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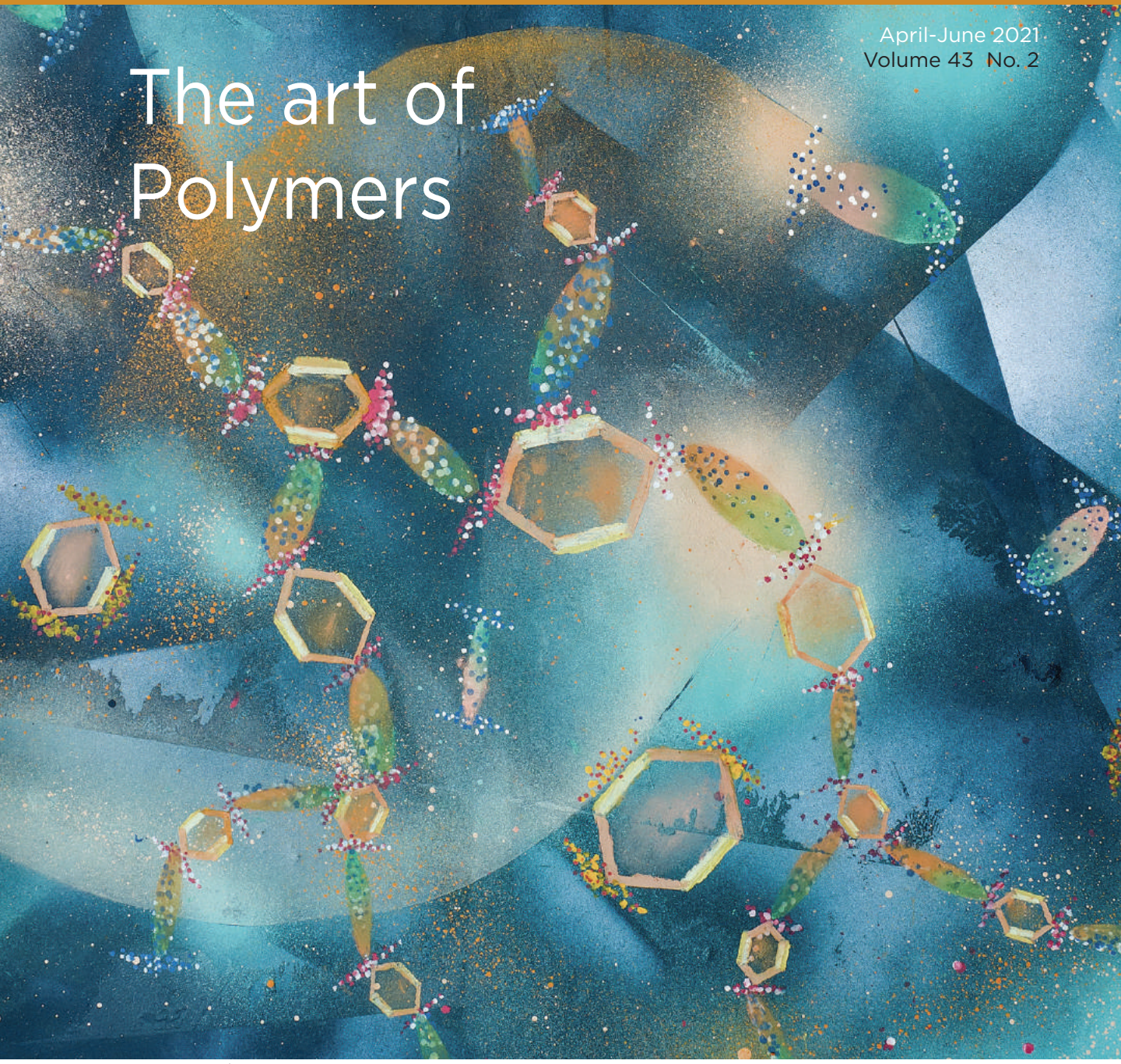

The art of Polymers

INTERNATIONAL UNION OF
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Chemistry International

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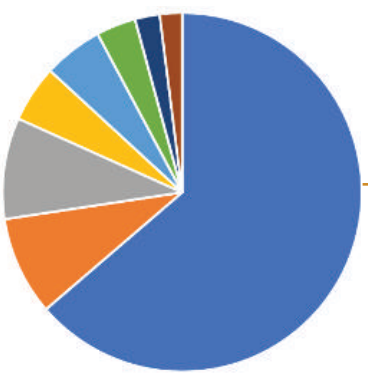
Cover: Polymers are all around us since the evolution of life on Earth. A SciArts project by @Merna_group aims to celebrate the anniversary by introducing selected basic terms in polymer science to a broader chemical community and to the publics. This cover illustrates POLYCONDENSATION. **See more page 9.**



continued on page 3

Vice President's Column

Advancing Chemistry Worldwide

by Javier García-Martínez

As we come out of this pandemic, we must find the most effective and useful ways so that IUPAC fulfills its mission of contributing to the worldwide understanding and application of the chemical sciences to the betterment of humankind. New technologies provide us with the tools to achieve this goal in a very effective manner. For example, our next General Assembly, which will be held completely online, represents an unprecedented opportunity to engage with our NAOs in a way that will allow for discussing our most pressing needs in a new and effective way. We are already working on different options to have working groups meeting at different times in virtual rooms, so everybody can participate, raise any issues, and discuss how we can create a more effective, responsive, and agile organization. I encourage all delegates to our General Assembly to make full use of this opportunity. Also, I would like to invite the wider IUPAC community, including our members, Associated Organizations, Company Associates, and also our sister Chemical Societies, to let us know any ideas, things we must improve, or any opportunities for collaboration, so we can include them in our discussions during our next General Assembly.

No one could imagine that after all the celebrations of 2019, the following year would bring us a pandemic that has affected us in so many ways. I want to take this opportunity to remember those who have lost a loved one, their jobs, or who have suffered in any way during these difficult months. The mobility restrictions imposed on most parts of the world have impacted businesses and individuals. IUPAC has been no different. In a very short time, we have changed the way we hold our meetings and carry out our activities. Our employees have made every effort to continue attending to their many responsibilities from home, which speaks volumes about their commitment and professionalism. I also want to express my gratitude to all our volunteers—to the great family of IUPAC—who, in addition to dealing with family and job responsibilities in the middle of a pandemic, have continued to contribute to our Union in many different ways. Thank you all!

Technology has been an essential tool during the last months. Thanks to the use of the online platforms nowadays available, our Divisions, Standing Committees, and other working and governing bodies of IUPAC have carried out their duties in an effective and timely manner. Both our Bureau and Executive Committee had already been holding their official meetings remotely since 2019. Also, many IUPAC working groups have been carrying out their activities remotely for years.

It is precisely for these reasons that our 2021 General Assembly and World Chemistry Congress will be held entirely online. It has not been an easy decision. Nor was it the one we would have liked to make. But travel restrictions and the safety of all of us have been paramount in this decision. Our Canadian colleagues deserve our recognition because of all their many efforts, hard work, and dedication. For no one has it been more difficult than for them to decide to move the entire Congress and General Assembly into a completely virtual mode. After all the excitement and months of work, their decision is the most sensible and responsible, but also the most difficult. Thank you very much for your efforts and good judgment. I would like to take this opportunity to invite everyone to participate in the IUPAC-CCCE virtual meeting from the 13 to 20 of August. The fact that it is online will allow many people, who otherwise would not have been able to travel to Montreal, to participate in one of the major Chemistry events of the year.

Technology is here to stay, but we, at IUPAC, must evaluate and critically assess which aspects of remote working we should keep and which of our activities should be in-person moving forward. Without a doubt, in a volunteer organization, it is fundamental to have plenty of opportunities to interact beyond the screen and to enjoy those moments of friendship and camaraderie that have been so important for each of us to decide to join and serve at IUPAC.

One of the lessons we have learned already in the first year of our second century of history is how quickly things can change. Organizations that aim at playing a significant role in these complex times must be agile and responsive. Our structure must be simpler and our governing bodies of a size and composition that allow for effectively discussing and decision making between General Assemblies. At the same time, our Divisions and Standing Committees—where most of the scientific work of the Union is done—must be empowered to ensure that we serve the chemistry

community in the most effective and meaningful way.

But beyond organizational changes and the use of new technologies, if IUPAC is to continue to play a leading role in our second century of history, each of us must work to make it happen. Our core activities, such as nomenclature and terminology, the atomic weights, and the naming of new chemical elements, will continue to be a priority and one of the most important things we do. All these activities, and many others we carry out at IUPAC, are vital for the present and future of chemistry. While continuing with our core activities, which are unique to IUPAC, we have to strengthen our involvement in the new areas that are redefining chemistry; in most cases, at the crossroad with other disciplines, such as artificial intelligence, automation, and life sciences. During the last years, we have learned the enormous potential and global outreach of some creative online activities such as the Periodic Table Challenge, the Global Women Breakfast, ChemVoices, and the Top Ten Emerging Technologies in Chemistry. All these initiatives are legacies of our Centenary. All of them were launched during 2019, coinciding with both IUPAC100 and IYPT. Every one of these activities has been a great success in terms of impact, outreach, and public image of chemistry in general and IUPAC in particular.

Another priority moving forward is to improve communication within IUPAC, with our stakeholders, and with the public in general. Technology can be a great ally in achieving this goal. There are many things we can do, from making better use of social media and our website to explore online platforms to have more interactive online meetings. But technology alone will not be sufficient. In an organization of volunteers, the role of each one of us, especially those in a position of leadership, is to motivate and mobilize others. This is one of my top priorities. Because of that, I want to take this opportunity to invite all of you to share your concerns or suggestions. I want to listen to you so we can work together.

We must also provide value to our stakeholders, more specifically, to our NAOs. Each one of them has its own needs and challenges. They represent an opportunity to do things together. At IUPAC, we can serve NAOs in many different ways, from providing them with information and untapped opportunities, to working in joint programs to advance chemistry in their countries. We want to learn from you how we can serve you better while we are working in many programs that you can find on our website, including our projects, the many awards we offer, our global activities, and our publications.

As a society, we do face many risks, from new and emerging illnesses to climate change, and chemistry has a key role to play in the understanding and solution of these and many other global challenges. IUPAC, in collaboration with other organizations and our NAOs, can make a difference in this regard and be, as stated in our Vision, an indispensable worldwide resource for chemistry. I know that I can count on all of you to make our organization accomplish the task for which it was created, namely to serve humankind by advancing chemistry worldwide.

Javier García-Martínez <j.garcia@ua.es> is a Professor of Inorganic Chemistry and Director of the Molecular Nanotechnology Laboratory of the University of Alicante where he leads an international team working on the synthesis and application of nanostructured materials for the production of chemicals and energy. Javier is IUPAC Vice President since 2020. Previously, he served as member of the Executive Committee and as Titular Member and Vice-President of the Inorganic Chemistry Division.

Contents (cont.)

Macromolecular Science Turns 100

by Christine K. Luscombe and Gregory T. Russell

Being 100 years since the birth of macromolecular science, 2020 was meant to be the "Year of Polymers," but instead it turned into the year of the pandemic. Actually the two are not unrelated—most PPE is made of polymer, and without it the health-care response to COVID-19 would have looked completely different and been far more treacherous. But that's another story, one with which the IUPAC Polymer Division is engaging [1]. Here is the story behind the centenary year that wasn't. It all centers on Hermann Staudinger, who changed everything in 1920.

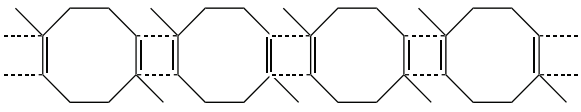
Who was Staudinger and what is the significance of 2020?

Hermann Staudinger circa. 1950.

Hermann Staudinger was a German organic chemist who won the 1953 Nobel Prize in Chemistry. He was born in Worms in 1881 [2-4], where his interest in science began, encouraged by his father, who was a high school teacher and neo-Kantian philosopher! While initially Hermann studied botany at the University of Halle, he quickly shifted his focus to chemistry, progressing via Darmstadt and Munich to obtaining a PhD in organic chemistry in Halle in 1903, where his work on the addition of malonates to unsaturated compounds foreshadowed the interest through which he was to obtain scientific immortality. After Halle he became an assistant to Johannes Thiele at Strasbourg, receiving his habilitation in 1907 for work on ketene chemistry. He then became an assistant professor at Karlsruhe, before succeeding the future Nobel laureate Richard Willstätter at ETH Zürich in 1912. His final move was to Freiburg in 1926, where he remained for the rest of his days. The geography of his life seems well described by the phrase "a river runs through it", for aside from his years as a student, he was always very close to the Upper Rhine.

During the early years of his academic career, Staudinger's research focused on small molecule chemistry, publishing 215 papers and becoming internationally recognized. But starting in 1917 he turned towards rather larger molecules. Specifically, his interest was piqued by rubber, of obvious importance at that difficult time. In the 19th century, polymers were used for commercial purposes but their structure was misunderstood. For example, Charles Goodyear had discovered vulcanization of natural rubber in 1839 to give birth to the rubber industry. By the end of the 19th century, nitrocellulose and celluloid were used as thermoplastics. In 1907, Baekeland developed a phenolic thermoset resin trademarked as Baekelite. These commercial successes occurred without knowledge of the molecular architecture of polymeric materials, and the properties of polymers were described using colloidal theory, where the measured high molecular weights were thought to be caused by the aggregation of small molecules into colloids. An example of the thinking at the time is presented below, which shows a proposed structure for natural rubber, suggested to be composed of dimethylcyclooctadiene units polymerized by self-assembly involving noncovalent interactions between double bonds on neighboring molecules [2].

Staudinger rejected such notions. In 1920, from his base in Zürich (not Freiburg!), he published a paper simply entitled "Über Polymerisation" [6]—next page. This is regarded as marking the birth of macromolecular science, which is why 2020 was so significant. Remarkably, it was not until the eve of this centenary that there was an English translation [7] of the 1920 paper. It makes clear that the celebrated work was really just a discussion piece in which Staudinger presents his hypothesis that polymers are in fact long molecules comprised of units linked together by covalent bonds. As Mühlhaupt observed, "At this early time Staudinger did not present convincing experimental evidence for his hypothesis" [2]. Such was to come two years later, when Staudinger and Fritschi reported hydrogenating the double bonds of natural rubber and showing that it retained its mechanical properties even in the absence of the double bonds, thereby proving that non-covalent interactions between these double bonds (see below) could not be the reason behind the properties of rubber [8]. Furthermore, it is in this 1922 paper that the word *macromolecule* is used for the first time. Thus between these two papers one has the birth of the so-called *macromolecular hypothesis*, which more or less occupied Staudinger for the rest of his life.



Proposed structure of natural rubber by Harries [5].

125. H. Staudinger: Über Polymerisation.

[Mitteilung aus dem Chem. Institut der Eidgen. Techn. Hochschule, Zürich.]

(Eingegangen am 13. März 1920.)

Vor einiger Zeit hat G. Schroeter[1]) interessante Ansichten über die Zusammensetzung von Polymerisationsprodukten, speziell über die Konstitution der polymeren Ketene veröffentlicht. Danach sollen diese Verbindungen Molekülverbindungen darstellen und sollen keine Cyclobutan-Derivate sein, wie früher angenommen wurde[2]); denn diese polymeren Ketene unterscheiden sich nach den Schroeterschen Untersuchungen in wesentlichen Punkten von Cyclobutan-Derivaten, die durch Synthese aus Aceton-dicarbonester-Derivaten zugänglich sind.

Title and opening paragraph of [6] – there was no fancy artwork in those days!

Isn't it obvious?

The macromolecular hypothesis – that of covalent linkages to give genuinely 'macro' molecules – seems so obvious now that it can be hard to grasp that it was enough of a paradigm shift to warrant a Nobel Prize. But consider the famous anecdote about Staudinger being told to forget his "grease chemistry," as well as friendly advice he received from Heinrich Wieland, himself a future Nobel Prize winner [2]: "*Dear colleague, abandon your idea of large molecules, organic molecules with molecular weights exceeding 5000 do not exist. Purify your products such as rubber, they will crystallize and turn out to be low molecular weight compounds.*" These stories show just how radical Staudinger's idea was at the time. While these days it is difficult to imagine how anyone would have rejected the notion of a macromolecule, it is worth noting that concepts of molecules and molecular structures were not well established a centenary ago. In a sense Staudinger should be regarded as the Galileo of macromolecular science—the person who took a revolutionary concept and turned it into a notion so obvious that one wonders how the alternative was ever entertained.

There are a number of curiosities about the 1920 paper. As already mentioned, despite its fame, it was only in 2019 that it was first translated from German into English [7], which in itself suggests just how quickly the central idea passed into accepted, obvious knowledge—few people felt the need to read about it! Similarly, the paper has been cited remarkably little—225 times as of April 2019, elevated to 378 by February 2021 courtesy of a centenary boost from historical interest rather than the scientific content *per se* [9]. These days such citation statistics would barely be sufficient to earn a faculty position, let alone a Nobel Prize! A final curiosity is an irony: as we pass 100 years of the macromolecular hypothesis, supramolecular chemistry looms ever larger on the landscape, it being chemistry that "examines the weaker and reversible non-covalent interactions between molecules" [10]. In other words, supramolecular chemistry involves molecular assemblies exactly of the nature that people thought "normal" macromolecules were pre-Staudinger. Accordingly, there is much debate as to whether or not supramolecular materials are polymers.

How has polymer chemistry evolved over the years?

