Links – Swedish Science Council via a network grant.

Additional sponsoring organizations: University of California –Berkeley, USA, through the Berkeley Global Science Institute; Chalmers University of Technology through the Area of Advance Energy; IUPAC through the Financial Support for Conferences in Scientifically Emerging Regions; University of Helsinki

Nations present (by residence and origin): Botswana, South Africa, Zimbabwe, Namibia, Nigeria, Cameroon, Kenya, Ghana, Sweden, Finland, Spain, Italy, Germany, Slovakia, USA, Peru, Jordan, Singapore.

Attendance: Around 60

Venue: University of Botswana Conference Center in Gaborone, the capital of Botswana. With about 500 000 inhabitants it is the country's largest city with around 20 % of the total population.

www.chalmers.se/en/conference/Organic_Inorganic_Chemistry/Pages/default.aspx



nevertheless delivered an inspiring talk about IUPAC and our goals and ambitions; even more impressive as Dr. Nkomazana's comes from the UB School of Medicine.

Other memorable talks of the morning's open session were Prof. Omar Yaghi's (Univ. California – Berkeley, USA) on "An Obsession with Science Discovery" and the "Philatelic Tour of Chemistry in Africa" from Div. II project manager Prof. Daniel Rabinovich (Univ. North Carolina, Charlotte, USA). Daniel impressed the audience when he showed a stamp featuring the first buildings on the UB Gaborone campus from the mid 1960s [2].

The announcement of the Periodic Table of Young Chemist awards for Mo, W, Te, and Sr was another point that briefly put Botswana in the limelight of the world-wide chemical community. It was presided by IUPAC Executive Committee member Prof. Javier Martínez and Chemical Society of Botswana president Dr Florence Nareetsile. This short event was broadcast live on IUPAC's Facebook page [3].

But the real highlight were the brilliant talks given by the young emerging scholars from southern Africa, among them Dr Banothile Makhubela (Univ. of Johannesburg, South Africa) and Dr Gift Mehlana (Midlands State Univ., Gweru, Zimbabwe. 2017 Green Chemistry for Life IUPAC/UNESCO/PhosAgro grantee). Also, the poster session had several high-quality contributions.

A break-out session of the division meeting was also held in the evening of the first symposium day with invited observers from Namibia, Botswana and Zimbabwe. The division had postponed items dealing with reports from the various IUPAC organizations, and



Top: Attendants off the 2nd Symposium on Organic and Inorganic Chemistry, Southern Africa in Gaborone, 4-5 October 2018. First row 2nd from left is Chemical Society of Botswana president Dr Florence Nareetsile and in the centre we find conference co-chair professor Prof Ishmael Masesane. Directly above: Break-out session from the Div II off-year meeting. Standing, from the left: Daniel Rabinovich, Olayinka Oyetunji (Botswana), Gift Mehlana (Zimbabwe), Lars Öhrström, Javier García Martínez (Spain), Milan Drábik (Slovakia), and Veikko Uahengo (Namibia). Sitting, Lidia Armelao (Italy), Thomas Walczyk (Switzerland), Markku Leskelä (Finland), and Florence Nareetsile (Botswana)

the general project discussion and presentation. This gave the observers a good insight into IUPAC activities and the potential benefits of membership.

The meeting also gave a rare opportunity for chemistry BSc and MSc students from an African country to meet and talk to world leading scholars in the discipline. Networking was of course extensive also among students, and we are likely to see new collaborations emerging from this meeting. Interestingly, feedback received by the organiser indicate that intra-African

networking was also important, as it's not guaranteed that chemists in neighbouring countries actually have many opportunities to meet.

For the local chemists, the symposium offered an opportunity to hone their skills of how to organize and run an international chemistry event. The symposium was particularly beneficiary to the graduate students of the University of Botswana who acted as ushers and interacted with renowned chemists from all over the world. Their attendance of the symposium helped them to appreciate the role that chemistry research plays in everyday necessities such as water availability, healthcare, and food. Together with participants from other countries in Africa, local chemists were left with a better understanding of IUPAC and its activities.

With ambitions to work more with Africa and have more African NAOs, this was a unique chance for IUPAC people at different levels to see and experience Africa, and African science, with both its challenges and opportunities.

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1. Lars Öhrström, Peter Weiderud, Morsy Abu Youssef, and Omar M. Yaghi, "Global Engagement in Science: The University's Fourth Mission?" *Science & Diplomacy*, Vol. 7, No. 2 (June 2018). <http://www.sciencediplomacy.org/perspective/2018/global-engagement-in-science-universitys-fourth-mission>
2. The University of Botswana, popularly known as UB, was established in 1982 as the first higher education institution in the country. The Gaborone campus, however is older as it was one of the sites of the university system known as UBBS, or the University of Bechuanaland (Botswana), Basotoland (Lesotho), and Swaziland; which was founded, pre-independence, in 1964.
3. Available also on LinkedIn: <https://www.linkedin.com/feed/update/urn:li:activity:6454604653307916288>

Chemistry in Peru

by Olga R. Lock Sing

CIbQ Organizing Board – President

Under the sponsorship of the Peruvian Chemical Society (SQP), two conferences took place in Lima-Peru, between 16 and 19 October 2018. These conferences were the **IV Iberoamerican Congress** and the **XXIX Peruvian Congress of Chemistry**. This joint event is referred as ClbQ (from its acronym in Spanish). The ClbQ was organized to coincide with the 85th anniversary of SQP's foundation. Details of the ClbQ event were publicized through its web page www.spperu.org.pe/congreso-2018/.

www.spperu.org.pe/congreso-2018/.

The event was sponsored by universities like PUCP, UNMSM, UNI, UN Agraria La Molina, UNAP, UNSAAC, and, UTEC; professional associations like CIP, CQP, CPQF; associations and institutes like CONCYTEC, FLAQ, IPPN, IUPAC, ACS, ANC; and, the direct sponsorship of CONCYTEC/FONDECYT, Hersil Laboratories, HACSA, CLARIANT, among others.

Attendance included about 400 participants: industrial chemists, researchers, academics, as well as graduate and undergraduate students from the country and abroad. A total of 220 summaries were submitted for publication.

IUPAC participated by providing six grants for Young Scientists, and the American Chemical Society provided awards to three investigations submitted to the Ernest E. Eliel Award, as well as covering the registration of 10 undergraduate and graduate Chemistry students. All guidelines, submissions, and results have been publicized in the ClbQ web page.