This question may be answered by considering Nobel Prizes awarded for work in macromolecular science—see table below. It is important to remember that there is a lag time: what is seen on the stage in Stockholm usually reflects what was happening at the research coalface about 20 years earlier. Thus Staudinger's

Year	Winner(s)	Work
1953	Staudinger	"for discoveries in the field of *macromolecular chemistry*"
1963	Ziegler, Natta	"for discoveries in the field of the chemistry and technology of high polymers" (*coordination polymerization*)
1974	Flory	"for his fundamental work, both theoretical and experimental, in the *physical chemistry of macromolecules*"
1991	de Gennes	"for discovering that methods developed for studying *order phenomena* in simple systems can be generalized to more complex forms of matter, in particular to polymers"
2000	Heeger, MacDiarmid, Shirakawa	"for discovery and development of *conductive polymers*"
2002	Fenn, Tanaka, Wüthrich	"for development of methods for identification and structure analyses of macromolecules ... for development of soft desorption ionisation *methods for mass spectrometric analyses of macromolecules*"
2005	Chauvin, Grubbs, Schrock	"for the development of the *metathesis* method in organic synthesis" (in particular polymerization)

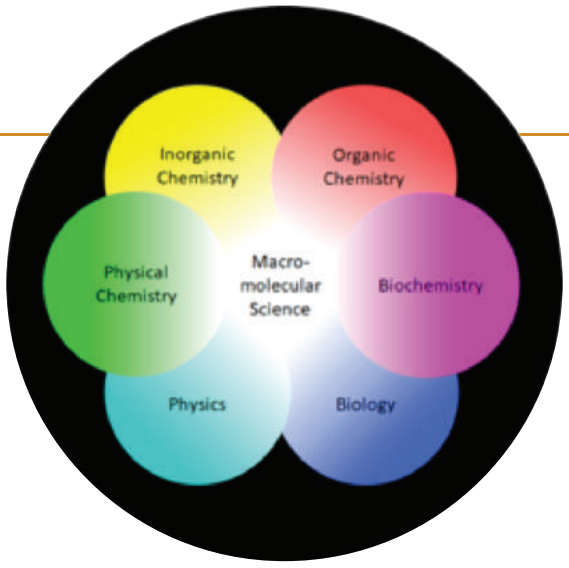
Nobel Prize winners in macromolecular science (all Chemistry [13] apart from Physics [14] in 1991).

prize in 1953 stems from organic chemistry being to the fore in the 1920s and 1930s, with Staudinger and W.H. Carothers (of DuPont) being the leading lights. By the 1940s through to the 1960s, polymer chemistry was largely a branch of physical chemistry, with Paul Flory the dominant figure, along with other giants such as G.V. Schulz, H. Mark and M. Szwarc. Indeed, IUPAC's *Commission on Macromolecules* was formed at this time as a branch of its Physical Chemistry Section [11], and Flory's 1953 textbook [12]—still the most celebrated in polymer science—largely consists of physical chemistry. This trajectory was taken even further in the 1970s, with the soft-matter physics of the dazzling de Gennes and his school taking a lot of the limelight. By the 1980s polymer science was spreading its wings and taking root in many different areas, as reflected in the flurry of Nobel Prizes around the turn of the century: materials chemistry (2000), instrumental chemistry (2002) and organic chemistry (2005) are all represented. Truth be told, macromolecular science has never strayed far from synthetic chemistry, with the Nobel Prize of Ziegler and Natta in the midst of all the above being a good example of this. The current period is certainly one in which the spirit of Staudinger has been recaptured and synthesis is dominant, with figures such as Krzysztof Matyaszewski, Mituso Sawamoto, Graeme Moad, Robert H. Grubbs, Craig Hawker, and Jean Fréchet leading the way. But really, it should be clear that macromolecular science has evolved to be broad and overlaps with all areas of chemistry. Furthermore it is intimately linked to other major scientific disciplines—the image above attempts to capture this [15].

The table on the previous page makes clear that Staudinger initiated a chain of Nobel Prizes being awarded in polymer science (or as Bob Grubbs puts it, the chemistry of the carbon-carbon double bond!) approximately every 10 years. Given that the last award was in 2005, one wonders if another Prize is due? It's a pity that the chance to make it 2020 was missed!

How has IUPAC been involved?

In what would seem to be pure coincidence, IUPAC was founded just one year prior to Staudinger's 1920 paper, so the two will forever celebrate the same landmarks in close succession. But it was not until the late 1940s, with the formation of IUPAC's *Commission on Macromolecules,* that explicit overlap of the two started [11]. In 1952 this body put out its first publication on systemized naming of macromolecules. It introduced, for example, the use of parentheses in source-based polymer names when the monomer consists of more than one word. In recognition of the



Macromolecular science started as organic chemistry but has spread its tentacles into all areas of chemistry and many areas of science. Reproduced with permission from Isr. J. Chem. 2020, 60, 9-19. Copyright 2020 WILEY.

ever expanding importance of polymer chemistry and no doubt via impetus from the Nobel Prizes in 1953 and 1963 (see above), the *Macromolecular Division* of IUPAC was formed in 1967, just shy of the half-centuries of IUPAC and the macromolecular hypothesis. The first Division President was the Czech chemist Otto Wichterle, inventor of soft contact lenses. This formalized what continues to be a very strong and powerful relationship between IUPAC and macromolecular chemistry. For example, the *Commission on Macromolecular Nomenclature* of the Macromolecular Division was established in 1968, and it was immediately into its work, producing a series of major documents during the 1970s that shaped modern polymer language, including defining basic terms and structure-based nomenclature for regular single-strand polymers. The Commission remained prolific in the 1980s, during which were published recommendations relating to stereochemical definitions, terminology for molar masses in polymer science, structure-based nomenclature of inorganic and coordination polymers, and systematization of source-based nomenclature for copolymers. In 1991 the first edition of the Purple Book (the Compendium of Macromolecular Nomenclature) was published. The Division, through what is now known as the *Subcommittee on Polymer Terminology* (SPT), continues to publish regular recommendations that try to keep pace with the ever-increasing complexity of macromolecules being synthesized. This all represents IUPAC playing a vital role in the forward progress of macromolecular science.

The *Polymer Division* (PD), as Div. IV has been known since 2004, currently consists of four subcommittees: SPT, the Subcommittee on Modeling of Polymerization Kinetics and Processes, the Subcommittee on Polymer Education (SPEd), and the Subcommittee on Structure

and Properties of Commercial Polymers. SPT is a very active group that develops terminological rules and definitions related to polymers. It also works closely with IUPAC Div. VIII (Chemical Nomenclature and Structure Representation) to provide recommendations on polymer nomenclature. The Subcommittee on Modeling and Polymerization Kinetics and Processes performs studies that aim to create uniform standards related to polymerization kinetics. While literature reports kinetic parameters related to polymerizations, these values frequently differ from group to group because of different assumptions that have been made. The Subcommittee addresses the situation through international collaboration. SPEd tries to provide support toward recurrent educational activities for students in underdeveloped countries. It organizes special symposia at the biannual MACRO conferences where speakers can share best practices on polymer education in their respective countries. We are also in the process of creating a freely available "syllabus" that provides guidance on the core chemistry content that should be covered in an undergraduate course on polymer science, together with sample questions illustrating each of the topics so that those who do not have easy access to textbooks can still learn basic polymer science. The Subcommittee on Structure and Properties of Commercial Polymers dedicates its work toward obtaining and reporting accurate information about mechanical properties of commercial polymers.

As we enter the 2nd century of macromolecular science, the PD remains extremely active, arguably the most active within IUPAC given that it runs around 30 projects at any one time [16]—see the picture below for evidence of this activity!

How has the Staudinger centenary been recognized?

With 2019 being the International Year of the Periodic Table (not to mention the centenary of IUPAC!), it was not feasible to seek a UNESCO designation of "Year of Polymers" in 2020. Arguably this is in accord with the largely understated role of polymers in the modern world—it would only be if all polymers were removed that most people would realize just how ubiquitous and indispensable they have become in everyday life. But even without official recognition, there were still considerable plans for quiet acknowledgement of the Staudinger centenary within the scientific community. As one would expect, many of these events have had to be postponed due to the pandemic. For example, the ACS Spring 2020 National Meeting, entitled "Macromolecular Chemistry: The Second Century," was cancelled at the time and is now being held online over 5–30 April 2021, with live events 5–16 April. This time period is longer than the usual ACS meeting as each day will be much shorter so as to accommodate multiple time zones in this virtual era. A special ACS Division of Polymer Chemistry symposium, "Macromolecular Science at the Dawn of its Second Century," is being co-organized by Timothy Lodge, Krzystof Matyjaszewski and Peter Zarras [17].

Our IUPAC Polymer Division flagship conference, the IUPAC World Polymer Congress, a.k.a. IUPAC-MACRO meeting, is the largest biennial international multi-symposium conference dedicated to all aspects of polymer science and engineering. The 48th World Polymer Congress (MACRO 2020) had been scheduled for 5–9 July 2020 at Jeju Island, South Korea with PD Titular Member Doo Sung Lee as Congress Chair.

Screenshot of one of many Zoom meetings—including both of your authors!—that was held for SPT & PD in July 2020.

This has now been rescheduled to 16–20 May 2021, rebranded as MACRO 2020+, and will be a hybrid event where many scientists in South Korea are expected to attend in person while most international participants are expected to participate virtually [18].

Publishers have also had special initiatives to commemorate the centenary. For example, the Editor-in-Chief of the ACS journal *Macromolecules*, Marc Hillmyer, curated a series of editorials from leading polymer scientists to comment on *Macromolecules* papers that they thought had been particularly impactful or influential [19]. The editorials reflected the broad range of polymer science, highlighting work on block copolymers, discovery of RAFT, twisted crystals, kinetics of ATRP, random ionomers, non-radiative energy transfer studies of miscibility in polymer blends, hydrogels, branched polymers, syndiotactic polystyrene, spinodal decomposition, organocatalysis, polymer membranes, theory, living cationic and radical polymerizations, glass transition, polymer mechanochemistry, non-covalent interactions, polyion complexes, and tensile deformation mechanism in semicrystalline polymers. The breadth of these contributions highlights just how far polymer science has come in 100 years.

Both *Macromolecular Rapid Communications* and *Macromolecular Chemistry and Physics*, the latter founded by Hermann Staudinger, commemorated the event by having double special issues that were made freely available for the entire year. These special issues contained articles that represented various aspects of modern macromolecular chemistry ranging from synthesis to characterization and application.

What does the future hold?

As the new century for macromolecular sciences begins and we look to the future, the editors and advisory board members of *Macromolecular Chemistry and Physics* published a paper [20] sharing their views on the future of polymer science that addressed new synthetic methods, polymers with advanced properties and function, as well as sustainability. The IUPAC Polymer Division also wrote an essay reflecting upon the centenary [15], writing about the need to develop polymers that can ameliorate today's pressing problems related to climate emergency, sustainable development, and the preservation of the environment and human health. Given the ability of polymers to touch upon so many aspects of life, polymer science will remain a vigorous field that will attract scientists from all walks including but not limited to chemists, physicists, engineers, and those from the biological sciences. IUPAC can play a central in this regard by providing effective ways to communicate, attracting young scientists, and promoting a lively and intellectually exciting research area.

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Christine K. Luscombe <luscombe@uw.edu>, current President of the IUPAC Polymer Division, is professor at the University of Washington, Seattle and Gregory T. Russell <greg.russell@canterbury.ac.nz>, Past President of the Polymer Division, is professor at the University of Canterbury, New Zealand.

Polymer Science Language to Publics through Arts

SciArts on occasion of 100th anniversary of understanding of polymer structure by Hermann Staudinger.

by Jan Merna, and Jan Pražan

SciArt Exhibition by http://janprazan.com and @Merna_ group endorsed by @IUPAC and @VSCHT developed in collaboration with @IUPACPolymer and celebrating Macromolecules Centenary and Staudinger opened on 30 Nov 2020 at UCTPrague under the patronage of UCT rector prof. Dr. RNDr. Pavel Matějka and IUPAC Polymer Division vice-president Dr. Igor Lacík.

Polymers are all around us since the evolution of life on Earth. Polymers made by Nature (natural polymers) are key for Earth life: nucleic acids (polynucleotides), proteins (polypetides) and polysacharides (like cellulose). We also use some of them in technical applications *e.g.* natural rubber (polyisoprene). Polymers made by men (synthetic polymers) only bit more than hundred years ago—(Bakelite 1909), become major class of materials after WWII and ensures quality of our lives.

People use currently ~400 millions tons of synthetic polymers per year worldwide, which by volume is more than the production of steel, making polymers No 1 material of today. Extensive range of polymers (plastics and rubbers) applications helps to save, harvest and store energy, protect food, clean and save water, protect other materials from corrosion (coatings) and save lives in biomedical applications (drug delivery systems, soft tissue implants) or in personal protective equipment (gloves and masks in fight against bacteria a viruses).

In 2020 we celebrate 100 years from Hermann Staudinger recognition of polymer structure, i.e. that these compounds are composed of giant molecules- macromolecules.

This *SciArts* projects aims to celebrate the anniversary by introducing selected basic terms in polymer science into broader chemical community and to publics. These terms are defined by scholars associated within IUPAC since 1949, when Czechoslovak chemist Otto Wichterle became the first president of IUPAC Polymer Division. IUPAC is major authority in defining of nomenclature and terminology—chemical language.

IUPAC terms are widely accepted and used by industry, in defining standards (ISO, DIN) and in legal documents created by governments, where clarity in communication between experts is essential to protect intellectual property (patents) and avoid confusion which may lead to accidents with serious consequences (e.g. due to mistaken conversion of imperial units to metric systems orbital satellite was damaged causing billion dollar losses). IUPAC acts as global organization and creates partnerships with organization like UNESCO or OPCW, to promote access to chemistry education and sustainable chemical technologies.

Chemical language is highly precise and by principle abstract or difficult to understand on the first sight. The intention of this project is to familiarize selected principal terms of Polymer Science to broader chemical community and lay publics by their reformulation to common langue. To attract the initial interest of eager for knowledge readers and to stimulate taking the challenge to understand these abstract definitions, the form of abstract Art is used.

See https://pol.vscht.cz/sciart for more.

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NAO-CNR: The Italian voice at IUPAC

by Matteo Guidotti, Augusta Maria Paci, and Maurizio Peruzzini

Italy was a founding member of IUPAC in 1919. Italian participation is still vivid thanks to the proactive, collaborative spirit that motivated its initial support of the establishment of IUPAC. The National Research Council, CNR, the largest research institution for public research in the country, is the official representative of Italy at IUPAC through the National Commission operating as the IUPAC National Adhering Organization.

The main operational objectives of the NAO-CNR are: strengthening the Italian presence in the Union and opening new collaboration opportunities; identifying Italian experts keen to bring about collaborations in existing areas; and increasing the relationship between NAO-CNR and the Scientific Divisions of IUPAC to plan and promote initiatives, congresses, and schools at international level. In general terms, the National Commission will take part in the challenge of global sustainable development, exploiting its know-how and methods of chemical sciences to meet the demands of society and markets for sustainable solutions. NAO-CNR also aims to participate in IUPAC to advance chemistry worldwide, the overall goal of all the IUPAC NAOs.

Origin of the Italian membership at IUPAC

Italy has been a member of IUPAC for 100 years, since the very beginning. It was one of the five founder countries, together with Belgium, France, the UK, and the US. Since then, Italy has been an active member in the Union. In 1920, Rome hosted the first International Conference on Chemistry. Within this event, the equivalent to today's General Assembly met for the first time in the presence of Charles Moureu (1863-1929), President of IUPAC. In 1934, the Italian chemist Nicola Parravano, pupil of famous scientists such as Cannizzaro and Paternò, was elected President of IUPAC. He was the main chairman of the 10th International Congress of Chemistry, held once again in Rome, in May 1938. The event had the ambitious goal of showing to the world the benefits of Chemistry in the everyday life of humankind. The congress had a noteworthy participation, despite the difficult international geopolitical situation that led one year later to the outbreak of World War II [1].

The Italian National Research Council, CNR, represented Italy in IUPAC for decades. CNR is the largest public research body in the country and continues to play a noteworthy role—in agreement with other Italian chemistry actors—in planning, implementing, and organizing international scientific and educational events at the facilities of CNR headquarters in Rome, and in other locations in Italy.

CNR represents Italy in more than 40 international Scientific Unions and international Institutions, and covers a very broad spectrum of scientific and technical disciplines as well as humanities. More specifically, the Department of Chemical Sciences and Materials Technologies, DSCTM-CNR, thanks to its role as the chemists' home for CNR researchers, is the point of contact in international organisms relevant for the national chemical community, such as the International Union of Crystallography (IUCr) or the Centre Européen de Calcul Atomique et Moléculaire (CECAM). Since 2019, DSCTM-CNR also serves as national representative in the International Science Council, ISC. IUPAC is indeed an active member of ISC participating in various initiatives with its IUPAC Divisions. Through the wide participation of Italian experts, DSCTM-CNR works to maximize benefits from cooperative and complementary actions and to strengthen the relevancy of the increased role of chemical sciences in the future societal challenges.

NAO-CNR, the Italian National Commission

The National Commission for IUPAC, NAO-CNR, gathers relevant chemists active in the academic, and industrial sectors in the largest chemistry association, *i.e.* the Italian Chemical Society, SCI. The two institutions, CNR and SCI, promote together scientific projects and events that, in most cases, receive IUPAC's endorsement and see the participation of Italian IUPAC Officers. In particular, in 2010, under the CNR Presidency of Luciano Majani, Mario Malinconico was appointed as CNR delegate for IUPAC and served in this role from 2011 to 2018.

During this period, the first National Committee for IUPAC was established in 2013 [2] to enable a larger collaboration of the Italian scientific community linking academia and industry, and to re-launch a stronger synergy with IUPAC's initiatives. This endeavor was well supported by IUPAC President Kazuyuki Tatsumi, who met CNR's President Luigi Nicolais and the Italian Committee in 2013 in an official visit. This new trend was also highlighted in the important national workshop "IUPAC and Italy: state of the art and future strategies," held in Rome one year later and officially opened by a joint opening speech from the presidents of CNR and SCI.

The Italian NAO National Commission is composed of 7 members nominated by CNR and is supported by experts, including IUPAC Italian Officers, to ensure

multidisciplinary competencies and activities. The current Commission, appointed by the President of CNR Massimo Inguscio, is chaired by Maurizio Peruzzini for 2019-2022 [3]. The National Commission has been promoting an ever-increasing participation of Italy in IUPAC, by providing technical and management support to international initiatives and projects carried out in the framework of the Union's activities. Efforts are devoted to increase the interest of communities of professionals, experts, and stakeholders working in the Italian scenario in each area of interest for chemical science and technologies, paying a special attention to the industrial sector, in strict collaboration with the Italian Federation of Chemical Industry, Federchimica [4]. In particular, the National Commission highlights the role of chemical sciences in the fulfillment of the UN's Sustainable Developments Goals [5]. It is thus necessary to promote synergies of scientists, researchers, and professionals involved in the great challenges that humankind is facing in terms of sustainable economic growth, de-carbonization, and climate change mitigation.

In this role, the Commission pays constant attention to well-established IUPAC such as the Gold Book update project, as well as to recent IUPAC initiatives like the translation of the Periodic Table Challenge

10th IUPAC CONGRESS, ROME, 1938—SCIENCE AND PROPAGANDA*

by Marco Taddia

Although two nations, specifically France and the United Kingdom, played a leading role in the birth of IUPAC, the history of the Union reminds us that even Italy, along with Belgium and the United States, has been among the first nations that have actively cooperated in the foundation. Italian participation arose from the singular dynamism that at the beginning of the 20th century led to the organization of the VI International Congress of Applied Chemistry, which was held in Rome from 26 April–3 May 1906. The Proceedings of the Conference were edited by the distinguished chemists Emanuele Paternò (1847-1935) and Vittorio Villavecchia (1859-1937), formerly students of the famous Stanislao Cannizzaro (1826-1910). A proof that the Italian involvement was not a flash in the pan was the Union's first General Assembly organized in Rome in June 1920. Two more general assemblies were held in Italy. The 13th IUPAC General Assembly was held in Rome together with the 10th IUPAC Congress (14–21 May 1938). The event took place in a particular socio-political context. The fascist regime was on the top of its (*pseudo*) colonial fortunes and enjoyed popular support. Two years earlier (5 May 1936) the Italian army had entered Addis Ababa and conquered Ethiopia. In May 1938 the Fuhrer Adolf Hitler made an official visit to Italy: the arrival in Rome welcomed by Benito Mussolini. The Chemistry Congress was affected by the heavy rhetorical atmosphere which

Nicola Parravano (2nd from left) and Congressmen's homage to the Unknown Soldier

pervaded Rome and was a showcase for the fascist State. The President of the Organizing Committee Nicola Parravano (1883-1938), a prominent professor of General Chemistry at the University of Rome, was a supporter of the regime and held important positions. He and his colleagues appeared at official events in fascist uniform (picture above). Parravano died the same year (August 10) so the editor's name is not indicated in the conference proceedings. Despite the propaganda a merit must be acknowledged. Unlike previous meetings organized by academic subject areas, the 10th IUPAC Congress was structured in eleven thematic sessions, some of which concerned topics as food, health, hygiene and energy still relevant today.