The ClbQ was organized in different types of forums, including presentations in different Chemistry areas (aka Academic Sessions), Symposiums, Round Tables, and Courses.

Areas covered in the Academic Sections included Education, History, and Philosophy of the Chemistry Science; Chemistry as a Basic Science (Analytical, Inorganic, Organic, Physical Chemistry, Theoretical, and Computational Chemistry); Chemistry towards Life Sciences (Medicinal, Food and Functional Foods, Biochemistry, Toxicology); Environmental and Green Chemistry; Materials Chemistry; Natural Products Chemistry; and Chemical Engineering.

Participants offering presentations in these areas included 25 professionals from South American countries like Brazil, Bolivia, Chile, Mexico, Uruguay, as well as participants from the United States, Spain, France, and Switzerland. Peru was represented by 20 researchers and academics. Also, other professionals from the industry and academia were invited to present in the four Symposiums (28), four Round Tables (16), and three Courses (11).

The Symposiums addressed current topics like; Biodiversity: It's Study and Sustainable Use; The Teaching of Chemistry: Vision, Delivery, and Accomplishments; Environmental and Green Chemistry; and Applications of Nanomaterials.

The Round Tables were aimed at providing a view of the state of the art of different industries in the country, including: Technological Advances in Mining, Hydrocarbons, and Energy in Peru; Innovations in the Industries of Textile, Cosmetic, Paints, and Adhesives;

Conference Call

the Chemistry in the Peruvian Gastronomy; and Marine Biotoxins. The conclusions from two of these round table are reported below.

The Courses offered target training in topics like: Research of Medicinal Plants and Applications as Phytotherapics; Selected Topics in Theoretical and Computational Chemistry; Analytical Techniques in Infrared with Fourier Transform; Electronic Microscopy; Liquid Chromatography coupled to Mass-Mass; Nuclear Magnetic Resonance; and others.

A technology exhibit was also held as part of the ClbQ. Known as QUIMITEC 2018, the exhibit included companies who displayed advanced in equipment used in Chemistry research and development. Amongst these companies were Sulabsa, Oz Group, Techological Group of Peru, Andean Scientific SAC, Peruvian Electromedic SA, Osmo Service, Elicrom, Pesacon, and Quantum International Design.

Another activity held during the Congress was the “**Chemistry and Me**” contest, an event that called participants to reflect their notion, knowledge, or feelings on the essence of chemistry through drawings (kids category) or an up-to-150-word narrative (junior/senior categories). The winners were chosen by a committee formed by a chemist, an artist, and a linguist as a down-selection process, and eventually chosen by public voting through the Congress web-page.

Lastly, a special mention should be made to the Organizing Board, which worked tirelessly for over 15

months to make this event possible. This congress was made an official event in the country by the Peruvian Ministry of Industry, per resolution No. 251.2018-PRO-DUCE dated 8 Jun 2018 and published in the ministry's web page and the Diario El Peruano.

Round Table Conclusions

Innovations in the textile, cosmetics, adhesives, and painting industries

In the textile industry, the discussion was focused on the use of enzymes with the purpose of minimizing the use of water and energy in the dyeing process. Enzymes are proteins that catalyze biochemical reactions in a selective manner, which can improve efficiency of the chemical reaction in the textile processes and reduce water/energy consumption. The net result could be a reduction of contaminants in the effluents from the industry, as well as an improvement in textile finishing.

In the cosmetic industry, innovation is driven in the areas of production, by selection of proper raw materials to create new products, and training of personnel. The expectation is optimized production efficiency and cosmetic products that meet customers expected functionality.

In the adhesives industry, the effort is placed on ecological products with water-based and thermo-plastic adhesives.

In painting, innovation is also driven by reducing

The Peruvian Chemical Society at 85 years

The Peruvian Chemical Society (SQP) is a non-profit scientific institution whose main objective is to promote the chemistry sciences in the country. It was founded on 7 Oct 1933. Its membership includes professionals from a wide range of disciplines related to the Chemistry sciences, like chemists, chemical engineers, pharmacists, biochemists, biologists, environmental chemists, material sciences, computational and theoretical chemists, and others.

The SQP has been very active in the promotion of Chemistry, serving as an effective link and networking venue within its members. A quarterly publication serves as the official communication forum, where scientific articles and general news are broadly shared. This news magazine, known as the Peruvian Chemical Society Magazine, started its publications in July 1934. As such, it is the oldest scientific magazine in the country, and has worldwide reach as it is indexed in the Chemical Abstracts, Scielo, Latindex, and licensed to EBSCO.

Another means to fulfill the SQP's objective has been through its sponsoring role of numerous Chemistry events. In the 85 years of existence, the SQP has organized and sponsored several congresses and conferences, including 3 Ibero American, 4 Latin American, and 28 national. The SQP has also sponsored Symposiums, Scientific Conferences, as well as Courses in Chemistry Education, Environmental Chemistry, Nanotechnology, Phytochemistry, and other related areas.

In the 85 years of existence, 43 Board of Directors have governed the institute. Their dedication, professionalism, commitment, and passion have been an important factor to the success of the organization and the many contributions to the service of the country. It's through their leadership that the organization grew strong and made possible meeting its goals of promoting Chemistry across the country. The solid contributions made by the SQP has made it gain recognition and respect from the Peruvian scientific communities.

Conference Call

Colorful fabrics are ubiquitous in Peru. A round table discussion considered how traditional dyeing techniques could be improved to reduce water/energy consumption.



environmental impact, which include designing more eco-friendly products and reducing use of solvents in production. In addition, another area of innovation focus is the use of nanotechnology to develop paintings with special properties (e.g. magnetic paintings).

Technological Advances in Mining, Hydrocarbons, and Energy in Peru

The importance for the continued promotion of mining was recognized, not only as an important revenue generating source, but also as a way to foster development in the country. To that effect, it is necessary to first address corruption, informality, and the tendency towards centralism. It is possible to deploy an environmentally sensitive operation that considers a rational use of water and the use of appropriate remediation technologies, improving the quality of life for inhabitants living nearby mining operations. Technical development should take ownership of the challenges to solve problems arising from these activities.