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contest into Italian and the dissemination at the national level of the Top 10 Key Emerging Technologies [6]. In particular, the themes covered by the 10 Key Emerging Technologies issued in 2019 and relaunched in 2020 outline the need for chemical sciences to move towards an interdisciplinary approach, with evident points of contacts with biology, materials science, engineering, and information technologies, as well as to promote greater attention to sustainability, at environmental, economic, and societal levels. The National Commission participates with working groups to increase communication, knowledge, and outreach in areas of interest for the Italian chemical, scientific, and technical community, as well as for education and public opinion. Indeed, IUPAC, thanks to its supranational, non-commercial, and apolitical nature, represents an outstanding observation point to monitor and share the most revolutionary and innovative trends in the field of chemistry that are ready to be easily transposed from the laboratory level to commercially-available technologies.

The Italian Commission therefore started leveraging the value of IUPAC's message at the national level [7]. Such IUPAC initiatives are also relevant for providing chemists and researchers with sources of inspiration as well as guidelines at the international level to move towards challenging problems of global interest. The National Commission wishes to enable collaborative work by improving the active relationship with IUPAC's prestigious international reputation and to cooperate in projects sharing the latest developments and results.

Recent activities and scopes

Since 2014, the presence of Italian delegates gradually increased in IUPAC Divisions and Committees, holding positions as Titular Members, Associate Members and National Representatives. In 2015 the election of Pietro Tundo as a member of the Bureau represented a remarkable result for Italian participation in recent IUPAC's activities.

For the period 2020-2021, several Italian experts hold leadership roles in IUPAC Divisions: Lidia Armelao, Vice President of Division II—Inorganic Chemistry; Pierangelo Metrangolo, Vice President of Division I—Physical and Biophysical Chemistry; Roberto Terzano, Vice President of Division VI—Chemistry and the Environment; and Francesco Nicotra, Past-President of Division III—Organic and Biomolecular Chemistry.

The activities brought forward by Italian delegates and officers as well as the complete rebuild of the web page of the Italian National Commission for IUPAC (http://www.iupac.cnr.it/) increased IUPAC's scientific visibility by organizing and promoting initiatives in emerging fields of chemistry [8]. Some of these achievements are worth mentioning.

9th IUPAC International Conference on Novel Materials and Synthesis (NMS-IX), October 2013. Mario Malinconico, Italian delegate for IUPAC, receives the Distinguished IUPAC Award from Makoto Shimizu from Mie University, Japan, winner of a previous edition of the Distinguished Award.

Great efforts have been devoted in dissemination and awareness-raising activities to attract new generations of chemists towards Green and Sustainable Chemistry principles. Such a novel approach to chemistry marked a great change in the late 1980s and early 1990s after the scarce attention paid to environmental aspects in the previous decades. This led to the definition of the 12 principles of Green Chemistry in 1998 [9]. At the same time, this gradual change of perspective prompted the Italian members to design and organize a series of international summer schools on sustainable chemistry under the aegis of IUPAC and specifically addressed to PhD students and young scientists with non-permanent positions. Recently, it is worth mentioning the achievement of the Green Chemistry Post-graduate Summer School, held in Venice in July 2018. Building on this success, the 2020 edition of the school was held in the same city on July 6-10, involving 30 lectures and more than 190 participants from 43 countries all around the world. Due to the travel restrictions imposed by COVID-19 pandemic, the school sessions were managed online, in remote mode [10].

Italy hosted a major event to gather the supramolecular chemistry community, namely the 14th International Symposium on Macrocyclic and Supramolecular Chemistry, ISMSC2019, held in Lecce in June 2019, under the Chair of Vice-President of Division 1, Pierangelo Metrangolo. The symposium was attended by 712 participants from 43 different countries and addressed a wide range of key topic areas such as organic electronics, nanotechnology, biology, medicine and materials science, all sectors in

which supramolecular chemistry is a common tool for developing innovative materials, devices, macromolecules, or nanovectors [11]. Supramolecular chemistry is indeed flourishing across traditional borders and moving towards new interdisciplinary areas of research at the interface between chemistry, medicine, biology, and materials science.

Italian experts actively participated with the working group on nomenclature that has been continuously working on the definition of the names and terms in Italian of novel chemical subjects according to IUPAC's guidelines. An example worth mentioning is the project led by Italian coordinators, dealing with the definition of halogen bonding and other non-covalent interactions involving halogen atoms [12] or the basic terminology for crystal engineering, whose ambitious scope is to bring together world-renowned scientists working in various areas of crystal engineering [13]. In this framework, they completed the definition of Italian names of the most recent transuranic elements, whose discovery completed the seventh period of the Periodic Table of elements. Dissemination initiatives have included conferences for undergraduate and high-school students, interviews on newspapers, magazines, and TV programs, explaining to the public some scarcely known details about the long pathway from the initial discovery in the lab to the attribution of the name for a new chemical "object." This dissemination campaign culminated in the celebration of the 150th anniversary of the Periodic Table of Chemical Elements, with a broad series of events throughout 2019 and concluded in December in Milan, with the "X-mas Lecture" by Fabio Parmegiani.

Promotion and organization of congresses in Italy characterized the intense activity of IUPAC Divisions III (Organic and Biomolecular Chemistry) and II (Inorganic Chemistry). Italy offers attractive locations with excellent academies for top-level international scientific events. In the last few years Italy hosted the 22nd International Conference on Organic Synthesis in Florence in 2018, the 33rd International Conference on Organometallic Chemistry in Florence in 2018, and the 25th International Symposium on Glycoconjugates in Milan in 2019. Important Conferences programmed in Italy for 2020 under the aegis of IUPAC, such as the 44th International Conference on Coordination Chemistry scheduled in Rimini in July 2020, and the 31st International Symposium on Chemistry of Natural Products expected to be held in Naples last October, have been deferred and reprogrammed due to the current health emergency for the COVID-19 pandemic.

Italian Members promoted the organization of several national events in the framework of larger international IUPAC initiatives, such as or the 2020 edition of the Global Women Breakfast.

An authoritative delegation of the National Commission attended the 100 IUPAC Celebration and General Assembly 2019 in Paris and got a full understanding of the people who work for this great community and important related activities.

In this scenario, considering that multiple Italian actors have gained a recognized international role, the Italian Commission considered aspects that require particular attention in the next years. In detail:

1. Enhanced sharing of information on IUPAC's initiatives, and intensification of participation in

6th International IUPAC Conference on Green Chemistry, September 2016, Venice, Italy.

14th International Symposium on Macrocyclic and Supramolecular Chemistry, ISMSC2019, June 2019, Lecce, Italy

various contexts: academic institutions, public and private research sectors, industries, and scientific associations.

2. Support to initiatives targeting high-level educational programmes for young researchers; in particular fostering the presence of Italian participants in IUPAC's Young Observer Programme, with a thorough selection of candidates at national level.
3. Reinforcement of the participation of Italian experts and delegates in the Union's divisions and committees.
4. Definition of priority domains that are strictly related to sustainable development and circularity, in which competences and excellence by Italian actors can be exploited, with an increasingly stronger commitment.

These target domains are directed towards:

- decarbonization in energy and economy (CO_2 capture, storage and valorization; C_1 chemistry; "solar" fuels through innovative photochemical, photobiological, thermochemical, and/or electrochemical approaches; hydrogen production, storage and utilization);
- green and sustainable processes (high-efficiency low-impact catalysis; reduction or phase-out of critical materials in production processes; enzymatic technologies; biorefinery-derived intermediates and products);
- design, set-up and implementation of innovative next-generation materials (energy production and storage; 2D-materials; smart materials with unprecedented performance and/or functionalities; materials and bio-materials for targeted drug delivery and advanced medical diagnostics);
- next generation biobased polymers and polymeric materials; remediation strategies for microplastics and polymeric environmental micropollutants;
- health and medicinal chemistry (novel molecules for old and new pathologies; strategies against aging and chronic degenerative diseases; enabling methodologies in pharmaceutical chemistry; synthesis and characterization of new markers and molecules for molecular recognition).

In addition to these priority topics, in which several projects led by Italian experts were funded by IUPAC and are currently in progress, the recent outbreak of the global health emergency caused by the COVID-19 pandemic clearly highlighted the pivotal role of chemical sciences and technologies in the multidisciplinary struggle against SARS-CoV-2 coronavirus.

Therefore, the Italian Commission is planning activities, endorsed by IUPAC, for educational and awareness-raising purposes as well as to foster contrasting actions against this new pathogen in terms of detection, prevention, protection, and diagnostic capabilities [14].

In the coming months, the National Commission

aspires to gather experts from various professional backgrounds to increase projects and activities of international relevancy attracting also financial support.

International relations and cooperative activities are indeed a fundamental factor coming from Italian participation in IUPAC networks. To maximize benefits, it is also relevant to establish a continuous exchange between Italian officers in the IUPAC Divisions and Committees and the members of the National Commission of the Italian NAO. In order to accomplish this goal, other synergies are becoming relevant between IUPAC with other relevant international organisms, such as the European Chemical Society, EuChemS, or the Organization for the Prohibition of Chemical Weapons, OPCW, whose ultimate mission is the safe, sustainable and ethical use of Chemistry [15].

Conclusions

Starting from the unique and authoritative role for the definition of the official nomenclature of chemical compounds and the standardization of chemical quantities, IUPAC has become, in 100 years, the reference institution for scientists and professionals working in pure and applied chemistry—related disciplines in academic as well as in industrial sectors. For this reason, in coming years, the National Commission for IUPAC, NAO-CNR, aims to promote the participation of a larger number of experts in IUPAC international activities, with a special emphasis on the involvement of the last generations of chemists. NAO-CNR will therefore play the important role of catalyst for initiatives and actions proposed by the Italian chemical community to meet IUPAC's priorities and the UN's Sustainable Developments Goals. This will be carried out by promoting the organization of high-level international congresses, workshops, and educational events to be held in Italy. NAO-CNR will work with IUPAC to advance chemistry worldwide, the overall and common goal of all the IUPAC-NAOs.

Thanks to a stronger and more fruitful synergy among Italian universities, research agencies, chemical companies, and international organizations, it will be possible to meet the request of sustainable solutions and the needs of the society and market, for today's life and future wellbeing.

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3. The current National Committee was appointed on 19 April 2019. Members are Fabio Aricò (University of Venice), Angela Agostiano (University of Bari), Lidia Armelao (University of Padua and CNR Padua), Silvia Borsacchi (CNR Pisa), Matteo Guidotti (CNR Milan), Francesco Nicotra (University of Milan Bicocca), Maurizio Peruzzini (Chair, CNR Florence), Alessandra Sanson (CNR Faenza), Roberto Terzano (University of Bari) and Pietro Tundo (University of Venice).
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Malta X Anniversary and COVID-19

by Emma Zajdela and Zafra Lerman

In December 2021, the Malta X Conference "Frontiers of Science: Innovation, Research and Education in the Middle East—A Bridge to Peace" will mark the celebration of the tenth anniversary of the Malta Conferences. The first Malta Conference was held on the island of Malta in 2003 amidst the height of the Second Intifada. Since then, the Malta Conferences Foundation (MCF) has been a pioneer in using science diplomacy as a bridge to peace and sustainable development in the Middle East [1]. MCF uses science diplomacy to advance the following four UN Sustainable Development Goals: 1. Ensure inclusive and quality education for all (Goal 4) 2. Ensure access of Water and Sanitation for all (Goal 6) 3. Ensure access to affordable, reliable, sustainable, and modern Energy for all (Goal 7), and 4. Promote Peace and Justice, as well as inclusive societies (Goal 16). In 2016, MCF received the UN NOVUS Summit award for Goal 16: Peace and Justice [2]. The Summit was held in the UN General Assembly.

Widespread conflicts, spurred by a deteriorating environment, rapidly expanding populations, unsustainable water and energy supplies [3], inadequate educational institutions, unequal access to medical treatment and supplies, and most recently, the COVID-19 pandemic threaten civilization in the world. Science diplomacy is the best tool to address these issues, especially in regions of conflict. The Malta Conferences are the only platform in the world that brings together scientists from fifteen Middle East countries (Bahrain, Egypt, Iraq, Iran, Israel, Jordan, Kuwait, Lebanon, Oman, Palestine, Qatar, Saudi Arabia, Syria, Turkey, and the United Arab Emirates), Morocco, and Pakistan with several Nobel Laureates to form multinational collaborations in order to address these problems, which affect the region and the world. Although Pakistan is not part of the Middle East, Pakistani scientists requested to participate in the Malta Conferences in order to use the Malta model for science diplomacy between Pakistan and India.

Yaseen Al-Soud of Jordan discusses a poster at Malta IX.

Since its inception, MCF has held the strong belief that to use science diplomacy for peace and stability in the Middle East, all countries in the Middle East must be involved, not just Israel and Palestine, the focal point of tension in the region and the focal point of diplomatic efforts from the world. Therefore, MCF has worked on developing collaborations between Israel and other Arab nations. The attendees at the Malta Conferences were diverse in gender, religion, career stage, and cultures; they came from academia, industry, and government.

Many dignitaries have participated in the Malta Conferences. Director-General of UNESCO, Irina Bokova, and His Royal Highness Prince Hassan of Jordan [4] attended Malta V, which was held by invitation at UNESCO's headquarters in Paris as one of the last events of the 2011 International Year of Chemistry. His Excellency Dr. George Abela, President of the Republic of Malta attended Malta VI. Her Excellency Marie Louise Coleiro Preca, President of the Republic of Malta, the Maltese Minister of Education and Employment, and a member of the French parliament attended Malta VII (in Morocco) and Malta VIII. His Excellency Dr. George Vella, President of the Republic of Malta and the Maltese Minister of Education and Employment attended Malta IX. Several ambassadors participate in every Malta Conference.

More than 700 scientists have attended these conferences. Since these scientists, professors, and institute directors influence large numbers of students and the public, the impact represents an enormous multiplier over the conferences alone. The Malta Conferences have yielded results that are a cornerstone for a bridge to peace and sustainable development in the Middle East [5, 6], a model which could be implemented in other regions of conflict.

At Malta IX the introduction of interactive workshops co-chaired by a scientist and an entrepreneur encouraged collaborations and launching startups. A woman's forum was also initiated in Malta IX as a platform to discuss the role of women in science and in science diplomacy, in addition to developing guidelines

The Malta IX Head table from Left to Right: Fadila Boughanemi, Deputy Head of Unit, European Commission, DG Research and Innovation; Ambassador Roberto Tanzi-Albi, Senior Adviser, Ministry for Foreign Affairs of Finland; His Excellency George Vella, President of the Republic of Malta; Zafra Lerman, President, Malta Conferences Foundation; His Excellency Stuart Gill, OBE, British High Commissioner for Malta; and Mark Schapiro, Charge d'affaires, American Embassy in Malta

on how to encourage girls in the Middle East to pursue STEM fields. MCF provides an opportunity for students and early-career scientists to interact for five days with several Nobel Laureates and many distinguished scientists [7]. This forum is important in preparing the next generation to be successful in science diplomacy.

The COVID-19 pandemic has highlighted the importance of science diplomacy, which will continue to be crucial during the post-COVID period and especially among countries whose governments are hostile to one another. Science diplomacy can overcome cultural, religious, and political boundaries that other forms of diplomacy cannot.

With the current COVID-19 situation, dangerous misinformation has been appearing on social media and other outlets. COVID-19 prompted MCF to come up with creative ways to inform all the participants about the pandemic, research, and collaborations which contribute to the solution. MCF organized a series of virtual conferences for the participants of the Malta Conferences concentrating on COVID-19. The first virtual conference, held on 30 September 2020, was titled *Insights on the collaboration between Pluristem Therapeutics (Haifa, Israel) and Abu Dhabi (UAE) Stem Cells Center (ADSCC) concerning Covid-19.*

This is the first joint project which brings together the expertise and knowledge of Pluristem (Israel) and ADSCC (UAE) to advance a potential COVID-19 treatment**.** The project will involve the first-time administration of Pluristem's PLX cells via a nebulizer, a drug delivery device that helps a patient inhale a medication through a mask or mouthpiece, to COVID-19 patients. The collaboration will allow ADSCC to expand its stem cell therapy options using Pluristem's novel PLX cells, while enabling Pluristem to leverage ADSCC's nebulizer administration experience to develop a new treatment delivery model for PLX cells. ADSCC has reported effectively using nebulizers to treat patients suffering from COVID-19 infection with stem cells sourced from the patient's own blood.

Many publications were the result of this conference [8-14]. Yaky Yanay, Pluristem CEO and President, was hopeful about continuing collaborations following the conference. "We were very honored to unveil our first joint projects with the ADSCC at the Malta Conferences Foundation." He continued "We see our partnership as a movement between Israel and the UAE, which we hope will lay the foundation for future collaborations that will help potentially bring change to our region and the entire world. As we work together to develop regenerative medicine for key unmet medical needs of benefit to patients around the world, we are excited for the future and its possibilities."

Dr. Yendry Ventura, General Manager of ADSCC, was also optimistic about working with Pluristem "Embarking on this journey with Pluristem, to overcome one of this generation's most complex medical challenges, marks an exciting new chapter full of possibilities when it comes to knowledge sharing and medical innovation. Our partnership speaks volumes about the power of collaboration between partners across previously divided border." [8]

Although a virtual conference, the participants had the opportunity to interact with the presenters, ask questions, and have a discussion. Many of the participants discussed the opportunity to collaborate with the speakers. The reaction of the participants was extremely favorable. The speakers agreed to participate in Malta X.

The second virtual meeting on 14 October 2020, titled Insights into Science-Diplomacy on Covid-19, featured speaker Victor J. Dzau M.D., President of the US National Academy of Medicine [15].