Regarding new sources of energy, the benefits of lithium were highlighted as a way to store energy, which can lead to multiple applications. Lithium is a natural resource that will increase the value of the current mining industry. Its increasing price in the market makes this a potentially important revenue source for the inhabitants of Puno, as well as generating jobs in the area. A specific application of interest is electric vehicles, which contribute to the reduction of carbon dioxide release and mitigate its impact on global warming.

On hydrocarbons, discussions were centered around new technologies under development to obtain these raw materials with less environmental impact. The current emphasis is in reducing costs of extraction and production of hydrocarbons. One of these technologies being taken advantage of is the use of catalyzers in production processes. An important technical advancement is hydrocarbon volume reduction,

which significantly reduces costs of transportation.

Finally, regarding renewable technologies, the importance of researching options for cost effective alternatives was a point of discussion. There are several options for investigation in the energy segment. As an example, the use of electric transportation, which would translate in a significant reduction environment impact. An important field of investigation is the conversion of waste into energy, a topic that should drive attention and interest from different regions within the country. It is clear there is a need for a joint collaboration in this area from within Peruvian society, including the industry, academia, and the national government.

Emerging Polymer Technologies

by Tu Le, San H. Thang, and Graeme Moad

The **3rd Emerging Polymer Technologies Summit** combined with the **Emerging Material Technologies Summit 2018 (EPTS/EMTS'18)** was held on 4-8 November 2018 at Hanoi University of Science, Vietnam National University,



Dai-Phat Bui	Ho Chi Minh City University of Science	Vietnam
Ngoc-Chinh Le	Ho Chi Minh City University of Science	Vietnam
JaeYoung Cho	Kumoh National Institute of Technology	Korea
Nguyet-Linh Ho	Kumoh National Institute of Technology	Korea
Dieu Minh Ngo	Kumoh National Institute of Technology	Korea
Hong Zhang	National University of Singapore	Singapore
Ziming Chen	South China University of Technology	China
Manohar Prasad Bhandari	Tribhuvan University	Nepal
Nor Shafiqah Mohd Nasir	Universiti Malaysia Pahang	Malaysia
Lau Ngie Jun	Universiti Malaysia Pahang	Malaysia
Hairunnisa binti Ramli	Universiti Teknologi MARA	Malaysia
Suhaila Idayu Abdul Halim	Universiti Teknologi MARA	Malaysia
Huan Doan	University of Bristol	UK
Martin Seifrid	University of California, Santa Barbara	USA
Nhung Duong	University of Oklahoma	USA
Anh-Linh Hoang	University of Technology Sydney	Australia
Sergio Céspedes Gomez	University of Warwick	UK
Ba Tran-Van	Vietnamese German University	Vietnam
Kieu-Anh Doan	Vietnamese German University	Vietnam
Minh-Vu Chau	Vietnamese-German University	Vietnam

EPTS/EMTS'18 had five distinguished plenary speakers, including Clare Grey (University of Cambridge, UK), Kevin Plaxco (University of California, Santa Barbara, USA), Takao Someya (University of Tokyo, Japan), George Malliaras (University of Cambridge, UK) and Sarah Tolbert (University of California, Los Angeles, USA). In addition, the Summit included many eminent invited speakers, as well as a raft of young and early career scientists' contributions. All these formed the integral part of the EPTS/EMTS'18 scientific program. A total of 197 attendees from 23

Hanoi, Vietnam. The meeting chairs were Thuc-Quyen Nguyen (University of California Santa Barbara), San Thang (Monash University, Australia) and Graeme Moad (CSIRO Manufacturing). The meeting was devoted to the scientific and technological aspects of material sciences. It aimed to give participants a warm and friendly environment to exchange ideas, discover novel opportunities, re-acquaint with colleagues, meet new friends, and showcase their latest exciting innovations in material science, engineering and technology, including applications in the areas of health, personal care, and advanced materials for energy generation and storage. Additional details on the meeting can be accessed through the conference website www.emts18.org/epts18.html.

countries participated at the Summit. 20 talented students were awarded the travel bursaries sponsored by IUPAC. The list of these students is provided above.

As part of Summit, a public lecture series and a workshop on "Materials, Modeling, and Simulations" were organised on 3 November 2018. Lectures were delivered by Thuc-Quyen Nguyen, San Thang, James Warren (National Institute of Standards and Technology, USA), Alexe Bojovschi (IND Technology, Australia), Tu Le (RMIT University, Australia) and Cuong Nguyen-Tien (Vietnam National University, Hanoi, Vietnam).

The Summit was endorsed by IUPAC, sponsored by *ACS Journal of Applied Nano Materials*, *Materials Horizon* and the *Journals of Materials Chemistry A, B and C*.



Conference Call

Following the success of the meeting it is hoped to take the conference to other venues in South East Asia in future years.

Tu Le, is from RMIT University, Melbourne, Australia, San H. Thang is from Monash University, Clayton, Australia, and Graeme Moad, is from CSIRO Manufacturing, Clayton, Australia

MACRO 2018

by Melissa Chan Chin Han and Chris Fellows

The World Polymer Congress, MACRO 2018, latest in the series of biannual conferences that are the most important meeting of the global polymer community, was held in Cairns, Australia from 1-5 July 2018. Over 800 attendees from 44 countries participated in this extravaganza of polymer science, which featured a stellar array of plenary speakers: Prof. Steven Armes (Sheffield), Prof. Zhenan Bao (Stanford), Prof. Michelle



Coote (Australian National University), Prof. Paula Hammond (Massachusetts Institute of Technology), Prof. Ian Manners (Bristol), Prof Christopher Ober (Cornell), and Prof Ben Zhong Tang (Hong Kong University of Science and Technology). Cairns put on unseasonably cold weather for the occasion, with anecdotal

IUPAC on the Trade Floor

"IUPAC Polymer Division – Collaborate and Educate Grab your chance to have unique insight into IUPAC Polymer Division!"