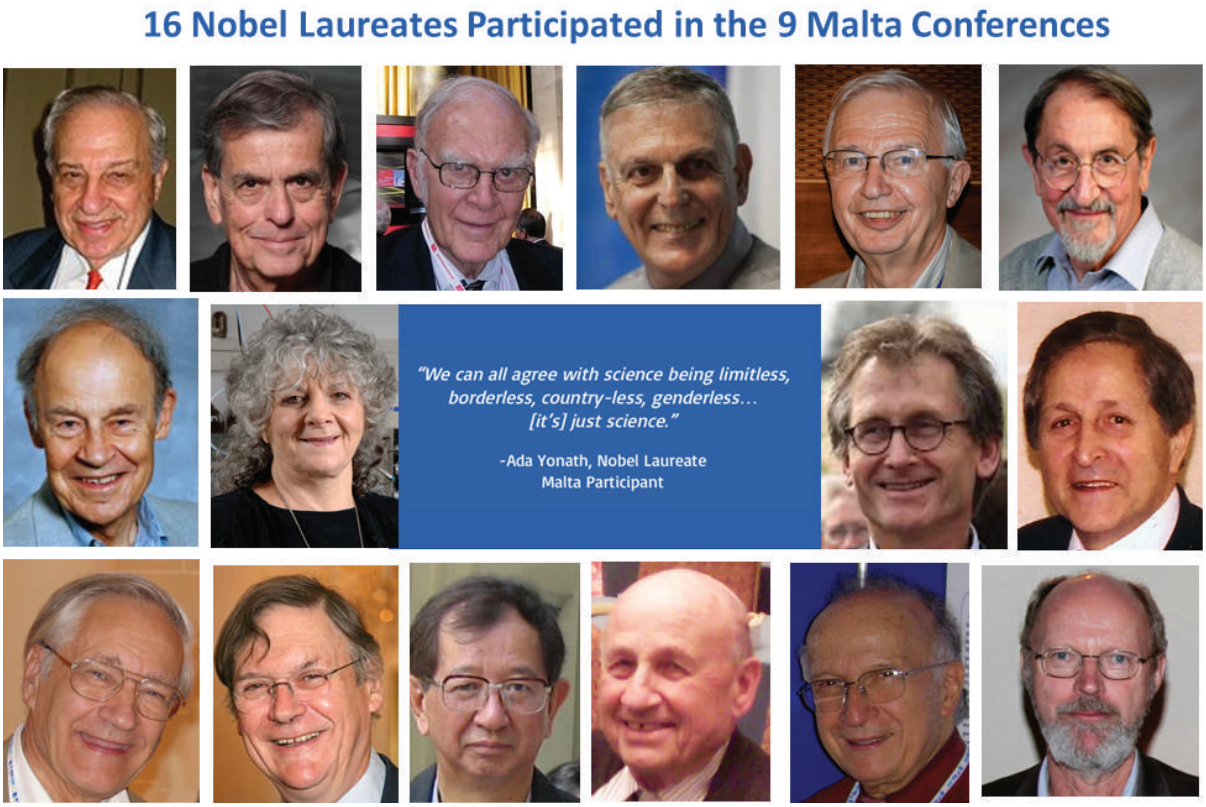
In his presentation, Dr. Dzau described the role of the Global Preparedness Monitoring Board (GPMB), which is an independent monitoring and accountability body to ensure preparedness for global health crises. It was created in response to recommendations from the UN Secretary General's Global Health Crises Task Force in 2017. The GPMB was co-convened by the World

Health Organization and the World Bank Group and formally launched in May 2018. Comprised of political leaders, agency principals and world-class experts, the Board provides an independent and comprehensive appraisal for policy makers and the world about progress towards increased preparedness and response capacity for disease outbreaks and other emergencies with health consequences. Its 2019 Annual Report, titled A World at Risk warned of the very real threat of "a rapidly spreading pandemic due to a lethal respiratory pathogen" and the need for determined political leadership at national and global levels (Figure 1). This report was published several months before COVID-19 but was largely ignored.

Dr. Dzau emphasized the impact of COVID-19, noting that the pandemic endangers all populations and is undermining all of the Sustainable Development Goals. For example, in global health, 90 % of healthcare systems were disrupted; in education, 1.6 billion students out of school; in climate, reduction of 30 % investment in clean energy transition; in poverty, there will be an increase of an additional 135 million people by 2030. He concluded that COVID-19 taught us that "we live in a world where a shock anywhere can become a catastrophe everywhere, which means we are interconnected."

Another initiative by MCF during COVID-19 is a virtual laboratory with an inventory of scientific equipment where Malta Conference participants who are lacking equipment for certain tests can send their samples to other laboratories in different countries to perform the required testing.

The Malta Conferences Foundation's mission is to address the shared desire to improve quality of life and political stability in the Middle East by identifying unique opportunities for collaboration to meet the scientific and technological challenges of the region. The Malta Conferences deal with issues of science education, air and water quality, nuclear and chemical security, access to medical treatment and supplies, and alternative energy sources, among other topics of



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mutual interest. Global leaders have recognized that science diplomacy is an extremely important mechanism for working toward stability in the Middle East, and this is what the Malta Conferences have done for the past two decades.

Many obstacles and challenges had to be overcome for every single Malta Conference. For example, the visa issue is almost insurmountable and requires working with embassies in many of the countries in the Middle East and with the government of the countries where the conference is hosted. Although work securing visas starts two years in advance of the conference, it is usually not clear until a few hours before the start of the conference that every invited participant will be able to attend. However, with tremendous effort from MCF, all the participants manage to arrive by the day of the opening ceremony.

Despite the immense challenges and obstacles, there are notable successes. Many personal friendships and cross-border collaborations have been formed. During the Malta VII in Morocco, meetings with several ministers from the government of Morocco and with the advisor to the King took place discussing relationships between Israel and Morocco. These negotiations started in 2015 and helped to achieve the normalization of the relationship between the two countries in 2020.

In a time when the world's eyes are focused on scientists for solutions, and media reports appear hopeless, MCF is offering a fresh approach through science diplomacy. The role of science diplomacy as a promoter of collaborative efforts among scientists is both diplomatic and educational. Improving human lives through science diplomacy has been, and continues to be, the mission of the Malta Conferences Foundation.

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The Continued Need for CHEMRAWN within IUPAC: A Personal Account

by Leiv K. Sydnes

At the General Assembly (GA) in Paris in July 2019, the IUPAC Bureau recommended to Council that CHEMRAWN should be dissolved. This led many to question 'What is the purpose of the CHEMRAWN committee?' and perhaps this can be seen most easily through what it has done and continues to do within its role in addressing topics relevant to the UN's sustainable development goals.

As the readers of this publication of course know, IUPAC celebrated its centenary in Paris last year. After having been active in the union in various capacities for almost 30 years I was indeed looking forward to the grand event. But the feeling of anticipation disappeared when I learnt that CHEMRAWN—*the* IUPAC Committee on Chemical Research Applied to World Needs—could cease to exist at the end of 2019 depending on the decision of Council. To me, serving both the presidential succession of the Union (2002-2007) and as Chair of CHEMRAWN for two periods (2008-2015), this caused significant dismay. Therefore, to make the IUPAC membership aware of what was going to be proposed at the GA, I took the initiative to write to all members of the Union and tell them what was about to happen. I was therefore not surprised when NAOs and delegates approached me and asked a number of questions before and after the GA. In fact, I still receive questions; not only that, it is clear that some people are not aware of the committee's work and so after some reflection, I decided to write this article.

IUPAC, CHEMRAWN, and the SDGs

CHEMRAWN was established through an active process in the middle of the 1970s, with the purpose of engaging IUPAC more in societal issues and focus on serving "as an international body and forum for the gathering, discussion, advancement, and dissemination of chemical knowledge deemed useful for the improvement of man and his environment." [1] When this quote from the CHEMRAWN Terms of Reference is compared with the text of the more recent United Nations (UN) documents related to the Millennium Development Goals and the Sustainable Development Goals (SDGs), it is clear that IUPAC, through CHEMRAWN, focused on and discussed many of these goals and associated challenges several decades before the UN. It is really impressive to look at the themes covered by the CHEMRAWN conferences (Box 1) and see how widely they have addressed the 17 SDGs that were adopted by the UN in 2015 (Fig 1).

With this as a backdrop, it would have been expected that the CHEMRAWN committee would become involved when IUPAC seriously started to address how to respond to the United Nations Millennium Development Goals first and then explore IUPAC's role in achieving the UN SDGs at the World Chemistry Leadership Meeting (WCLM) at the GAs in 2013 and 2015. That did not happen. The former topic was developed by a committee comprised of members from the Committee on Chemistry and Industry (COCI), the Committee on Chemistry Education (CCE), the Inorganic Chemistry Division (Div. II), and Fabienne Meyers supported by President Mark Cesa [2], the latter by President Natalia Tarasova, and members from COCI, CCE, and the Division on Chemistry and the Environment (Div. VI) [3]. No presentation dealt with CHEMRAWN's achievements related to, for instance, green chemistry, greenhouse gases, herbal drugs, and water management, which became central topics at both meetings. It may be that many in IUPAC are unaware of the CHEMRAWN's history and expertise in these areas, but I hope this article helps to spread the information that CHEMRAWN has a strong history in addressing existing and emerging world needs, and is 'open-for-business' to continue discussions, work in partnerships, and facilitate action in these important matters.

One person that was speaking at the 2015 WCLM, was the current Vice President of IUPAC, Javier G. Martinez, who gave an excellent lecture entitled "The Chemical Element: How Chemistry is Key to Solving our Global Challenges." However, CHEMRAWN and its contributions in this area were overlooked, according to my notes, and also in the later follow-up article "The Role of Chemistry" [4]. Since it was not normal practice to overlook CHEMRAWN in an IUPAC setting [5], this experience was disappointing because what was emphasized to be important to be successful in contributing towards the SDGs, is an integrated part of the CHEMRAWN approach and has been for decades. One example is the statement that "the collaboration between policy makers, the scientific community, and other stakeholders is critically important, and requires careful attention" [4]. Yes, indeed, that is why CHEMRAWN conferences include scientists, representatives from a range of industrial branches, research councils, international organizations, funding agencies, and politicians even at a ministerial level and as such, CHEMRAWN conferences have been unique IUPAC events. There are of course challenges in conducting such events when people from different environments come together. A politician will have a very different

focus than someone from a non-governmental organization, and an industrial scientist will have different priorities compared with an academic. However, it is essential that such groups come together, and it is my opinion that through CHEMRAWN, IUPAC should continue to support such events. Difficulties in establishing such meetings that tackle a problem from multiple angles become more apparent when we try to do this in more economically disadvantaged regions of the world. However, if as a union we are to act on global challenges, shouldn't all people and regions be represented? At the present time, CHEMRAWN is working with the Chemical Society of Nigeria on CHEMRAWN XXII: E-waste in Africa. If successful, CHEMRAWN hopes that this meeting can act as a model for similar events in different regions around the world, *e.g.* South-East Asia, because although e-waste is a global problem, sometimes the solutions need to be local and address regional needs.

IUPAC and green chemistry

Green chemistry has been on the IUPAC agenda for a long time, and the need to develop this field of chemistry, which involves many of the subfields dealt with by the IUPAC Divisions, was one of reason for the establishment of CHEMRAWN in 1973-75. This was reflected in CHEMRAWN I (1978), which, among other topics, discussed the use of renewable resources as organic raw materials for industrial application – this has since become one of the 12 principles of green chemistry. Later, two green-chemistry CHEMRAWN conferences were held; the first in 1992 on Chemistry and Sustainable Development: Towards a Clean Environment (CHEMRAWN VIII) and the second in 2001, entitled Toward Environmentally Benign Processes and Products (CHEMRAWN XIV).

The latter conference had indeed an impact within IUPAC. The vigor at the conference and the spirit among the participants certainly called for a follow-up meeting, but CHEMRAWN could not implement the idea because the committee organizes only stand-alone meetings and not conference series. The idea of starting such a series of IUPAC conferences outside CHEMRAWN then emerged and materialized when the 1st International IUPAC Conference on Green-Sustainable Chemistry (ICGC-1) was organized in 2006 in close collaboration with the German Chemical Society. Within IUPAC, the conference series became associated with the Subcommittee for Green Chemistry under the Organic and Biomolecular Chemistry Division.

From ICGC-4 (2012) onward, CHEMRAWN has been connected to this conference series through what is now called the CHEMRAWN VII Prize for Green Chemistry, an IUPAC biannual award funded from the

Fig. 1. The matching between the topics covered by the CHEMRAWN conferences and the UN Sustainable Development Goals, with the SDGs icons scaled proportionaly to the number of relevant CHEMRAWN conferences specified in roman numerals.

surplus made by CHEMRAWN VII and regularly presented at the ICGC conferences [6]. I was in charge of the award ceremony on behalf of CHEMRAWN both in 2012 (San Carlos, Brazil) and 2014 (Durban, South Africa) where in both cases the winner was celebrated with enthusiasm. In 2014, I also recall to attend a meeting of the Subcommittee on Green Chemistry to discuss a few issues regarding sustainability and its coverage within the IUPAC family. I left Durban a bit puzzled but I did not anticipate what might happen with respect to the future of CHEMRAWN. The few times the IUPAC Presidents interacted with us, no essential feedback beyond "Keep up the good work" was uttered. So when the Terms of Reference for the new Interdivisional Committee on Green Chemistry for Sustainable Development (ICGCSD) became available [7], the committee was baffled to learn that

- ICGCSD would be responsible for advancing the strategic plan of the Union for green and sustainable chemistry;
- ICGCSD would work actively with COCI and CCE to stimulate and increase interest in green and sustainable chemistry (*no mention of working with CHEMRAWN)*;
- ICGCSD would be responsible to promulgate the work of the Union in green and sustainable chemistry;
- ICGCSD would give advice on suitable persons for appointment as Representatives of IUPAC on other bodies concerned with green chemistry for Sustainable Development Goals.

Thus, those involved in the formation of ICGCSD created a committee with tasks that overlap significantly with those of CHEMRAWN and contributed to give IUPAC yet another committee, even though "IUPAC may have a larger number of sub-groups and committees than it really needs, which then leads to substantial administrative overhead and higher costs for running the organisation" [8]. In 2015, ICGCSD superseded the Subcommittee on Green Chemistry; the subcommittee was dissolved and the chair, Pietro Tundo, became the chair of ICGCSD.

ICGCSD has been in action several years already and its Chair presented a biannual report at the GA in July 2019 in Paris under item 16.6. This biannual report can serve to show that ICGCSD and CHEMRAWN actually work in different but complementary ways inside the Union. ICGCSD had organized or been part of a number of interesting events, but none of them gathered and involved a wide variety of stakeholders in a typical CHEMRAWN fashion, in discussing future actions to meet world needs and address SDGs. In the future, I hope both committees can work with each other, the Divisions and other Standing Committees towards a stronger, unified IUPAC because surely progress toward the SDGs need more, not less, effort to be achieved in a shorter timeframe.

CHEMRAWN conferences

In the recent assessment of CHEMRAWN (2018), the Evaluation Committee and the Executive Committee focused on the "number of conferences and follow-up or realization of future actions, plus other activities" [9]. Regarding the number, 19 CHEMRAWN conferences took place between 1978 and 2018. On an average, that corresponds to almost two years between each event, which is the standard for most IUPAC conference series. That is indeed a remarkable achievement because most of the CHEMRAWN conferences have focused on challenges and issues of main importance in developing countries, and that has made conference funding very challenging. Traditional supporters of chemistry conferences, such as chemical companies, suppliers of scientific equipment, and publishers, have not come forward. Then, to get financial support in developing countries, even when they will benefit the most from the meetings, has turned out to be very difficult. This has been a major handicap in the fundraising for CHEMRAWN conferences. In fact, the handicap has been so severe that close to half of the conference proposals developed through hard work by the volunteers of the committee in my time as chair were not announced and did not materialize because even combined efforts by the task groups and the CHEMRAWN committee gave insufficient funds for a meeting. Financial problems were also the main reason why two conferences that had been advertised, were later cancelled (see box).

Unlike field-specific scientific meetings, CHEMRAWN conferences are multidisciplinary and include, in addition to traditional scientific sessions, planning of practical projects for implementation after the meeting, discussions of benefits and societal impact, and planning of the fundraising for these projects. Thus, these conferences have a multifaceted group of stakeholders, which includes scientists, representatives from a range of industrial branches, research councils, international organizations, funding agencies, and politicians even at a ministerial level. Such meetings are therefore much more difficult to organize and run than traditional scientific meetings, which have a focused scope and essentially one homogenous group of stakeholders, *viz.* researchers with a specialization in the scientific subfield

An overview of the CHEMRAWN conferences held so far [1]	
CHEMRAWN I	Future Sources of Organic Raw Materials (1978)
CHEMRAWN II	Chemistry and World Food Supply; the New Frontiers (1982)
CHEMRAWN III	Resource Material Conversion: (Bio)Chemical Process Bridges to Meet Future Needs (1984)
CHEMRAWN IV	Modern Chemistry and Chemical Technology Applied to the Oceans and Its Resources (1985)
CHEMRAWN V	Current and Future Contribution of Chemistry to Health (1986)
CHEMRAWN VI	Advanced Materials for Innovations in Energy, Transportation and Communications (1987)
CHEMRAWN VII	Chemistry of the Atmosphere: its Impact on Global Change (1991)
CHEMRAWN VIII	Chemistry and Sustainable Development: Towards a Clean Environment, Zero Waste and Highest Energy Efficiency (1992)
CHEMRAWN IX	The Role of Advanced Materials in Sustainable Development (1996)
CHEMRAWN X	*The Globalization of Chemical Education—Preparing Chemical Scientists and Engineers for Transnational Industries*
CHEMRAWN XI	Latin American Symposium on Environmental Analytical Chemistry (1998)
CHEMRAWN XII	Chemistry, Sustainable Agriculture and Human Well-Being in sub-Saharan Africa (2007)
CHEMRAWN XIII	*Chemistry for Clean Energy*
CHEMRAWN XIV	Toward Environmentally Benign Processes and Products (2001)
CHEMRAWN XV	Chemistry for Water: Contribution of Chemistry to Quantity and Supply (2004)
CHEMRAWN XVI	Innovation in the Chemical Industry: The way from pure to applied chemistry (2003)
CHEMRAWN XVII	Greenhouse Gas Mitigation: Mitigation and Utilization (2007)
CHEMRAWN XVIII	Ethics, Science, and Development (2009)
CHEMRAWN XIX	Renewable and Sustainable Energy from Biological Resources (2011)
CHEMRAWN XX	Herbal Medicine for Health Care in the 21st Century (2015)
CHEMRAWN XXI	Solid Urban Waste Management (2016)

[1] Two advertised conferences, X and XIII, did not take place for financial reasons.

under consideration. I have been involved in organizing and running a large number of international conferences myself, and some of the CHEMRAWN conferences have indeed been the most difficult to put together and carry through. For instance, to be overall responsible and in charge of fundraising and programme development for the 18th IUPAC International Conference of Organic Synthesis (ICOS 18) in Bergen, Norway, in 2010 was a minor task compared to be *involved in* organizing CHEMRAWN XX: Herbal Medicine for Health Care in the 21st Century, which was held in Dhaka, Bangladesh, in 2015. So one might ask why bother with these events if they are so difficult to organize? We need only look to CHEMRAWN's unabbreviated name to understand, it is because there are world needs that urgently require addressing.

It is interesting to observe that the Executive Committee (EC) seemed to be of the opinion that the CHEMRAWN-conference format is out of fashion. In a letter from Past President Zhou to CHEMRAWN, the following reflection is presented: "CHEMRAWN was founded in response to specific needs arising from global responses to the challenges of sustainable development. The UN sustainable development agenda has evolved significantly since then, and with this the priorities of the scientific community and the challenges it faces have also changed. The methods and mechanisms by which we, as a worldwide

The main points in the letter sent to CHEMRAWN by President Zhou after the EC meeting in Alcala de Henares, Spain on 17-18 November 2018

• The EC appreciates all the work CHEMRAWN volunteers have done on behalf of IUPAC.

• IUPAC is forced to make some hard choices between the various activities it currently undertakes.