The short description above was our aim for having an IUPAC trade booth at MACRO2018 for the conference participants and as the *"Treffpunkt"* (meeting point) for Polymer Division members and friends. Almost all division members volunteered to man the booth at different times. We had Prof. Qifeng Zhou, President of IUPAC, offering his assistance on setting up the booth. A session "Meet the President and Vice President of IUPAC Polymer Division" (Greg Russell and Christine Luscombe) was well received, as they invited visitors to the booth to: *"Know who we are, what we do, how we do it, and what the future might hold."* During the "Meet the Course Instructor" sessions, participants in the Educational Workshop were able to have further discussions with the three instructors. Roger Hiorns (Chair of the Subcommittee of Polymer Terminology) happily shared the publications of his subcommittee, especially the popular "A Brief Guide to Polymer Nomenclature." Chris Fellows and Patrick Théato (Chair and Secretary of the Subcommittee of Polymer Education) recruited academics from around the world to join the projects of their subcommittee. We had Doo Sung Lee (Korea) and Lena Horne (Canada), organisers of MACRO2020 and 2022, respectively, promote these upcoming MACRO conferences. And we were sure to



promote IUPAC2019 in Paris as well!

While the IUPAC secretariat does not typically have booth materials nor the resources to support a trade booth, the support of the MACRO2018 organising committee made the IUPAC trade booth experiment possible. With encouragement from Greg Russell, strong support from Fabienne Meyers, Lynn Soby and De Gruyter publishing house, self-initiative in providing their own exhibition materials from the members of the Polymer Division, we had a wealth of material to offer to our many visitors. In summary, we had a successful experiment, with a dynamic and interactive IUPAC booth in Cairns.

Conference Call

evidence from locals that it was the coldest winter since 1937; the 25 °C days were a welcome relief for delegates escaping the Northern Hemisphere summer.

MACRO 2018 had 165 invited speakers, nearly 200 poster presentations, and almost 500 oral presentations given over four days in sixteen symposia that reflected Australia's historic strength in Polymer Chemistry. World-renowned master of ATRP (atom transfer radical polymerisation) Prof. Krysztof Matyjaszewski spoke in the "Recent Developments in Polymer Design" symposia along with 21 other high-profile invited speakers. An excellent symposium on "Kinetics of Polymerization" surpassed any meeting on that theme that the authors have attended in the last twenty years. There were also excellent symposia on "Polymers in Biotechnology, Medicine, and Health," "Polymers and Nanotechnology," "Energy, Optics and Optoelectronics," "Smart and Functional Polymers," and "Renewable Resources and Biopolymers."

Polymer science has traditionally straddled chemistry, physics, and engineering; and non-chemical aspects of polymer science were well represented with symposia on "Polymer Engineering and Modelling," with speakers including Prof. Anna Balazs who is renowned for her biomimetic mechanical polymer structures, "Polymer Characterization and Polymer Physics" and "Porous Polymers." A symposium on "Polymer Education" brought together teaching innovations from every inhabited continent, while the "Industry and Innovation" symposium highlighted innovative practices for the future and reminded us of the rich history of the polymer industry. Last but not least, three sessions were devoted to the strong and growing bilateral links between Australian polymer science and polymer science in other nations: an Australian-Korean



At top: Christine Luscombe (left), Vice President of the IUPAC Polymer Division acknowledging the work of the local organizers, here represented by Martina Stenzel, co-chair of MACRO 2018 program committee. Above: Christopher Ober, recipient of the 2nd Bob Stepto Award.



symposium, Australian-German symposium, and a session organised by the Royal Society of Chemistry.

Awards presented at the conference included the 2018 Hanwha-Total-IUPAC Young Scientists Award, awarded to Prof. Andreas Walther (Albert-Ludwigs-Universität Freiburg) for his work defining the emerging new field of "Adaptive, Active and Autonomous Bioinspired Material Systems." The 2016 Hanwha-Total-IUPAC award was also presented formally at Cairns to Prof. Brent Sumerlin (University of Florida); the presentation of this award having been disrupted by the Turkish coup attempt of 2016. The 2018 Polymer International Award was presented to Prof. Richard Hoogenboom (Ghent), while the similarly affected 2016 Polymer International Award went to Prof. Cyrille

Conference Call

Boyer (University of New South Wales) and the 2016 DSM Materials Award to Prof. Steven Armes.

From a very competitive field of excellent work, IUPAC poster prizes were awarded to Eeseul Chin (Ulsan National Institute of Science and Technology), Chloe Cho (Auckland), Tobias Johann (Mainz) and Tuan Nguyen (University of Queensland).

The conference closed with the presentation of the 2nd Bob Stepto award to Prof Christopher Ober: this

IUPAC award recognises a polymer scientist who is not only a true world leader in their research field, but—in the spirit of Prof Stepto, a tireless contributor to IUPAC activities—should also have made an indelible contribution to the polymer science community beyond the research domain.

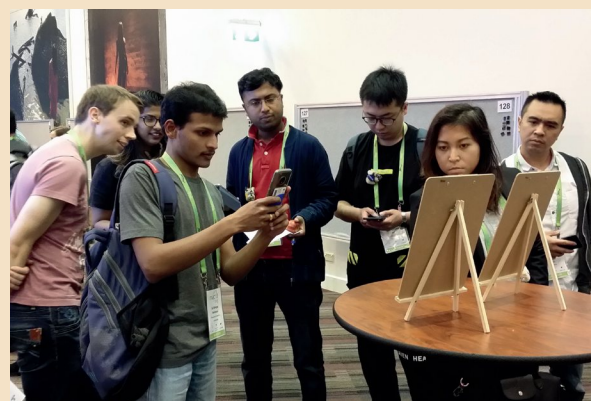
Special acknowledgement to Volker Abetz, Andrij Pich, Peter Halley, Roger Hiorns, and Greg Russell for their contributions to the preparation of this report.

Educational Workshop in Polymer Sciences

Themed *Polymer Processing*, this interactive educational workshop was structured for roughly 200 post-graduates or researchers from all countries to update their knowledge through interactive lectures. It was the third in a projected series of four workshops, respectively covering synthesis, characterisation, processing, and applications of polymers—the final one of the series is planned for MACRO2020 on Jeju island, Korea.

All three lectures in the workshop covered the understanding of the basic science, terms and concepts that are critical to polymer processing from the laboratory scale to the pilot scale and beyond. Thought-provoking insights into experimental design, process optimization and counter-intuitive research results were presented. The lecturers were:

- **Prof. Volker Abetz**, University of Hamburg and Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research, Germany
- **Prof. Andrij Pich**, RWTH Aachen University, Germany



- **Prof. Peter Halley**, University of Queensland, Australia

Before the workshop, the instructors shared their power point slides on the IUPAC and conference websites accessible to the general public—see the link below! After the workshop, “Meet the Course Instructor” sessions for further discussion at the IUPAC trade booth were well received by the workshop participants.

This activity is part of IUPAC 2017-029-2-400. For detailed program and lecture notes, see <https://iupac.org/project/2017-029-2-400>

Where 2B & Y

Macrocyclic and Supramolecular Chemistry

2-6 June 2019, Lecce, Italy

The **14th International Symposium on Macrocyclic and Supramolecular Chemistry** (ISMSC2019, <https://ismsc2019.eu/>) will be held in Lecce, Italy, from 2-6 June 2019 with the endorsement and support of IUPAC. Lecce, a Baroque Florence in Southern Italy and capital of the charming peninsula called Salento, is nowadays among the most popular touristic destinations in Italy.

ISMSC2019 will provide a forum to discuss all aspects of macrocyclic and supramolecular chemistry, and also topics on materials and nanoscience, following the spirit and style of the thirteen preceding conferences. Within this conference framework, a IUPAC supported Symposium entitled “**New Directions in Supramolecular Chemistry: Nanomedicine**” will also be organized to show how Supramolecular Chemistry has recently been exploited for pioneering new directions in bio-engineering and nanomedicine. Overall, this symposium will be a unique opportunity for researchers’ brainstorming and promoting



cross-disciplinary collaborations that will certainly have an impact on their research and related fields of applications (biomedical engineering, food science, energy storage, biosens-

ing, etc.). It will also offer networking opportunities among peers, recognized leaders in the field, young scientists, and students. The program will include lectures from the 2016 Nobel Laureates in Chemistry, the 2019 Izatt-Christensen Award, Cram-Lehn-Pedersen Prize, and Sessler Early Career Researcher Prize winners. ISMSC2019 will also host the Natural Product Reports Emerging Investigator Lectureship. Several keynote and invited oral lectures from distinguished researchers are scheduled. Oral lectures, flash presentations, and poster presentations will also be selected from submissions. Bursaries covering the registration fees of young scientists will be available, selected from the best contributions.

<https://ismsc2019.eu/>

Spectroscopicum

9-14 June 2019, Mexico City, Mexico

We are pleased to invite you to participate in the “**41st Colloquium Spectroscopicum Internationale**” (CSI XLI), which will be held from 9-14 June 2019 at the main campus of the National Autonomous University of Mexico (UNAM) in Mexico City, Mexico. The CSI is a series of conferences, held every two years, aimed to congregate scientists from universities, research institutions and industries, working in all fields of analytical spectroscopy, to discuss the results of basic research, development of new methods, and applications of spectroscopy on a great diversity of fields.

The upcoming CSI is organized by the Institute of Applied Sciences and Technology of the UNAM with the support of the IUPAC, the Mexican Physical Society, and the Mexican Chemical Society. The CSI 2019 will be held in parallel with the first Latin-American Meeting on Laser Induced Breakdown Spectroscopy (I LAMLIBS). The first LAMLIBS seeks to bring together the largest possible number of groups in Latin America working on LIBS in a symposium with the participation of prestigious scientist from all around the world. This



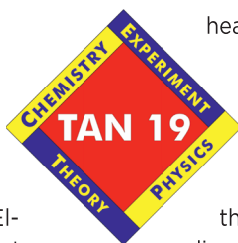
will promote the collaboration and strategic alliances to solve specific problems and challenges within the region and will encourage young researches and students to join to this effort. The participants can attend both events with a single registration. The contributions related to LIBS will be presented in the I LAMLIBS, regardless of the author’s country of origin.

Abstract submission and on-line registration are available in the web page www.csi2019mexico.com. Grants for PhD students will be available upon online application. Selected contributions will be published in special issues of *Spectrochimica Acta Part A* and *B*.

www.csi2019mexico.com

Chemistry and Physics of the Transactinide Elements

25-30 August 2019, Wilhelmshaven, Germany



The 6th International Conference on the Chemistry and Physics of the Transactinide Elements (TAN 19) is the sixth in the series of international conferences dedicated to recent achievements and developments in experiments and theory of the chemistry and physics of transactinide elements. The scientific program will cover experimental and theoretical aspects of the superheavy elements, including synthesis, nuclear reactions, nuclear structure, chemistry, atomic properties, and related topics. The program will consist of invited talks, oral presentations selected on the basis of submitted abstracts, and poster contributions.

TAN 19 will open with a Special Symposium on occasion of the “International Year of the Periodic Table” as proclaimed by the United Nations. The extension of the Periodic Table by new chemical elements is at the

heart of the TAN conference. Accordingly, the conference will open with a special symposium honoring the International Year of the Periodic Table. The symposium program will include presentations by discoverers of elements 107 to 118 and by directors of the laboratories at which these elements were discovered.

Further presentations will look back in time and illustrate the spreading of the concept of the periodic table, discuss the transformation of the concept of chemical elements, or address questions associated with the placing of new elements in the periodic table in historical times. Welcome addresses of presidents of international and national scientific organizations will complete the symposium program.

The TAN 19 conference takes place in Wilhelmshaven, a coastal town located on the North Sea in the state of Lower Saxony, Germany. It is situated on the western side of the Jade Bight, a bay of the North Sea.

www.gsi.de/tan19 • General Inquiries e-mail: tan19@gsi.de

Noncovalent Interactions

2-6 September 2019, Lisbon, Portugal

Noncovalent interactions were first taken into consideration by van der Waals in 1873, helping to revise the equation of state for real gases. In comparison to covalent bonds, intra- and intermolecular noncovalent interactions are in general weak and exhibit much lower energy and directionality, as reflected by the term “noncovalent.” Nevertheless, in many cases these interactions can collectively play a dominant role in synthesis, catalysis and design of materials.

Currently, based on the nature of the particular elements or synthons involved in the interactions, noncovalent bonds are classified into hydrogen, aerogen, halogen, chalcogen, pnictogen, tetrel, and icosagen bonds, as well as agostic, anagostic, cation- π , anion- π , $n-\pi^*$, $\pi-\pi$ stacking, metal-metal, dispersion-driven, hydrophobic interactions, and others.