• There are now many mechanisms for scientific communication and engagement in addition to conferences. It was therefore concluded that there are higher priorities for the use of funding currently allocated to CHEMRAWN.

• EC unanimously decided to recommend to Council that CHEMRAWN should be disbanded at the end of this biennium.

• Current CHEMRAWN activities and initiatives can continue as projects, with the same people.

• Within CHEMRAWN, there are volunteers, who are eager to contribute to IUPAC activities and eligible for positions on other IUPAC bodies. They are encouraged to make themselves known so that they can be considered for positions so that their valuable expertise is not lost.

science organisation, can address them have similarly evolved. There are now many mechanisms for scientific communication and engagement in addition to conferences." [9] My experience with a number of the alternative mechanisms alluded to is that they are more commercial, less science-based, and completely lacking the IUPAC societal perspective. But then, adopt the EC position for a while and ask: Why not look at the traditional IUPAC conferences and apply the same line of thinking to them? Many chemical societies like American Chemical Society (ACS) and Royal Society of Chemistry (RSC) run a number of high-quality international conferences and so do regional federations of chemistry and publishers like Elsevier and Wiley, so why continue to run IUPAC meetings? Has the time come to consider other communication channels like webinars and online meetings? Such ideas have been briefly discussed by CHEMRAWN with the aim of increasing the societal input to CHEMRAWN's multidisciplinary and stakeholder-engaged conferences and thereby strengthening CHEMRAWN's societal relevance. As far as I am aware, CHEMRAWN is still discussing such possibilities and is excited by opportunities presented by ChemVoices, a joint initiative of the International Younger Chemists Network (IYCN) and IUPAC [10].

During CHEMRAWN XXI on Solid Urban Waste Management (April 2016, Rome, Italy), I got the opportunity to meet the Pope briefly and present IUPAC and talk about the topics discussed at the conference, which took place in Rome, Italy in April 2016. With a BSc in chemistry, Pope Francis showed keen interest in the topic.

Regarding the outcomes of the CHEMRAWN conferences, I agree with the Evaluation Committee that more could have been achieved. Although there is ample evidence of successes [11], there are also examples of follow-up actions that, for various reasons, have not been reported [12]. But it is my experience that the outcome of the CHEMRAWN conferences has been highlighted to the satisfaction of the local organizing committees in the countries where the conferences have been held (see picture above). In addition, all activities have always been reported to Council at the GA, and on no such occasion in my time in the Presidential succession (2002-07) and as committee chair (2008-15) was any dissatisfaction with the committee's work expressed. And again, why not also look at the traditional IUPAC conferences and the IUPAC Congresses in an output perspective and search for proof of impact beyond documenting the number of participants and who lectured and presented posters about what, where, and when? Although impacts from an IUPAC (or ACS, RSC or other) conference may be good for an individual's CV—they are probably not making an impact on society. Changes in academic and scientific culture are afoot, even more so since the COVID-19 pandemic, therefore, non-traditional conferences (virtual or otherwise) will become more important.

Was the work of CHEMRAWN volunteers satisfactory or not?

Since a proposal to abandon CHEMRAWN was put on the Council agenda when IUPAC gathered to celebrate its centenary, it is clear that a considerable dissatisfaction with the CHEMRAWN committee must have piled up. What is puzzling, however, is that since 2005, no such sentiment has ever been alluded to

when the IUPAC Presidents have interacted with the committee. And even when the decision to disband the committee was communicated in writing, the EC opinion is that the committee members possess valuable expertise and should continue to work for IUPAC (must have done a fairly good job). It is also stated that the current "activities and initiatives of CHEMRAWN can continue as projects with the same people" [9], which means that the ideas developed in CHEMRAWN must have been at least satisfactory.

Postlude

The leadership has great expectations for the Union, and ambitious goals have been outlined through *Chemistry International* for the global chemistry community [4,13]. In order to reach these goals, the Union has to build on "the amazing work that our thousands of volunteers do" [4] with a strong feeling of "we are all on the same team." [13] If such a human resource is going to be available and stay on working in a good IUPAC fashion, the Union has to be operated and governed in a collegial and transparent way. With changes underway influenced by the findings of the IUPAC Organizational Structure Review Group, I remain hopeful for the future of IUPAC and CHEMRAWN's position within it. As we have all got more used to talks and meeting via zoom and similar tools during 2020, our collective ability to come together while we are apart and make meaningful changes around the world through chemistry perhaps has greater potential than ever before.

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A Response by Christopher Brett, IUPAC President

In the article by Professor Leiv Sydnes on page 20, he shares his personal view on the proposal to dissolve CHEMRAWN that was submitted to Council in 2019. It is important to understand the context of the discussions that led Bureau to make this proposal. It was the result of several years of deliberation, first by the Evaluation Committee, and over a number of meetings by the Executive Committee and by Bureau. Many people, from different IUPAC bodies, analysed and debated how best IUPAC should continue to address the challenges of Sustainable Development and the Sustainable Development Goals as one of the Union's key strategic priorities, as described in the strategic plan and mission, which highlights the importance of chemistry to serve humankind and world needs, and CHEMRAWN's recent contribution

to these challenges. We thank all those who, within CHEMRAWN and in other IUPAC bodies, have contributed to achieving these goals.

For all of us who made that recommendation, it was a difficult decision. The following points are to give clarification to what was done.

1. The recommendation that CHEMRAWN should be dissolved was the culmination of a process starting in 2016, that involved (i) an investigation into CHEMRAWN's recent activities, principally by the Evaluation Committee, (ii) a unanimous decision to recommend dissolution by the Executive Committee in November 2018, (iii) endorsement by Bureau of the Executive Committee recommendation to Council, in its meeting in April 2019.

2. The Evaluation Committee (EvC) was tasked by the Executive Committee in 2017 to examine the past and current activities of CHEMRAWN, over recent years. The EvC conducted an extensive review that included many communications with the Chair of CHEMRAWN. The EvC report presented to the Bureau Meeting in Bratislava in April 2018. Further, complementary, information was requested and furnished in September 2018.

3. The decision taken by the Executive Committee in November 2018 was clearly stated in the letter from the IUPAC President and the Secretary General sent to the CHEMRAWN chair and secretary on 6th December 2018, and which was answered by the chair in mid-January 2019, outwardly accepting the decision but with disappointment. It was assumed that the CHEMRAWN chair had circulated this letter to the members of the committee.

4. Prof. Sydnes' article quotes sentences from the President's letter which can lead to the wrong conclusion, if it is not remembered that the situation in the 1970s was very different to that in the last 10-15 years. In particular, to quote the first sentence: "*CHEMRAWN was founded in response to specific needs arising from global responses to the challenges of sustainable development.*" In the 1970s, the importance of sustainable development was less recognised, whereas it is now a guiding principle.

5. CHEMRAWN, like all our Division and Standing Committees, is part of the standard IUPAC presentations, which are used by the IUPAC President, Vice President and other officers, and by the IUPAC representative in IUPAC-endorsed conferences. It is not correct to imply that CHEMRAWN has been systematically ignored, just because it has not been mentioned in two instances.

Chemistry faces many challenges, and the Sustainable Development Goals are central to the current strategy of IUPAC and are highly relevant for the whole organisation. Each of the Divisions and Committees has an important role to play. The only issue is how best to achieve these goals in a dynamic organisation. We are in the process of reviewing IUPAC's organizational structure and everybody is invited to contribute in an effective and constructive way to build a better IUPAC, so chemistry can keep serving humankind and world needs.

IUPAC CHEMRAWN XXII: E-waste in Africa Lagos, November 2021

ELECTRONIC WASTE MANAGEMENT—RECYCLING AND DISPOSAL
in partnership with the Chemical Society of Nigeria

Timothy Noel is awarded the 2020 IUPAC-ThalesNano Prize for Flow Chemistry

The 2020 IUPAC-ThalesNano prize for Flow Chemistry has been awarded to Professor Timothy Noël of the University of Amsterdam's Van 't Hoff Institute for Molecular Sciences. The prize, consisting of an award of USD 7500, honours outstanding contributions in the field of flow chemistry, microfluidics, micro fabrication, and micro systems engineering.

The coveted prize was established by the Hungarian Technology company ThalesNano to acknowledge the key role that flow chemistry plays towards the improvement of chemical processes. It is awarded by an international jury under the auspices of IUPAC.

In 2020, the jury has chosen Professor Timothy Noël as the winner out of a list of highly respectable scientists, nominated and recommended by leading scientists of the field. The jury comprised the chair of the IUPAC Committee on Chemistry and Industry (COCI), a representative of the Flow Chemistry Society, and three more international experts.

"Less than a decade ago, my team and I have challenged ourselves to expand the synthetic options for organic chemists by embracing flow chemistry as the prime technology," says Noël. "I'm very honoured by this tremendous recognition from the community for the research we are so passionate about. I want to thank all the people I worked with through the year. I want them to see this award as their award as well."

Noël is one of the leaders in the field of flow chemistry and, in the last decade, he has produced creative scientific contributions at the interface of chemistry and chemical engineering, pioneering novel continuous-flow catalytic strategies and technologies for organic synthesis. These tools have found a vivid implementation in the pharmaceutical industry, overcoming synthetic challenges often encountered at the bench in a variety of applications. In 2011 Noël received the Incentive Award for Young Researchers from the Comité de Gestion du Bulletin des Sociétés Chimiques Belges and he was a finalist of the European Young Chemist Award in 2012. In that year he was also awarded a VENI scholarship from the Dutch Science Foundation NWO. In 2015, he obtained the prestigious VIDI award from NWO. In 2016 Noël received the Thieme Chemistry Journal Award, in 2017 the DECHEMA award and in 2019 the Hoogewerff Jongerenprijs. He has been the editor in chief of the Journal of Flow Chemistry since 2019.

The prize was to be presented to Timothy Noël during the 2021 Flow Chemistry Congress Conference scheduled to take place in Boston (USA) in April but recently postponed because of the Covid-19 pandemic. Updated details of the award ceremony will be announced later.

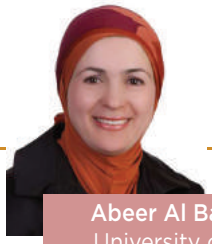
Previous awardees of the bi-annual prize were Prof. Oliver Kappe (University of Graz, Austria) in 2018, Prof. Volker Hessel (Eindhoven University of Technology; currently University of Adelaide, AU) in 2016, Prof. Steven V. Ley (University of Cambridge, UK) in 2014 and Prof. Klavs F. Jensen (MIT, USA) in 2012.

https://iupac.org/timothy-noel-is-awarded-the-2020-iupac-thalesnano-prize-for-flow-chemistry/

Awardees of the IUPAC 2021 Distinguished Women in Chemistry or Chemical Engineering

On time to celebrate International Day of Women and Girls in Science on February 11, IUPAC announced the awardees of the IUPAC 2021 Distinguished Women in Chemistry or Chemical Engineering:

- Professor Abeer **Al Bawab,** The University of Jordan, Amman, Jordan
- Professor Anne **Andrews,** University of California in Los Angeles, CA, USA
- Professor Mei-Hung **Chiu,** National Taiwan Normal University, Taipei, China/Taipei
- Professor Jingbo **Liu,** Texas A&M University-Kingsville, Kingsville, TX, USA
- Professor Katja **Loos,** University of Groningen, Netherlands



Abeer Al Bawab, The University of Jordan, Amman, Jordan

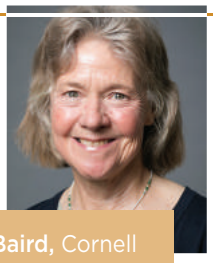
Anne Andrews, University of California in Los Angeles, CA, USA

Mei-Hung Chiu, National Taiwan Normal University, Taipei, China/Taipei

Jingbo Liu, Texas A&M University-Kingsville, Kingsville, TX, USA

Katja Loos, University of Groningen, Netherlands

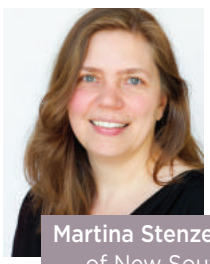
Françoise M. Winnik, University of Helsinki, Finland



Barbara Baird, Cornell University, Ithaca, NY, USA

Rachel Mamlok-Naaman, The Weizmann Institute of Science, Rehovot, Israel

Kyoko Nozaki, The University of Tokyo, Japan



Martina Stenzel, University of New South Wales, Sydney, Australia

Marcy Towns, Purdue University, West Lafayette, IN, USA

Supawan Tantayanon, Chulalongkorn University, Bangkok, Thailand

- Professor Marcy **Towns,** Purdue University, West Lafayette, IN, USA
- Professor Françoise M. **Winnik,** University of Helsinki, Finland
- Professor Barbara **Baird**, Cornell University, Ithaca, NY, USA
- Dr. Rachel **Mamlok-Naaman,** The Weizmann Institute of Science, Rehovot, Israel
- Professor Kyoko **Nozaki,** The University of Tokyo, Japan
- Professor Martina **Stenzel,** University of New South Wales, Sydney, Australia
- Professor Supawan **Tantayanon,** Chulalongkorn University, Bangkok, Thailand

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. Each year since 2011, the award has gained more attention in the community. 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. The awards will be made during the IUPAC World Chemistry Congress to be held in August 2021.

Christopher Brett, President of IUPAC, commented: "The group of this year's awardees comprises highly worthy recipients from all over the world who have all made a significant contribution to advancing the chemical and chemical engineering sciences. The award has been the focus of increasing attention since its inception in 2011, the International Year of Chemistry, and that we certainly plan to continue in the future."

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 marks a call to action for further achieve gender equality and the empowerment of

women and girls. IUPAC also celebrated that day with a Global Breakfast event on Feb 9 and with the theme of "Empowering Diversity in Science."

https://iupac.org/iupac-2021-distinguished-women/

Huizhen Liu and Banothile Makhubela have been awarded the 2020 IUPAC-CHEMRAWN VII for Green Chemistry

Huizhen Liu (China) and Banothile Makhubela (South Africa) have been awarded the 2020 IUPAC-CHEMRAWN VII Award for Green Chemistry in recognition of their outstanding contributions to the field of green chemistry.

Dr. Makhubela is a Senior Lecturer in the Department of Chemical Science at the University of Johannesburg in South Africa. She has published over 35 publications in internationally reputable journals and has been awarded two patents. Her research focuses on aspects of conversion of greenhouse gases into valuable chemicals, conversion of bio-derived molecules into chemicals and fuels as well as computational approaches to elucidate how molecules interact with each other. Makhubela performs research in the field of nano- and organometallic-catalysis directed towards catalytic transformation of renewable bio-derived feedstocks. Her catalysts allow access to valuable chemicals, fuels/fuel additives and smart materials prepared from sustainable starting materials. In this area, her team has developed hexanuclear RuII4-ZnII2 complexes that gave very high turnover frequencies for the hydrogenation of levulinic acid. She has already contributed in the area of using bio-based materials for the production of useful chemicals and in further bringing light into how these reactions work at molecular level so as to aid precise and waste-less synthetic process in benign solvents such as water, ionic liquid and deep eutectic solvents. This work contributes to the sustainable development goal of responsible production and consumption. http://makhubelaresearchgroup.com/the-group.html

Dr. Huizhen Liu is a professor at the Institute of Chemistry of the Chinese Academy Sciences. She has published 65 papers in peer-reviewed scientific journals. Her work is focused on the transformation of CO2 and biomass. She is especially well-known for her chemistry in selective catalytic transformations of lignin. Biomass is vital renewable feedstock and lignin is an important component. Lignocellulose is the most abundant form of biomass; cellulose is used to produce paper and many other products. However, lignin is a very challenging material to convert and is often discarded as waste. Most approaches aimed at converting lignin into valuable chemicals and fuels focus on breaking it down into low molecular weight compounds, which are further converted into useful products. Mixture was always obtained for the transformation of lignin because of its complex structure. Liu proposed a novel strategy for the transformation of lignin, where methoxy group in lignin was selectively transformed and acetic acid with high selectivity was prepared. She is able to perform this research with different types of lignin including kraft lignin and organosolv lignin. This work opens the way to produce pure chemicals using lignin as the feedstocks.

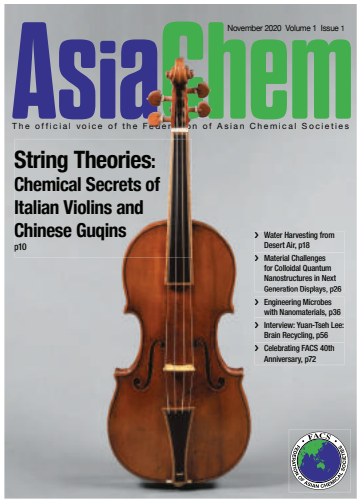
The CHEMRAWN VII Prize was first announced in August 2008 and since, has been awarded every two years at the IUPAC International Conference on Green Chemistry. The Prize is granted to a young investigator (less than 45 years of age) from an emerging region who is actively contributing to research in Green Chemistry. The 2020 CHEMRAWN VII Prize will be presented to Dr Makhubela and Dr Liu at the 9th IUPAC Conference on Green Chemistry that has been postponed to 2022 due to the current COVID-19 pandemic. The IUPAC CHEMRAWN VII prize has previously been awarded to Noureddine Yassaa (Algeria) in 2010, Rashimi Sanghi (India) in 2012, Vania G. Zuin (Brazil) in 2014, Ali Maleki (Iran) in 2016, and Mirabbos Hojamberdiev (Uzbekistan) in 2018.

https://iupac.org/what-we-do/awards/chemrawn-vii-prize/

The AsiaChem magazine is born

The newly born AsiaChem magazine echoes the voice of the Federation of Asian Chemical Societies (FACS). We believe that this biannual, free-access magazine will attract worldwide attention because it features cutting-edge science, history, essays, interviews, and anything that would interest a broad readership within the chemical community. All articles are authored by scientists who were born in Asian countries or actively working in Asia. Accordingly, the inaugural issue represents eight FACS countries, including Australia, China, India, Israel, Jordan, South Korea, Taiwan, and Turkey: https://www.facs.website/november-2020

In his best-seller, Clash of Civilizations, Samuel Huntington argues that after the end of the Cold War, when the age of ideology had ended, the world had



returned to a state of affairs characterized by cultural conflicts at the cultural interfaces. Huntington never suggested that one culture has an advantage over the others; rather that all should be equally respected. By comparison to other regional federations of chemical societies, including the European (EuChemS), Latin American (FLAQ), and African (FASC), the FACS represents the most diverse organization, spanning seven different cultures: Buddhist, Chinese, Hindu, Islamic, Japanese, Orthodox, and Western. This enormous heterogeneity, which has created significant challenges over the long Asian history, offers exciting opportunities in our times.

The center of gravity of the global economy is steadily shifting to Asia, and so is the scientific activity. These trends position the FACS member societies at a unique intersection with new opportunities and significant responsibilities. Asian countries notoriously known for brain-drain symptoms have become increasingly attractive to their scientists. We witness an increasing reverse flow of scientists who previously preferred to develop their professional careers abroad. Homeland culture, social awareness, and national solidarity attract emigrant scientists and their descendants born and educated abroad. Nobel Prize Laureate Yuan-Tseh Lee proposed replacing the term brain-drain with the adequate notion of brain-circulation.