As the fields of noncovalent interactions are growing intensively, several books in Wiley, Royal Society of Chemistry, Elsevier, or Springer and four thematic issues on these weak forces have been published in *Chemical Reviews* in 1988, 1994, 2000 and 2016. The hydrogen and halogen bonds have already been defined by IUPAC (Recommendations 2011 and 2013, respectively), the definitions for chalcogen, pnictogen

and tetrel bonds are under progress. Moreover, there are international conferences/symposia on Supramolecular Chemistry, and particular types of noncovalent interactions, such as The International Conference on “Horizons in Hydrogen Bond Research” (established by Prof. Lucjan Sobczyk in Poland in 1977), the International Symposium on Halogen Bonding (established by Prof. Pierangelo Metrangola and Prof. Giuseppe Resnati in Porto Ceresio (Lecce, Italy) in 2014), and others.

Thus, the chemistry of this century is expected to be largely driven by noncovalent interactions and it is timely to establish a general/regular series of **International Conferences on Noncovalent Interactions (ICNI)**, the first one to be held on 2-6 September 2019 in Lisbon.

Further editions within this series will be followed every two years, in odd number years (2021, 2023, etc.), thus avoiding competition with other major series of conferences, *i.e.*, the ICOMC and ICCM, which are being held in even years (2014, 2016, 2018, etc.).

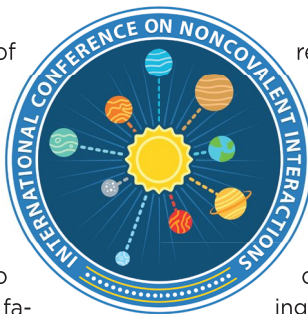
We are thankful to all **International Advisory Board** members of ICNI, who are well recognized scientists in this field, representing Europe, Asia, Africa and America for their support and suggestions,

Hence, on behalf of the Organizing Commission, it is our pleasure to invite you to attend the **1st International Conference on Noncovalent Interactions (ICNI)**. It is an honor for us to host the first Conference of this

series in Portugal. The scientific level of the conference will be provided by its attendants and thus you are cordially invited to present your best and recent scientific work orally, by poster or by poster with a flash oral presentation. The final selection of the type of presentation will have to take into account the scientific programme and facilities layout. Not only senior researchers are welcome, but also the younger ones, encouraging the exchange of ideas among different generations.

The conference aims to highlight the role of Noncovalent Interactions in Synthesis, Catalysis, Crystal engineering, Molecular recognition, Medicinal chemistry, Biology, Materials science, Electrochemical immobilization, etc. including Theoretical aspects. All approaches will be considered, from fundamental to applied ones, including discussion of new types of noncovalent interactions (aerogen, halogen, chalcogen, pnictogen, tetrel, and icosagen bonds) and multidisciplinary studies.

The Conference venue is in a convenient position concerning travel requirements. Lisbon is easily



reachable from any place of the World, the airport and the main train stations are located inside the town itself (this is a unique case within the European capitals) and all are well served by the Metro. The Conference place, at the Universidade de Lisboa campus, is also within the town and has close access to public transportation, including the Metro. Diverse and convenient accommodation facilities are available close to the venue, including low-cost University residences.

Attention will also be paid to the social programme, providing opportunities for mixing, visits to cultural places, excursions to sites of unique natural beauty, tasting the typical Portuguese cuisine, and experiencing our wines!

Armando J.L. Pombeiro, Chair,
Kamran T. Mahmudov, Chair,
Maximilian N. Kopylovich, Co-Chair,
M. Fátima C. Guedes da Silva, Co-Chair

<https://icni2019.eventos.chemistry.pt/>

Small Satellites for Sustainable Science and Development

4-8 November 2019, Herzliya, Israel

The 4th Symposium of the Committee on Space Research (COSPAR), COSPAR 2019, will be hosted by the Israel Academy of Sciences and Humanities, in November 2019.

COSPAR was established by ICSU, now the International Science Council (ISC), in 1958. Among COSPAR's objectives are the promotion of scientific research in space on an international level, with emphasis on the free exchange of results, information, and opinions, as well as providing a forum open to all scientists for the discussion of problems that may affect space research. These objectives are achieved through the organization of symposia, publications, and other means.

Every other year COSPAR calls for a Scientific Assembly (SA). These are conferences gathering—most recently—more than three thousand participating space researchers and dealing with—via parallel sessions—all the COSPAR topics of interest. The most recent Scientific Assembly was in August 2018 in Pasadena. The next COSPAR Scientific Assembly will be in 2020 in Sydney.

In years between SAs COSPAR holds a symposium. The 3rd COSPAR symposium took place on Jeju Island,

in South Korea. The 4th symposium will take place in Israel. Symposia are smaller meetings than the general assemblies; gather a few hundred participants; and are more focused on specific topics.

The 2019 COSPAR symposium topics include:

- Satellite and nanosatellite observations of ground and underground soil
- Ground water, seas, and oceans
- Atmosphere and ionosphere
- Magnetosphere
- Solar system objects (planets, asteroids, interplanetary space)
- Extrasolar planets and the interstellar medium
- The Milky Way and intergalactic space
- Education for space engineering
- Space sciences

Selected papers will be published in *Advances in Space Research* and *Life Sciences in Space Research*, fully refereed journals with no deadlines open to all submissions in relevant fields.

Scientific Program Chair: Professor Morris Podolak, Tel Aviv University, Dept. of Geosciences • <http://www.cospar2019.org/>

2019

9-12 April 2019 • Croatian Meeting of Chemists • Šibenik, Croatia

26th Croatian Meeting of Chemists and Chemical Engineers (26HSKIKI)

Prof. Dr Aleksandra Sander, Chair of Scientific and Organizing Committee, E-mail: hskiki@fkit.hr, <http://www.26hskiki.org>

15-18 April 2019 • Macromolecular Engineering • Stellenbosch, South Africa

13th International Conference on Advanced Polymers via Macromolecular Engineering (APME)

Bert Klumperman, Conference Chair, <bklump@sun.ac.za>, Aneli Fourie, Conference Secretary, <aef2@sun.ac.za>, <http://academic.sun.ac.za/apme>

12-19 May 2019 • IUPAC for Africa • Dar es Salaam, Tanzania

IUPAC for Africa: Postgraduate Summer School on Green Chemistry

Prof. Egid Mubofu – Chair of the Organizing Committee, Vice Chancellor of the University of Dodoma (UDOM), E-mail: ebmubofu@gmail.com • http://www.tcs-tz.org/iupac_summer_school_2019.htm

19-23 May 2019 • Polymers for Sustainable Global Development • Kathmandu, Nepal

International Polymer Characterization Forum (IPCF) POLY-CHAR 2019

Chair: Rameshwar Adhikari, E-mail: nepalpolymer@yahoo.com, <https://polychar2019.org/>

19-24 May 2019 • Crop Protection • Ghent, Belgium

14th IUPAC International Congress of Crop Protection Chemistry

Prof. ir. Pieter Spanoghe; E-mail: Pieter.Spanoghe@UGent.be, Onderzoeksgroep Fytofarmacie/Crop Protection Chemistry, Campus Coupure, 9000 Ghent, Belgium, www.iupac2019.be

20 May 2019 • World Metrology Day • The day celebrates the signing of the Metre Convention on that day in 1875 in Paris by 17 nations attending. In 2019, it will coincide with the implementation of the new SI.

2-6 June 2019 • Supramolecular Chemistry • Lecce, Italy

14th International Symposium on Macrocyclic and Supramolecular Chemistry (ISMSC2019)

Pierangelo Metrangolo, Chair of Program Committee, Laboratory of Supramolecular and BioNano Materials (SupraBioNanoLab), Department of Chemistry, Materials, and Chemical Engineering “Giulio Natta,” Politecnico di Milano, Italy, E-mail: pierangelo.metrangolo@polimi.it, <https://ismc2019.eu/>

9-14 June 2019 • Spectroscopicum Internationale • Mexico City, Mexico

Colloquium Spectroscopicum Internationale XLI (CSI XLI)

Chair: Citlali Sánchez Aké, Institute of Applied Sciences and Technology, National Autonomous University of Mexico, Mexico, E-mail: citlali.sanchez@icat.unam.mx or info@csi2019mexico.com, <http://www.csi2019mexico.com/>

10-13 June 2019 • Macromolecule-Metal Complexes • Moscow, Russian Federation

18th International Symposium on Macromolecule-Metal Complexes (MMC-18)

Chair/contact: Prof. Eduard Karakhanov, Lomonosov Moscow State University, Russia Faculty of Chemistry, Russia, 119991, Moscow 1; E-mail: kar@petrol.chem.msu.ru or mmc-18@yandex.ru <http://mmc-18.org/>

23-27 June 2019 • Polymers in Medicine • Prague, Czech Republic

83rd Prague Meeting on Macromolecules—Polymers in Medicine

Conference Office: Daniela Illnerová and Marie Rodová, E-mail: sympo@imc.cas.cz <https://imc.cas.cz/sympo/83pmm/>

1-5 July 2019 • IUPAC, Wikipedia and Wikidata • Milano, Italy

Wikipedia and Wikidata for application of IUPAC terms across Wikipedia, IUPAC project 2018-038-1-400,

Contact: Raos Guido, Dept. of Chemistry, Politecnico di Milano, E-mail: guido.raos@polimi.it, <https://iupac.org/project/2018-038-1-400>

3-5 July 2019 • ISOTOPCAT2019 • Poitiers, France

International Symposium on Isotopic studies in Catalysis and Electrocatalysis
Co-chairs: Nicolas Bion, E-mail: nicolas.bion@univ-poitiers.fr and Daniel Duprez,
E-mail: daniel.duprez@univ-poitiers.fr, IC2MP, 4 rue Michel Brunet – TSA 51106
F-86073 Poitiers, France, <https://isotopcat2019.sciencesconf.org/>

5-12 July 2019 • IUPAC Congress/General Assembly • Paris, France

contact@iupac2019.org, www.iupac2019.org



IUPAC and Chemistry: a Century of Intertwined History, a Common Heritage for the Future

IUPAC Congress—Symposium 6

Conveners: Danielle Fauque <danielle.fauque@u-psud.fr>,
Université Paris Sud/Paris Saclay, France, and Brigitte Van Tiggelen
<vantiggelen@memosciences.be>, Louvain-la-Neuve, Belgium, and
Science History Institute, Philadelphia, USA, <https://www.iupac2019.org/a-century-of-history>



21-26 July 2019 • Novel Aromatic Compounds • Sapporo, Japan

The 18th international Symposium on Novel Aromatic Compounds (ISNA-18)

Prof. Dr. Shigehiro Yamaguchi, Chair of Program Committee,
E-mail: yamaguchi.shigehiro@b.mbox.nagoya-u.ac.jp, www.isna18.org

21-25 July 2019 • Organometallic Catalysis • Heidelberg, Germany

20th International Symposium on Organometallic Catalysis Directed Towards Organic Synthesis (OMCOS)

Contacts: A. Stephen K. Hashmi <hashmi@hashmi.de> (Chair), Mark Lautens <Mark.lautens@utoronto.ca>,
Congress and Conference Management (UniKT) <unikt-kongresse@zuv.uni-heidelberg.de>
<https://www.omcos2019.de/>

26-28 July 2019 • Mendeleev 150 • Saint Petersburg, Russia

Mendeleev 150: 4th International Conference on the Periodic Table endorsed by IUPAC

Co-organizers: Mikhail V. Kurushkin (ITMO University, Russia), Eric R. Scerri (University of California,
Los Angeles, USA), Philip J. Stewart (Oxford University, UK)
E-mail: mendeleev150@scamt-itmo.ru, <http://mendeleev150.ifmo.ru/>

28 July 2019 • IUPAC 100th birthday!

30 July - 1 August 2019 • Inter-Asian Chemistry Educators • Taipei, Taiwan

8th International Conference for Network for Inter-Asian Chemistry Educators (NICE)

Chin-Cheng Chou, Department of Science Education, National Taipei University of Education
E-mail: ccchou62@tea.ntue.edu.tw, <http://www.8thnice.org/>

4-8 August 2019 • Solution Chemistry • Xining, China

36th International Conference of Solution Chemistry

Dr. Yongquan Zhou, Qinghai Institute of SaltLakes, Chinese Academy of Sciences, Xining 810008, China,
E-mail: icsc2019@isl.ac.cn, <http://icsc2019.csp.escience.cn/>

4-9 August 2019 • Electrochemistry • Durban, South Africa

70th Annual Meeting of the International Society of Electrochemistry - Electrochemistry: Linking Resources to Sustainable Development

Chair: Kenneth I. Ozoemena, University of the Witwatersrand, E-mail: kenneth.ozoemena@wits.ac.za,
<https://annual70.ise-online.org/>

25-30 August 2019 • Transactinide Elements • Wilhelmshaven, Germany

6th International Conference on the Chemistry and Physics of the Transactinide Elements (TAN19)

Co-Chairs: Prof. Dr. Christoph Düllmann, Institute of Nuclear Chemistry, Johannes Gutenberg University Mainz, Germany and Prof. Dr. Michael Block, GSI Helmholtz Center for Heavy Ion Research, Darmstadt, Germany. E-mail: tan19@gsi.de, <https://www.gsi.de/tan19/>

Mark Your Calendar (cont.)