Most global challenges, including global warming, food for everybody, the race for sustainable energy, water quality, dwindling raw materials, and health problems, are chemical problems by nature. Therefore, humankind cannot meet these challenges without the chemical sciences and will not solve any of these problems without global cooperation. Chemists have always been doing much better than politicians in meeting these challenges, working together across borders through unique collaboration and friendship. Despite fundamentally different political systems and cultural diversity, chemists go beyond borders, find each other, share their findings, and solve problems together.

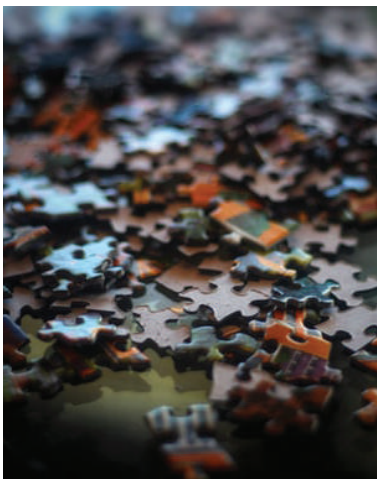
The global changes and the unique role of chemistry in meeting global challenges offer the IUPAC and regional federations, such as the FACS with new opportunities and significant responsibilities.

As the Communications Director at the FACS, AsiaChem's Editor-in-Chief, and a member of the IUPAC Bureau, I am proud to help catalyze the unification and cooperation among multiple chemists' communities of various cultures. I'll be grateful for receiving comments and new ideas on how to improve the magazine.

Ehud Keinan <keinan@technion.ac.il>, Technion—Israel Institute of Technology and President, Israel Chemical Society

https://www.facs.website/asiachem-magazine

Not an Epilogue, but a Commencement!



You might recall that in July 2019, IUPAC published a special issue of *Chemistry International* on various issues related to its history. This special issue demonstrated at length the challenges met in the past by an international scientific organization in a world where geopolitical and cultural contexts shift constantly, and in which science, and in particular the chemical sciences, evolves and grows, even as its role and responsibility in a globalized society grows in parallel.

The experience and history of your NAO are equally valuable to complete the accounts of IUPAC and of chemistry around the globe. As we look forward to pursuing the historical work with the IUPAC community, we will welcome an opportunity to hear from you and receive information and historical material (pictures, manuscripts, publications) that you might have.

IUPAC is seeking for your input! See survey from **https://iupac.org/not-an-epilogue/**

Thanks in advance for your consideration and for completing this short survey online. If you have any questions/suggestions, please do not hesitate to email Brigitte van Tiggelen <vantiggelen@memosciences.be>.

https://iupac.org/not-an-epilogue/

Nomenclature vs. Terminology

by Bernardo Herold

IUPAC is best known for its publications on chemical nomenclature. The results of more than a century's work on chemical nomenclature can be found in several of the so-called "Color Books." However, not all "Color Books" deal only with nomenclature as its main subject. One example is the "Gold Book" with the title "Compendium of Chemical Terminology." But is there a difference between chemical nomenclature and chemical terminology, and if there is, are they mutually exclusive, and how?

At first sight this seems to have the following simple answer: chemical nomenclature is about how to name chemical substances and terminology about explaining the meaning of terms used in Chemistry. When trying to draw an exact frontier between both concepts, one finds out, however, that the Devil is in the details and that many chemists have their own ideas about these details.

The first difficulty lies in defining very precisely the term chemical nomenclature, whereas defining chemical terminology is much simpler. Terminology is indeed a much broader concept, sometimes defined in dictionaries as being "the body of terms used with a particular technical application in a subject of study, profession, *etc.*" and "terms" being "words or phrases used to describe a thing or to express a concept, especially in a particular language or branch of study." One may add that a term may also be used to label a category into which one can place anything that fits the criteria defining that category.

With nomenclature, the question is much more complex. In most dictionaries the entry "nomenclature" is defined as "names of any material object and other things," and beyond that, even persons.

In Chemistry's case this would also include devices, tools, apparatus, instruments, *etc.*. However, most chemists do not consider these items to be under chemical nomenclature, but rather chemical terminology.

If we accept the above definition of chemical nomenclature as "how to name chemical substances" we are excluding as a logical consequence, the names themselves singly or as a group. They are not chemical nomenclature but the product of its application. It would then be better to classify the names under chemical terminology.

This is however quite different to what is done in other branches of Science. The term nomenclature appears to have been used for the first time in Botany and Zoology, where it refers to names of species and their genus, based on the system created by Linnaeus. In this case the names are part of nomenclature, but not so in Chemistry.

But is it possible to accept without any restriction the definition of chemical nomenclature as "how to name chemical substances"? This would mean that whatever the procedure to name a chemical substance is used, it would be called "chemical nomenclature." This is not accepted by the majority of the Chemistry community. Therefore, a more restrictive definition of chemical nomenclature is needed. One might expect to find such a definition in one of IUPAC's Color Books. This is not the case. There is indeed no entry in the Gold Book for the term "nomenclature." Wikipedia, however, fills the gap with the following definition: "A chemical nomenclature is a set of rules to generate systematic names for chemical compounds." It is however puzzling that instead of defining "chemical nomenclature" it defines "a chemical nomenclature." The difference is subtle, but it is there.

Some chemists are quite happy with this definition. One colleague suggested to add "the name given to the study and application of these rules." Sticking to these definitions would improve clarity and order in the way chemists communicate with each other when dealing with matters concerning chemical nomenclature.

But is it acceptable and necessary to restrict the meaning of the term nomenclature to such an extent? If one considers only Inorganic Nomenclature, there is indeed no contradiction between this definition and the recommendations of the Red Book's 2005 edition "Nomenclature of Inorganic Chemistry." There, the rules are exclusively about systematic nomenclature. The only names mentioned in the book which are non-systematic (if we disregard exceptions like water and ammonia) are mineral names. These are however explicitly excluded from chemical nomenclature by the Red Book, by saying that they "should be only used to designate actual minerals and not to define chemical composition."

Regarding Organic Nomenclature, the situation is however quite different, because many recommended names are non-systematic.

Let us see in the first place how the term "systematic name" is defined.

The "Blue Book," "Nomenclature of Organic Chemistry" in its 2013 edition defines "systematic name" in a slightly circular way as "a name composed entirely of specially coined or selected syllables with or without numerical prefixes and other structural

symbols and constructed following the rules of a systematic nomenclature, for example; cyclopropanecarbonitrile and 2-chloroethan-1-ol." Obviously, there is a logical flaw in using the term "systematic" both in the term, which is being defined as well as in its definition. The *ipsis verbis* adoption of this definition would lead us to the conclusion that a systematic name is a name generated by systematic nomenclature, which does not help very much. What is missing in this definition is to say that systematic names and systematic nomenclature are based on the composition and structure (connectivity and spatial arrangement of atoms). The same book recommends however, not only systematic names, but in many cases the use of so-called trivial names, which are defined as "a name no part of which is used in a systematic sense, for example xanthophyll." The same book also gives the following definition: "Semi-systematic name or semi-trivial name. A name in which only a part is used in a systematic sense, for example, methane, but-2-ene, and chalcone." In the nomenclature of natural products many trivial names are retained. For example, the list of so-called "fundamental stereoparents" in Chapter 10 of the New Blue Book contains more than a hundred trivial names and being "nonlimiting," especially for compounds whose structures are not yet well known, can be expanded at any time. These trivial names can be used as a basis to construct semi-systematic names for derivatives of these stereo-parents.

Since Organic nomenclature does not deal exclusively with generating systematic names, the definition in Wikipedia cannot be taken too literally. A broader definition is therefore needed. But can it be as broad as including everything which can be or has been done in order to name chemical substances? For somebody who looks up in a dictionary the meaning of nomenclature in general and for whom "chemical" means just "referring to Chemistry" this could be argued, but in practice the term "chemical nomenclature" is not used in such a broad sense. This is exemplified by excluding from chemical nomenclature the naming of pharmaceutically active ingredients by WHO World Health Organization by assigning them INNs (International Non-Proprietary Names), in spite of the ingredients to be named being chemical substances. Although they also have some kind of system for that purpose, it is not based on composition or structure of the substances.

The aim of the present essay is however not to discuss or propose an improved definition of chemical nomenclature, but to draw the line between chemical nomenclature and terminology.

There is no doubt that chemical terms, being "words or phrases used to describe a thing, a category of things or to express a concept within the domain of Chemistry," encompass many words or phrases, which are not covered by chemical nomenclature. They may refer to material objects as well as to their characteristics, their properties or their components, as well as physical and chemical phenomena, chemical substances and their classes, devices such as laboratory equipment, analytical methods and instruments thereof, theoretical concepts, *etc.*, all concerning Chemistry.

The names of chemical substances are not excluded explicitly from chemical terminology. Chemical nomenclature may therefore be considered as being a special branch of chemical terminology. In short: many terms used in Chemistry are not part of chemical nomenclature but all names that are the product of chemical nomenclature are also part of chemical terminology.

However, when some chemists speak loosely about chemical terminology, they exclude chemical nomenclature, which should not be done.

To complicate things further the "Orange Book's" title is quite misleading. Although the title is "Analytical Nomenclature," the book does not deal with chemical nomenclature at all. This can be easily verified, by scanning through the alphabetical "Index of Terms", which makes up the last 124 pages of its 3rd edition. Among its almost 6000 entries, names of chemical substances and the term "nomenclature" are nowhere to be seen. The title would perhaps be less misleading if it were "Terminology of Chemical Analysis" or something similar. It is not my intention to propose changing the title of the "Orange Book" because, in my opinion, no harm is caused by keeping its traditional name.

I do hope however, that the present contribution helps to clarify this complicated matter for some puzzled readers.

Professor Bernardo Herold is a member of the Centre for Structural Chemistry of the University of Lisbon and a member of the Lisbon Academy of Sciences. He has been a member of IUPAC for about 30 years. In 1991, he became a member and later the secretary of Commission III.1 on Organic Nomenclature. From 2002 to 2011, he served as secretary of the ICTNS Interdivisional Committee on Terminology, Nomenclature and Symbols. Since 2002, he has been a member of the Advisory Subcommittee of Division VIII Nomenclature and Structure Representation.

A Path to Entrepreneurial Education

by Joseph A. Martino III, James K. Murray, Jr., James Skinner, and Mukund S. Chorghade

In conversations with independent consultants and CEOs of successful small and mid-sized businesses, entrepreneurship is accessible to anyone, and anyone can do it.

Dr. Robert Hormann, a consultant in the chemical and pharmaceutical industry, defines entrepreneurship as "...first and foremost, fulfilling a need in society by solving someone else's problem and/or engendering joy. This goal is pursued through initiative, creativity, and resourcefulness by forming a new organization guided by economic considerations." [1]

Hence the question: Why is Entrepreneurship so difficult?

The Foundations to Entrepreneurship—A Pyramid, But Not a Scheme

The best way to look at an entrepreneurial approach is to view it as a pyramid:

All careers begin with a foundation. From an industrial perspective, the early career experience forms the basis for an entire career. This must be coupled with the education received at a college or university. As one advances through their career through the mid- and senior levels, one gains experience which builds upon their education. During the mid- and senior level, one's professional network grows, which allows the individual to effectively engage the chemical professional. Capitalizing on this engagement piece is critical to entrepreneurship. However, key to its effectiveness is the educational and experiential foundations from which it is built upon. These are gained in tandem with the career ladder. A question now becomes how to make this process more efficient to promote effective entrepreneurship.

Education

The traditional chemistry curriculum, at both the undergraduate and graduate levels, is focused on preparing students for their career as a chemist. This includes the necessary course work for preparing laboratory capable chemists who can secure meaningful employment in an industry or government laboratory or undertake graduate studies. This approach has been successful for many years. As time moves forward and technological advances are occurring at a lightning pace, revisions to this paradigm are beginning to take hold. One is now hearing the term "non-laboratory" positions for chemists; those that may involve only a minimal amount of laboratory work.

There are several widely recognized positions that chemists hold that can be thought of as "non-laboratory." These include patent law, scientific writing, sales and marketing, and chemical sector business analysis, to mention a few. One area which appears to be lacking is that of chemical entrepreneurship. There are examples of companies being built from the research efforts of faculty members. There are also companies that have been started by those who may have been affected by a downsizing or merger and acquisition. The scenario that is seen much less is a company that was started by an early career chemist, a person with a true entrepreneurial spirit.

Chemical entrepreneurship is a legitimate and viable career option for chemists that needs to be introduced early in the career of a chemist. There are those students who are incredibly skilled and dedicated chemists but have the desire to do something other than strictly laboratory work. They have ideas, see the bigger picture, and see a need in society that can be filled. If students are made aware of this as a viable career option, they can be mentored as to what types of courses, in addition to chemistry, that they need to take. Topics such as business plans, marketing and communications strategies, business operations and management, and avenues for securing capital are all part of what takes ideas from the mind, to the bench, to the market.

Students desiring this type of career path can be directed toward internship and mentoring opportunities that would allow them to explore this firsthand. Certain aspects of the chemistry curriculum could be adapted to allow students to explore entrepreneurship. These are all aspects that can be included in the education of chemists, but they need to know that this is an option earlier in their careers, not later.

1. Email correspondence from Dr. Robert Hormann to Joseph A. Martino III, October 12, 2020.

The goal here is to design ways of introducing students to chemical entrepreneurship. This can be done by additions to existing curricula, outreach, and mentoring. The material presented will provide the foundation on which the educational aspects can be developed, implemented, and assessed.

Tech Transfer

One way to make the process of entrepreneurial education and experience acquisition more effective is the tech transfer capabilities of an exceptionally large research university. The concept is this: A primary investigator develops novel technology in their research laboratory. This technology is then patented to protect its intellectual property. The tech transfer office at the university has in-house expertise to assist the primary investigator in either utilizing this novel intellectual property to form a start-up company that is affiliated with the university, or otherwise licensing the technology to other companies seeking such a technological application.

One of the limitations of the tech transfer process is that since it is located within the confines of the university setting, its services and expertise are restricted to the specific university community that it serves. Such services are not necessarily open to the public. Furthermore, there is no consistent tech transfer service across universities. Some tech transfer operations are extraordinary, while other universities either do not have the local or in-house expertise to pursue an effective tech transfer office or otherwise establish a tech transfer presence merely to compete with other universities that do. Smaller universities tend to utilize the resources of in-house general counsel as their tech transfer office due to a lack of resources for a fully staffed operation. Other universities establish a tech transfer group to satisfy federal grant requirements upon becoming recipients of such funding. As a result, a hodge-podge of entrepreneurial education at the graduate student, post-doctoral and tenure-tracked professor level results. Furthermore, since this track is limited to the student population, experienced professionals do not have access to such expertise.

Tech transfer processes can be improved two ways:

- A standardization of tech transfer operations among large universities
- The establishment of a tech transfer entity—an independent clearing house—to assist mid- and senior-level entrepreneurs with the marketing of novel intellectual property and entrepreneurial set-up

A Proposal for Entrepreneurial Education

We are proposing a three-tiered approach for entrepreneurial education. Any chemist at any level could participate in this endeavor for their own educational purposes. However, the program is geared for graduating doctoral students, finishing post-doctoral associates and experienced professionals who are exploring entrepreneurship as a legitimate and viable career path. The tiers are as follows:

- A general overview
- A practice “shark tank” environment with feedback
- A concierge service where entrepreneurs can find the resources and support that they need to start their own business

Tiers 1 and 2 would serve as milestone workshops, where budding entrepreneurs would determine whether or not they would move forward in entrepreneurship to the next tier. Tier 3 is where the budding entrepreneur has complete ownership and responsibility for their business, and this tier serves as a resource for support as well as a venue for networking.

TIER 1: GENERAL OVERVIEW

This general overview would consist of a workshop where the basic concepts of entrepreneurship are covered. This would be followed by testimonials from successful entrepreneurs as to what it takes to become one. Based on the information provided, the budding entrepreneur can either continue to the next

tier or decide that entrepreneurship is not for them. If entrepreneurship is not an appropriate path, the workshop may provide ideas for these individuals in terms of what they want to explore in their own career path.

TIER 2: PRACTICE "SHARK TANK"

Like the popular television show, this tier would allow budding entrepreneurs to pitch their business idea to real-world venture capitalists, angel investors and other representatives of funding agencies for real-time feedback as to whether or not their idea has business potential. The feedback could be utilized to confirm the business potential of their ideas, provide constructive feedback to make a legitimate business idea more marketable to investors and funding sources, or to determine that entrepreneurship is not for them. If it is determined that entrepreneurship is not viable, constructive feedback is given so that the individual can make a satisfying career choice based upon their ideas.

TIER 3: CONCIERGE SERVICE

For this tier, the budding entrepreneur has fully committed to entrepreneurship. This tier provides a resource of legal, tax and human resources advisors as well as venture capitalists, angel investors and industrial real estate brokers who can work with entrepreneurs to make their business vision a reality.

Conclusion

For too long, entrepreneurship has been underutilized as a legitimate career path. In our ever-changing economy, it is now clear that entrepreneurship as viable career path for a chemist should be re-explored in a clear, stepwise fashion. Our hope is that our proposal allows adventuresome chemists with a passion for science and with an ambitious vision a way to succeed in making their vision a reality.

Comments/feedback are invited and should be sent to Mukund S. Chorghade <mukundchorghade@fas.harvard.edu>.

Joseph A. Martino III, is from the American Chemical Society. James K. Murray, Jr. is from the Department of Natural Sciences, Immaculata University, James Skinner is from Terregena, Inc., and Mukund S. Chorghade is from THINQ Pharma.

Stakeholders' Thoughts on the Future of IUPAC

Update on the IUPAC Organizational Structure Review project

by Lori Ferrins, Ito Chao, and Mark Cesa

The IUPAC Organizational Structure Review group (hereafter referred to as the Review Group) was established in 2019 following approval from the Council to assess whether IUPAC needed to evolve in order to ensure its relevance to the scientific community given the pressing challenges that we face (https://doi.org/10.1515/ci-2020-0205). The Review Group was chaired by Mark Cesa (USA, former IUPAC President and current member of the Finance Committee) and included Ito Chao (China/Taipei), Michael Droescher (Germany, former chair of COCI), Lori Ferrins (Australia, Chair of International Younger Chemists Network), and Zhigang Shuai (China/Beijing), and *ex officio* Javier Garcia-Martinez (Spain, IUPAC Vice President). To assess thoughts of IUPAC's stakeholders, the Review Group circulated a survey asking respondents to talk about the scientific work of the Union, its structure, and its financial situation. The survey was circulated to those who attended the IUPAC Council meeting in 2019, Associated Organizations, Bureau members, Company Associates, Division members, National Adhering Organization (NAO) and Associate National Adhering Organization (ANAO) representatives, project task group chairs and members, Standing Committee members, and Commissions. In total it was sent to 1724 unique respondents, and 447 responses were received. NAOs were invited to submit responses to the survey holistically to assure that their views, in addition to those of individual stakeholders, were considered. The views of the NAOs and the individual stakeholders were in general agreement and, as such, have been considered together.