25-31 August 2019 • Glycoconjugates • Milano, Italy

25th International Symposium on Glycoconjugates

Co-Chairs: Sandro Sonnino <sandro.sonnino@unimi.it> and Alessandro Prinetti <alessandro.prinetti@unimi.it>, General contact: <info@glyco25.org>, <http://www.glyco25.org/>

2-6 September 2019 • Noncovalent Interactions Lisbon, Portugal

1st International Conferences on Noncovalent Interactions (ICNI)

Armando J. L. Pombeiro, Universidade de Lisboa, and Kamran T. Mahmudov, E-mail: kamran_chem@mail.ru. General E-mail: icni2019@chemistry.pt, <http://icni2019.eventos.chemistry.pt>

8-13 September 2019 • Ionic Polymerization Beijing, China

13th International Symposium on Ionic Polymerization (IP 2019)

Yixian Wu, E-mail: wuyx@mail.buct.edu.cn, Beijing University of Chemical Technology, and Junpo He, E-mail: jphe@fudan.edu.cn, Fudan University, Dept. Macromolecular Science, co-chairs. web tba

9-13 September 2019 • General and Applied Chemistry Saint Petersburg, Russian Federation

The 21st Mendeleev Congress on General and Applied Chemistry

Co-chairs: A.M. Sergeev, President of RAS, Full Member of RAS and M.M. Kotyukov, Minister of Science and Higher Education of the Russian Federation. General Contact: Yulia Gorbunova, Corresponding Member of RAS, A.N. Frumkin Institute of Physical Chemistry and Electrochemistry of RAS, Leninsky prospect, 31, building 4, Moscow, Russian Federation, 119087, Tel: +74959545483, E-mail: yulia.gorbunova@gmail.com, <http://mendelev2019.ru/>

14-16 October 2019 • WMFmeetsIUPAC2019 Belfast, Northern Ireland

The World Mycotoxin Forum and the IUPAC International Symposium on Mycotoxins,

Rudolf Krska, BOKU Vienna, Austria, and Chris Elliott, Queen's University Belfast, Northern Ireland, conference co-chairs, E-mail WMF@bastiaanse-communication.com, www.worldmycotoxinforum.org

15-18 October 2019 • Coordination Chemistry • Kuala Lumpur, Malaysia

7th Asian Coordination Chemistry Conference (ACCC7)

Chair: Geok Bee Teh, E-mail: sharonteh2009@gmail.com; Contact: ACCC7 Secretariat, c/o Institut Kimia Malaysia, E-mail: secretariat@accc7.org.my, <https://accc7.org.my/>

5 Dec 2019 • IYPT2019 Closing • Tokyo, Japan

The Official IYPT2019 Closing Ceremony will be hosted by Science Council of Japan IUPAC subcommittee; <http://www.iypt2019.jp/eng/index.html>

2020

5-9 July 2020 • MACRO2020 • Jeju Island, Korea

48th World Polymer Congress

Chair: Doo Sung Lee, ex-President, PSK; program chair: Jun Young Lee; secretary general: Dong June Ahn (ahn@korea.ac.kr);

E-mail: macro2020@macro2020.org; <http://www.macro2020.org>

16-21 August 2020 • Theoretical and Computational Chemists • Vancouver, Canada

12th Triennial Congress of the World Association of Theoretical and Computational Chemists

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Stamps International

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

Bye-Bye, IPK!

The International Prototype Kilogram, after 130 years of dutiful service, is finally retiring. The IPK, a golf ball-sized cylinder made of a special platinum-iridium alloy (90:10), was introduced in 1889 at the first General Conference on Weights and Measures (CGPM) near Paris to define the unit of mass using an artifact fabricated with the utmost care and precision available at the time. New units were subsequently adopted for other physical quantities such as electric current (the ampere) and temperature (the kelvin), and the increasing need for a more cohesive set of units of measurement led to the implementation of the International System of Units (SI) in 1960.

In the ensuing decades, progressively more sophisticated definitions were adopted for certain SI base units but, remarkably, the kilogram remained until recently the only one still defined by a physical object rather than a fundamental property that could be independently measured in different laboratories. Things changed last November when the 26th CGPM voted unanimously to update the definitions of some base units and start defining the kilogram using a fixed value of Planck's constant (h), which is now known with a high degree of certainty. On 20 May 2019, World Metrology Day, an updated and more stable SI will become effective, and the venerable IPK will literally rest in peace.

There are at least 30 or 40 postage stamps dedicated to the metric system, including several issued in

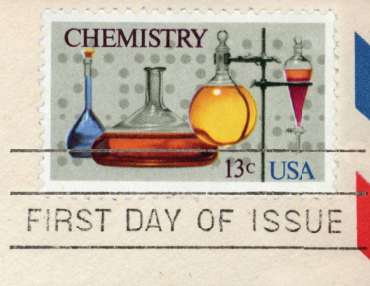
1975 to mark the centennial of the Meter Convention and others that feature SI base or derived units. Surprisingly, as far as I know, there are only three stamps that depict the IPK. The ones from Indonesia and Bulgaria, illustrated above, also show the International Prototype Meter, a rigid bar with a characteristic Xshaped cross-section made of the same alloy as Le Grand K and used to define the meter until 1960. In turn, the third stamp displays one of Mexico's original replicas of the IPK and was issued in 2015 to commemorate the 125th anniversary of the country's membership in the CGPM. So, this coming May 20th, let's all bid farewell to the revered prototype with a heartfelt "Au revoir, IPK!"

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Mail a Stamp to Dan!

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