The major objective of the survey was to understand the perceived impact and scope of the Union's activities from stakeholders' perspectives. We in the Review Group sought to understand stakeholders' perceptions of activities such as setting and recommending standards, identifying and sharing emerging technologies, building capacity worldwide, publishing, endorsing scientific meetings, and recognizing scientific contributions and expertise, and whether respondents felt that each activity was something unique to IUPAC. Respondents were asked to look to the future and describe which areas IUPAC should be focusing on, and how the Union could adapt to the evolving needs of the scientific community. We also wanted to understand the perceived benefits of IUPAC membership, and how IUPAC could better engage with scientific societies and with industry. From a structure and financial perspective we sought to understand how IUPAC could better serve all its stakeholders, whether the current organizational structure was sufficiently agile to adapt to the changing times, and whether and how the Union should restructure to ensure that it is more responsive moving forward.

Respondents to the survey spanned 61 countries, and the overwhelming majority came from academia (64 %) with responses also coming from industry, government, NPO/NGO, students, and retirees (see Figure 1). Most responses were submitted by people aged 46-65, with 73 % of respondents men, 24 % women, and a small number who choose not to identify. Anecdotally, this appears to be consistent with the demographic of the volunteers that work with IUPAC.

The breadth of stakeholders invited to respond to the survey meant that some respondents may not be as aware of IUPAC's work as others. This may explain why some respondents recommended that IUPAC do more in some areas where it is already working well.

Respondents reported, unsurprisingly, that IUPAC is known internationally for being a leader in defining

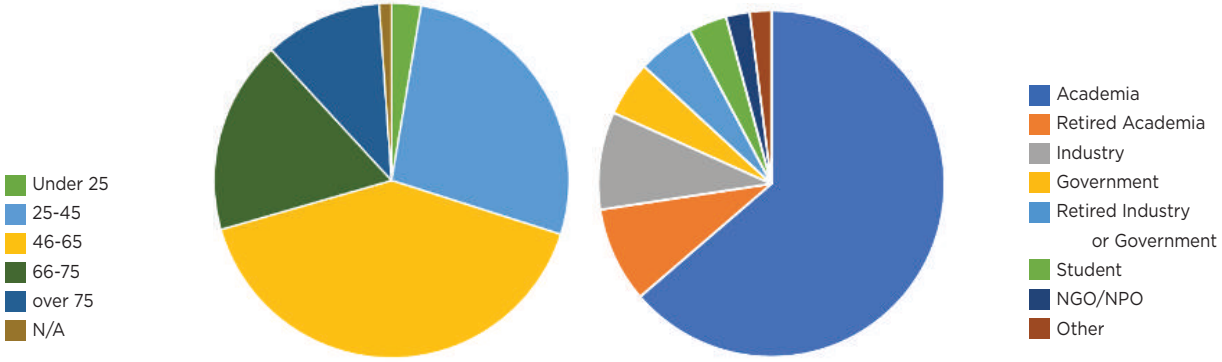


Figure 1. Demographics of the IUPAC Structure Review Group survey.

nomenclature, terminology, and symbols across the chemical sciences, and they acknowledged that this is a uniquely important activity and one of the Union's most valuable contributions. Setting and recommending other standards were also seen by many to be another unique feature of the Union. Respondents also highlighted the identification and sharing of key chemical technologies, building capacity worldwide, providing networking opportunities and catalyzing the formation of interdisciplinary collaborations as other valuable roles. Figure 2 summarizes the distribution of responses.

An important question asked in this survey was, "Does IUPAC need to change its structural organization?" While a large proportion (27 %) of people felt "ill-equipped" to answer this question, most respondents believed that the overall structure of IUPAC does not need to change (see Figure 3). However, around a third of respondents believe IUPAC should change its organizational structure, and interestingly, this percentage is greater among those who have been more involved (at higher levels) with IUPAC and are more familiar with the workings of the Union.

In terms of the scientific organization of the Union, there were several recommendations from respondents about which areas are missing from within IUPAC: for example, computational chemistry, materials science, and chemical engineering. Many also felt that IUPAC needs to refocus back to its "core" activities, particularly those that are unique to the union (including nomenclature, terminology, and standards). While these two ideas may seem contradictory, the Review Group believes that these goals can be accomplished by creating a structure of the Union that takes both core activities and emerging areas of science into account and promoting inter-divisional and inter-committee interactions.

The responsiveness of IUPAC to the rapidly changing scientific environment was a concern for respondents. Just over half of the respondents indicated that IUPAC is only somewhat responsive (45 %), or not responsive (6 %) to the changing world. Other scientific organizations have embraced the use of technology during the pandemic; running webinars and increasing their use of social media to deliver verified information, and better adapting to the current climate. This aligns well with many respondents who indicated that IUPAC should embrace technologies such as webinars, online voting, use of artificial intelligence, making color books digitally available, and open publishing. In addition, many people mentioned that IUPAC needs to incorporate these into the scientific work of the Union by looking at digital data standards, artificial intelligence, online streaming (lectures and laboratories), computational chemistry, deep learning, and open data.

When asked whether IUPAC should be a hub for information from and for NAOs, 76 % of respondents felt that IUPAC should fulfill this role. Sharing this information *via* the IUPAC website would ultimately improve the international visibility and relevance of the Union, though this would only be achieved through

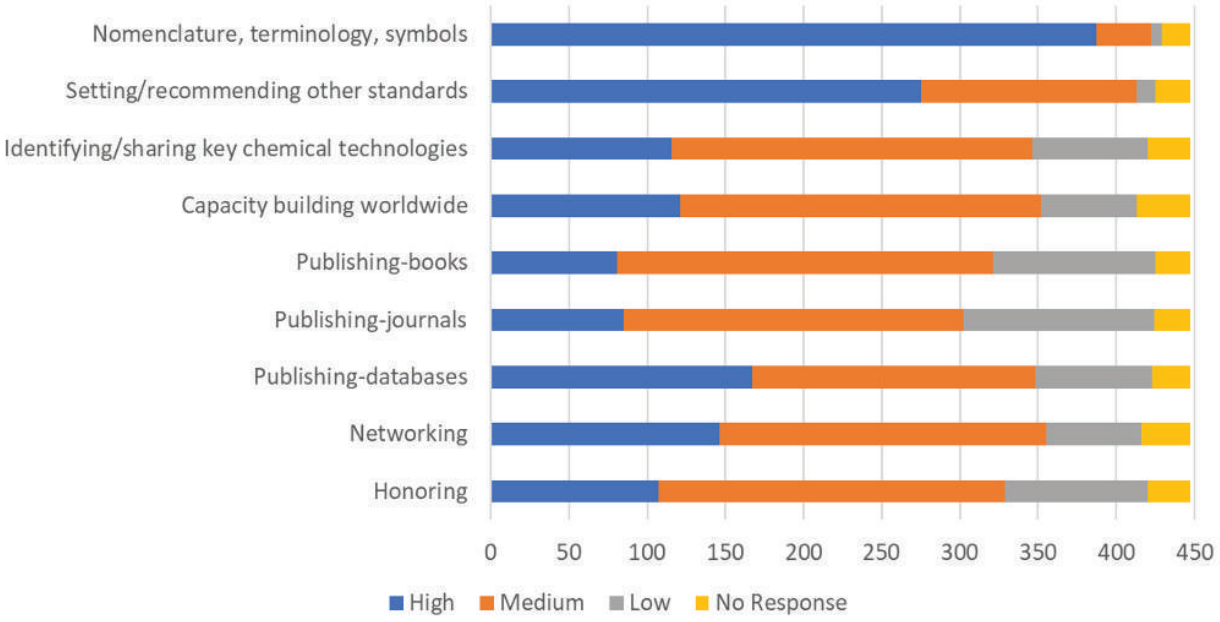


Figure 2. *How the respondents valued the various activities that IUPAC performs.*

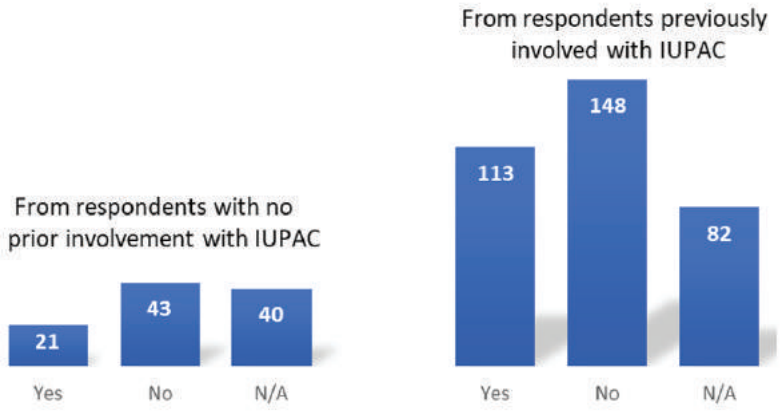


Figure 3. *Comparison of responses to the question "Does IUPAC need to change its structural organization?" between those with, and without, prior involvement with IUPAC.*

close collaboration with the NAOs and other scientific organizations. Several respondents called for IUPAC to increase its collaboration with major scientific organizations and some acknowledged that the current organizational structure may pose challenges for IUPAC to adapt to this rapidly changing world.

While most respondents were satisfied with the project system, there was concern among some about funding to cover the array of projects. Some respondents also would like to see projects managed effectively so that more projects are completed in a timely fashion.

Respondents had several ideas regarding how to decrease the operational costs of IUPAC, and how to go about raising additional revenue. Moving to online meetings, embracing the use of technology, setting of the Secretariat, and changing the organizational structure and project system were all suggested as ways to reduce costs. Respondents typically highlighted many of the efforts that the Secretariat and officers are already implementing to increase revenue (such as the endowment fund, or the IUPAC shop), though there were also suggestions to expand opportunities to bring back workshop offerings, hire a marketing manager, and expanding/promoting the membership offerings. Additionally, respondents believed that involving more industrial scientists in divisions and task forces and increasing communication with industry about the services and benefits that IUPAC offers to the community and the individual (*e.g.* the Company Associates program) would increase the revenue generated for the Union.

When asked for specific suggestions about how IUPAC could better serve its current members and volunteers, responses broadly fell into the following categories:

- Engagement/Assistance/Activities—provide/organize workshops, meetings, conferences, *etc.*; invite volunteers to Division and Standing Committee meetings (including provision of travel support); increase number of volunteers from developing countries; be involved in science policy development.
- Information/Communication—create an historical archive of IUPAC activities; develop newsletters; create awareness of activities amongst the NAOs and the broader scientific community.
- Recognition—provide certificates for service; provide support to enable participation in union activities (including funding to attend meetings).

In summary, there were several common trends amongst the responses to the survey. IUPAC should:

1. be more responsive, adjusting priorities in response to the rapidly changing scientific environment and culture;
2. remain focused on the core activities of IUPAC;
3. embrace technology in the day-to-day operation of the Union;
4. promote social equity and diversity in the chemistry community (this also needs to be reflected in the structure of the Union as a whole). There was an emphasis in the respondent's comments about having a formal younger chemists' program;
5. increase the visibility of the Union such that we can recruit top chemists to contribute to its activities; and
6. be more communicative—this applies to all facets of IUPAC'zs business, increasing communication with NAOs, Associated Organizations, and members.

The Review Group found the results of the survey valuable in preparing its report on the organizational structure of IUPAC. Respondents' comments and

suggestions helped inform the Review Group's recommendations on the governance and scientific structures of the Union. A report has been submitted to the IUPAC Executive Committee and Bureau for review and consideration in advance of the 2021 Council meeting. The Review Group hopes that the recommendations will help the Union become more flexible, facilitate better decision making, and make it more responsive in these rapidly changing times.

For more information and comments, contact Task Group Chair Mark Cesa <markcesa@comcast.net> | https://iupac.org/project/2020-007-1-020

A Database of Chemical Structures and Identifiers Used in the Control of WADA Prohibited Substances

WADA's role is to help regulate doping internationally working with international sports federations and governments. The list of regulated substances is published annually (https://www.wada-ama.org/en/what-we-do/the-prohibited-list), with substances listed in sub-categories (*e.g.* stimulants and anabolic agents) with their "common" names, for instance fenproporex, anastrozol. WADA laboratories are expected to report the names of such detected substances and/or their metabolites to their local regulatory bodies and partner laboratories alike. Although this is straightforward for substances specifically named on the Prohibited List, there is often inconsistency or lack of clarity for non-named substances that are still prohibited as "other substances with a similar chemical structure or similar biological effect(s)" under the rules. This may generate confusion and mistakes with respect to the nomenclature used during reporting procedures. There is a clear need in providing unambiguous compound identification and guidance to the anti-doping community.

This project will provide the antidoping community with a common language—guided by IUPAC experts—for the identification and reporting of doping substances across and beyond WADA-accredited laboratories. A IUPAC Technical Report will be published with these outcomes. This will be achieved via a compilation of the WADA Prohibited List of substances in the form of a set/database of chemical structures with WADA (common) names, their InChI and InChI Keys and other relevant identifiers. In addition to the regulated substances itself, it is important to include the key metabolites used in the specific identification procedures.

The intended database will be made available as supplementary material for the Technical Report for further dissemination. The database will be maintained by the authors for three years after the completion of the project or earlier if taken up by WADA, GlobalDRO (the online drugs information system for sport) or other competent body such as the Partnership for Clean Competition. The anti-doping community will therefore be equipped with a worldwide homogenous language code to report and disseminate doping cases with partner laboratories and regulatory bodies alike. Such a project will enhance the importance of already recognised IUPAC tools in anti-doping, providing a worldwide universal language to the intended stakeholders.

For more information and comments, contact Task Group Chair Vincenzo Abbate <vincenzo.abbate@kcl.ac.uk> | https://iupac.org/project/2020-017-2-700

Examples of the Introduction of Sustainable Development and Green Industrial Processes for Secondary School Chemistry and Introductory Chemistry

In secondary education, as well as in introductory chemistry courses in higher education, more and more attention is being given to the principles of green chemistry, as well as the ideas of sustainable development. This includes design principles like "cradle to cradle" and "cradle to grave," as well as life cycle analysis. The general ideas are not that difficult to grasp, but concrete examples about the way these principles are used in industry are not readily available, apart from two examples, adipic acid production and aspirin production.

In close cooperation between three standing committees, the Committee on Chemistry and Industry (COCI), the Committee on Chemistry Education (CCE), and the Committee on Chemical Research for Applied Applied World Needs (CHEMRAWN), as well as the Chemistry and the Environment Division and the Chemistry and Human Health Division, members will work together on describing ten industrial processes in which Green Chemistry and Sustainable Development principles have played a major role in the final design of the process. *Chemistry Teacher International* will be the ideal platform to share these descriptions with secondary education.

For more information and comments, contact Task Group Chair Jan Apotheker < j.h.apotheker@rug.nl> | https://iupac.org/project/2020-019-4-050

End-of-line hyphenation of chemical names (IUPAC Recommendations 2020)

Albert J. Dijkstra, Karl-Heinz Hellwich, Richard M. Hartshorn, Jan Reedijk, and Erik Szabo
Pure and Applied Chemistry, 2021
Volume 93, Issue 1, pp. 47-68
https://doi.org/10.1515/pac-2019-1005

Chemical names can be so long that, when a manuscript is printed, they have to be hyphenated/divided at the end of a line. Many names already contain hyphens, but in some cases, using these hyphens as end-of-line divisions can lead to illogical divisions in print, as can also happen when hyphens are added arbitrarily without considering the 'chemical' context. The present document provides guidelines for authors of chemical manuscripts, their publishers and editors, on where to divide chemical names at the end of a line, and instructions on how to avoid these names being divided at illogical places. Readability and chemical sense should prevail when authors insert hyphens. The software used to convert electronic manuscripts to print can now be programmed to avoid illogical end-of-line hyphenation and thereby save the author much time and annoyance when proofreading. The Recommendations also allow readers of the printed article to determine which end-of-line hyphens are an integral part of the name and should not be deleted when 'undividing' the name. These Recommendations may also prove useful in languages other than English.

Context and Example

When an article is about to be published, the author sends the electronic manuscript to the publisher who uses typesetting software to convert the manuscript into print. This conversion may entail dividing chemical names at the end of a line. The typesetting software used by the publisher, like the word processing software used by the authors, recognizes a hyphen as a location where a word can be divided. So, a name such as '1-methyl-1,2-dihydronaphthalene' may perhaps get divided at the third hyphen in this name. However, this does not make sense chemically. In chemical terminology, the '1,2' locants are closely associated with the 'dihydro'. Just listen to yourself when you pronounce the name. You stop after '1-methyl' and again after '1,2-dihydro' and you pronounce '1,2-dihydro' as if it were a single word. There is, therefore, a need to prevent software from using existing hyphens, or inserting new hyphens, to divide names at illogical places.

Actually, one can easily think of a few 'dos and don'ts' that will exemplify the concepts illustrated in the recommendation.

For example: 'poly[(chloromethylene)/methylene]' *can* be divided as:

Undest eaque mincto eriatem quosam fugiam poly-
[(chloromethylene)/methylene]' nonsequat quam, aut

or as:

Undest eaque mincto eriatem quosam poly[(chloro-
methylene)/methylene] fugiam nonsequat quam, aut

or as*:*

Undest eaque mincto poly[(chloromethylene)-
/methylene] eriatem quosam fugiam quam, aut

but not as

Undest eaque mincto eriatem quosam poly[(chlo-
romethylene)/methylene]' ugiam nonsequat quam

nor

Undest eaque mincto eriatem poly[(chlorometh-
ylene)/methylene] quosam fugiam quam, aut

nor

Undest eaque poly[(chloromethylene)/methyl-
ene] mincto eriatem quosam fugiam quam, aut

Following a series of definitions, this IUPAC Recommendations reviews a general approach to dividing chemical names at the end of a line, and provides guidelines to dividing chemical names in a chemically meaningful manner. It offers typesetting practices and presents numerous examples, before ending by reviewing the role of the author and that of the publisher/typesetter.

Chemical and biochemical thermodynamics reunification (IUPAC Technical Report)

Antonio Sabatini, Marco Borsari, Gerard P. Moss, Stefano Iotti
Pure and Applied Chemistry, AOP 30 Nov 2020
https://doi.org/10.1515/pac-2019-0908

According to the 1994 IUBMB-IUPAC Joint Commission on Biochemical Nomenclature (JCBN) on chemical and biochemical reactions, two categories of thermodynamics, based on different concepts and different formalisms, are established: (i) chemical thermodynamics, which employ conventional thermodynamic potentials to deal with chemical reactions; and (ii) biochemical

thermodynamics, which employ transformed thermodynamic quantities to deal with biochemical reactions based on the formalism proposed by Alberty. In this report, it is shown that the two worlds of chemical and biochemical thermodynamics, which so far have been treated separately, can be reunified within the same thermodynamic framework. The thermodynamics of chemical reactions, in which all species are explicitly considered with their atoms and charge balanced, are compared with the transformed thermodynamics generally used to treat biochemical reactions where atoms and charges are not balanced. The transformed thermodynamic quantities suggested by Alberty are obtained by a mathematical transformation of the usual thermodynamic quantities. The present analysis demonstrates that the transformed values for $\Delta_r G'^0$ and $\Delta_r H'^0$ can be obtained directly, without performing any transformation, by simply writing the chemical reactions with all the pseudoisomers explicitly included and the elements and charges balanced. The appropriate procedures for computing the stoichiometric coefficients for the pseudoisomers are fully explained by means of an example calculation for the biochemical ATP hydrolysis reaction. It is concluded that the analysis reunifies the "two separate worlds" of conventional thermodynamics and transformed thermodynamics.

Vocabulary of radioanalytical methods (IUPAC Recommendations 2020)

Zhifang Chai, Amares Chatt, Peter Bode, Jan Kučera, Robert Greenberg, and David B. Hibbert
Pure and Applied Chemistry, 2021
Volume 93, Issue 1, pp. 69-111
https://doi.org/10.1515/pac-2019-0302

These recommendations are a vocabulary of basic radioanalytical terms which are relevant to radioanalysis, nuclear analysis and related techniques. Radioanalytical methods consider all nuclear-related techniques for the characterization of materials where 'characterization' refers to compositional (in terms of the identity and quantity of specified elements, nuclides, and their chemical species) and structural (in terms of location, dislocation, *etc.* of specified elements, nuclides, and their species) analyses, involving nuclear processes (nuclear reactions, nuclear radiations, *etc.*), nuclear techniques (reactors, accelerators, radiation detectors, etc.), and nuclear effects (hyperfine interactions, *etc.*). In the present compilation, basic radioanalytical terms are included which are relevant to radioanalysis, nuclear analysis and related techniques.

IUPAC Provisional Recommendations

Provisional Recommendations are preliminary drafts of IUPAC recommendations. These drafts encompass topics including terminology, nomenclature, and symbols. Following approval, the final recommendations are published in IUPAC's journal *Pure and Applied Chemistry* (PAC) or in IUPAC books. During the commentary period for Provisional Recommendations, interested parties are encouraged to suggest revisions to the recommendation's author. https://iupac.org/recommendations/under-review-by-the-public/

Henry's law constants

Henry's law states that the abundance of a volatile solute dissolved in a liquid is proportional to its abundance in the gas phase. It applies at equilibrium and in the limit of infinite dilution of the solute. For historical reasons, numerous different definitions, names, and symbols are used in the literature to express the proportionality coefficient, denoted the "Henry's law constant." Here, a consistent set of recommendations is presented. An important distinction is made between two new recommended reciprocal quantities "Henry's law solubility constant" (H_s) and "Henry's law volatility constant" (H_v). Eight recommended variants of H_s and H_v are described and relations among them presented.

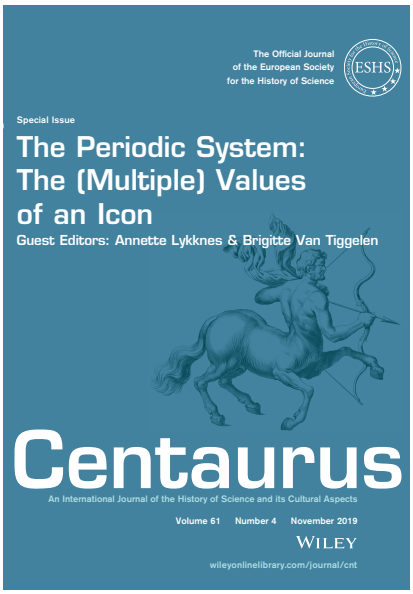
Comments by 31 May 2021

Corresponding Author: Rolf Sander <rolf.sander@mpic.de>

The Periodic System: The (Multiple) Values of an Icon

Centaurus Special Issue, Volume 61, Issue 4, November 2019
First published online 25 May 2020

reviewed by Annette Lykknes and Brigitte Van Tiggelen, Guest editors of the special issue



2019 was named the International Year of the Periodic Table, and rightly so. The periodic system is indeed an icon of science, with an exceptional level of usage around the world, as both a source of information and a pedagogical tool, and a recognizable imprint in popular culture, beyond the scientific community. Since 1869 when Dmitri I. Mendeleev proposed his first version, the periodic system has endured and developed, undergoing several additions, adjustments, revisions, and reinterpretations. Although many publications on the history and philosophy of the system have appeared over the years, few of them deal with its underlying values aside from predictability, which is usually presented as the main reason for its acceptance. In fact, the scientific community took several decades to endorse the periodic system and use it as the embodiment of chemical knowledge. In the special issue of *Centaurus—An international English language journal of the history of science and its cultural aspects* (volume 61- Issue 4) published earlier this year, scholars from different disciplines use the history of the periodic system to discuss what the system signifies and has signified for scientists and teachers, as well as for philosophers and historians. Two contributions by Bernadette Bensaude-Vincent and Helge Kragh underline how the evolving concept of chemical elements are tightly linked to the elaboration and expansion of the periodic system from Mendeleev's conceptual distinction between "element" and "simple substance" to the status and inclusion of manufactured superheavy nuclei in the process of constructing and expanding the periodic system.

Brigitte Van Tiggelen and Annette Lykknes stress the resilience of the periodic system, by contrasting different contemporary interpretations after radioactivity and the discovery of the neutron. Ann Robinson describes the tensions arising in selecting "the best" table for teaching purpose in the US scientific community, while Bettina Bock von Wülfingen analyzes the inclusion of colors and their value as added layers of denotation and understanding. Karoliina Pulkkinen shows how mathematical expressions of periodicity did not serve Mendeleev's intention despite his claim that periodicity was a natural law. Chris Campbell explores Charles Sanders Peirce's concept of icons applied to periodic tables.

By presenting different layers of underlying values as they appear in the eyes of the users, these contributions aim to provide a richer understanding of the periodic system, past and present, and the features that explain its endurance over the last 150 years, and in the many years to come.

Special issue content

1. Annette Lykknes and Brigitte Van Tiggelen, 'The periodic system: The (multiple) values of an icon'
2. Bernadette Bensaude, Vincent, 'Reconceptualizing chemical elements through the construction of the periodic system'
3. Chris Campbell, 'The periodic table as an icon: A perspective from the philosophy of Charles Sanders Peirce'
4. Helge Kragh, 'The periodic system and the idea of a chemical element: From Mendeleev to superheavy elements'
5. Brigitte Van Tiggelen and Annette Lykknes, 'A tale of resilience: The periodic table after radioactivity and the discovery of the neutron'
6. Ann E. Robinson, 'Chemical pedagogy and the periodic system'
7. Bettina Bock von Wülfingen, 'The periodic tableau: Form and colours in the first 100 years'
8. Karoliina Pulkkinen, 'Values and periodicity: Mendeleev's reception of the equations of Mills, Chicherin, and Vincent'

https://onlinelibrary.wiley.com/toc/16000498/2019/61/4

The Periodic Table: Past, Present, and Future

by Geoff Rayner-Canham, World Scientific Co, Singapore (2020); ISBN 978-981-121-848-4

reviewed by Jan Reedijk

With the International Year of the Periodic Table just behind us (www.iypt2019.org), it was a pleasure to learn that a new book has appeared dealing with the Periodic Table of chemical elements. In this case it is a book focused on the chemistry of the chemical elements, or more precisely on trends in the chemical properties of the elements of the periodic table. In fact, the extended book titles could well have been **"The Periodic Table for Chemistry**", or "**The Chemistry behind the Periodic Table"**, as the book is primarily written to show chemical relationships between the different chemical elements.

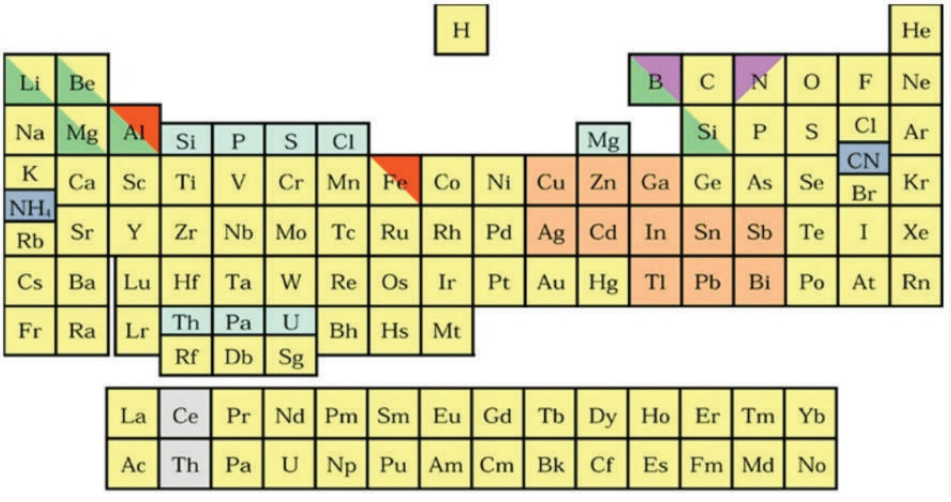
A specially composed periodic table on the front cover of the book, visualizes in multicolor coding how certain groups of elements are related chemically. As a result, certain elements even occur in two different positions of the periodic table! And also pseudo-elements, like ammonium and cyanide, are presented. Perhaps somewhat surprisingly, this Periodic Table ends at meitnerium, as from later elements not enough is known about their chemical properties.

A logical question, that I also asked myself, is: *Why has another book on the Periodic Table been written?* We have already so many, and why do we need to describe what Mendeleev devised over 150 years ago and which is worldwide shown in classrooms and cover pages of textbooks. But this is not just another book, as the author claims—and I do agree.

- There are many ways of organizing and grouping the elements based on their chemical properties. Some of these are generally seen as challenging, and they even may reveal philosophical thoughts. The present book shows much more, however, and deals with intriguing questions, like:
- What is the best position for hydrogen in the Periodic Table? Left, Right, Center?
- Could it be that an element may occupy more than one location on the periodic chart?
- Which elements are to be seen as the 'metalloids'?
- Why does vanadium behave so much like molybdenum, even in Mother Nature?
- Which elements should form Group 3 in the Periodic Table?
- Does aluminum belong in Group 3, or does it better fit in group 13?
- Why do silver(I) compounds resembling so closely those of thallium(I)?

Indeed, many of such questions are dealt with in a clearly written way in this stimulating and innovative book. The reader will quickly become interested in the subject and will be taken on tour through this Periodic Table in a very readable way, both for students and teachers.

The book comprises 14 chapters, starting with isotopes and nuclear patterns, including the long-known Ni-Co and Te-I anomalies in atomic weights, and the additions of the latest new element additions (2016). From the 118 currently known elements, only 80 of them have at least one stable isotope. A second



Cover Figure of The Periodic Table: Past, Present, and Future; used with permission from the book author.

introductory chapter deals with electronegativities and their discovery, but also with oxidation states and relativistic effects, all properly documented with almost 60 original references. As the author states: "the book is designed to make the many concepts of elemental relationships become alive and stimulating, not boring and soporific." It appears that the author has been quite successful in that approach, and I trust that students and chemistry teachers will find this a great set of introductions.

In Chapter 3 the author discusses some old problems of locations of the elements, like the "First-Period problems," in particular dealing with the question: Where should hydrogen be placed? Like some other recent textbook writers, the author defends the view that it should be central, as shown in the figure above.

Chapter 4 discusses in some detail "The Group 3 problem;" this case in fact is still very actual, also within IUPAC; but in the end the author gives strong arguments for the 15 lanthanoids and 15 actinoids, as used in the current IUPAC Periodic Table, grouped below the 7th row. [See *CI* January 2021]

Chapters 5 to 14 deal with topics based on the chemical properties of different elements and the similarities, even if placed in different positions of the Periodic Table. Chapter 5 is the one on "categorizations of the elements," and it is interesting to note how the author discusses and classifies such groups as: *Metals, chemically week metals (amphoteric), non-metals, metalloids, supermetals, refractory metals, noble metals, rare earth metals, superheavy elements and even ephemeral elements* (*i.e.* elements living very short, or less than a day).

Chapter 6 deals with isoelectronicity. Chapter 7 with main group elements (group and period patterns). This chapter is the largest one of the book; the author correctly concludes that periodic patterns and trends are the fundamental basis of the periodic table. The author makes clear that several limitations of periodicity exist, as illustrated by numerous examples.

In chapter 8 "Patterns among the transition metals" are discussed and the author shows that smooth patterns, systematic trends and continuities are in fact rare in this group of elements, and that their chemistry is largely unpredictable. In chapter 9 relationships between groups are discussed, like it was originally done in the "small form" of the periodic table, *i.e.* before the international community moved to groups 1-18 30 years ago, based on IUPAC initiatives; see E. Fluck, *Pure Appl. Chem*. 1988, **60,** 431-436 (https://doi.org/10.1351/pac198860030431).

Less common relationships between elements (chapter 10) are perhaps the so-called "Knight's Moves", *i.e.* two places to the right, and one place down, like Ag to Tl and Zn to Sn. It is shown that Ag(I) and Tl(I), have quite similar chemical properties, and the same holds for Zn(II) and Sn(II).

The last chapter deals with "pseudo-elements", *i.e.* combinations of elements that form ions that resemble the halogen ions (*e.g.* cyanide, thiocyanate), or resemble alkali metal ions (ammonium).

The number of illustrations is good, and they are clear, albeit largely in black and white; perhaps more colors could have been used for some figures. This book is indeed unique and quite thought-provoking. Looking backwards it is just a pity that it had not appeared in 2019 during the International Year of the Periodic Table.

Nevertheless, this book is highly recommended for students, teachers, researchers and not only chemists! Geologists, biochemist and also physicists will find it very interesting to read.

https://worldscientific.com/worldscibooks/10.1142/11775

EuroMedChemTalents

reviewed by Gerd Schnorrenber

The European Federation of Medicinal Chemistry (EFMC) celebrated its 50th anniversary in 2020. The EFMC was founded to promote science in Medicinal Chemistry and to support networking across European countries and their Medicinal Chemistry Societies.

From the early days, EFMC and IUPAC worked closely together, *e.g.* by organizing scientific congresses and educational events. Over the years EFMC accompanied developments in Medicinal Chemistry, including changes in indicational focus, or the emergence of new therapeutic modalities and technologies.

The recent foundation of the Young Scientists Network needs also to be acknowledged. It aims to support early career researchers in Medicinal Chemistry by stimulating networking and publishing of their results.

IUPAC congratulates EFMC and its representatives for their significant and impactful achievements made over half a century and looks forward to a continued and fruitful collaboration in the future.

The impressive history of EFMC is reviewed in a special edition of *ChemMedChem* published in December 2020, online at **https://chemistry-europe.onlinelibrary.wiley.com/doi/toc/10.1002/(ISSN)1860-7187.EuroMedChem-Talents.**

Bioinspired and Biobased Chemistry & Materials: N.I.C.E. 2020 hybrid

by Hernando S. Salapare III, Sonia Amigoni, Thierry Darmanin, and Frédéric Guittard

The **5th International Conference on Bioinspired and Biobased Chemistry & Materials** (N.I.C.E. 2020 Conference) chaired by Frédéric Guittard of the University of Côte d'Azur in France, was held concurrently at the Le Negresco Hotel in Nice, France and online via the Zoom platform from 12–14 October 2020. The aim of the N.I.C.E. conference series is to provide a venue to experts, researchers, managers, manufacturers, and policy-makers from various countries and with different scientific backgrounds, for the exchange of ideas, open discussion of current research problems, and the development of new ideas and collaborations aimed at finding sustainable solutions to materials challenges that will have an impact for generations. The event was held jointly with the 2nd International Conference on Optics, Photonics, and Materials, which was co-chaired by Stefania Residori and Umberto Bortolozzo, both from the University of Côte d'Azur in France.

Topics

The three-day event featured 2 plenary, 48 oral-parallel, and 1 poster sessions. They were divided into 3 general topics, 10 chemistry and materials symposia, and 5 optics and photonics symposia, namely:

General Sessions

NanoTech: nanostructured materials, polymer nanotechnologies, (anti)adhesive materials, mineralization, nanocomposites, micro and nanofluidics, nanomanufacturing, nanochemistry, nanostructured devices, nanoparticles, fluorinated materials, environment, and nanotechnologies in medicine

BioTech: green chemistry, tissue, biofouling, membrane, biobased chemicals and materials, bioadhesion, water technologies, building blocks, (anti) bioadhesion, bioengineering, biomanufacturing, biocomposites, biomass, biodegradable polymers, bioinspired catalysts, biosources for fuels, and polyethylene 2,5-furandicarboxylate

SmartTech: functional polymers, self-healing, biosensors, renewable energies, stimuli responsive materials (photochromic, ph-sensitive, thermochromic), interactive & autonomous materials, sensors, batteries, solar cells, optical devices, polymer brushes, and electrodes

Chemistry and Materials Symposia

Nature-Inspired Dyes and Pigments and their Applications: Focused on basic and applied studies of the chemistry and photochemistry of dyes and pigments modelled on natural plant pigments, the relevance for a deeper understanding of the biological roles of the pigments and the potentiam for innovative applications of natural and nature-inspired dyes and pigments. The symposium was chaired by Frank Quina of the University of São Paulo, Brazil.

Spin Dynamics, Spin Migration, and Spin-Spin Interactions in Chemistry and Biology: Covered topics on radical pair interactions in photosynthesis and artificial synthesis, methods for interrogating spin-spin interactions, the chirality induced spin selectivity effect, synthetic assemblies that control spin migrations, quantum coherence effects, spin transport, spin teleportaton, and generating/controlling spin currents. The symposium was chaired by Michael J. Therien of Duke University.

Bioinspired Chemistry and Materials for Sustainable Energy: Focused on key challenges pertinent to the impacts from energy production and consumption on the environment, the addressing of which requires not only innovative technological developments, but also unprecedented fundamental paradigms. The symposium was chaired by Valentine I. Vullev of University of California, Riverside, USA.

Bionic Surfaces and Interfaces: The broad thematic range of this symposium covered the recent challenges, technologies, and research trends on new biomimetic functional surfaces and interfaces. The symposium was co-chaired by Zhiguang Guo of Chinese Academy of Sciences, China, and Thierry Darmanin of University of Côte d'Azur, France.

Bioinspired Materials for Optics and Thermal Energy Applications: Focused on the emerging field of bioinspired engineering of optical and thermal materials, leveraging the diverse expertise from physicists, chemists, and engineers in discussing the fundamental mechanisms and innovative pathways for intelligent and efficient energy harvesting and utilization. The symposium was chaired by Tao Deng of Shanghai Jiao Tong University, China.

Nanobiocatalysts and Nanozymes: Covered strategies in the development of both new formulations and new enzyme biocatalysts and the development of artificial nanocatalysts for biologically important reactions in living organisms. The symposium was co-chaired by Vadim Kessler and Gulaim Seisenbaeva of the Swedish University of Agricultural Sciences, Sweden.

Tissue Extracellular Matrix Engineering: Covered topics on the molecular mechanisms of tissue mechanical modulations, biomimetic scaffolds and multifunctional materials, cross-linkers for skin regenerations, collagen binders, 3D bioprinting, and novel tissue engineering platforms. The symposium was chaired by Michele Marcolongo of Drexel University, USA.

Bioinspired Nanomaterials in Therapeutics: Covered advances in the development of nanomaterials towards therapeutics applications. The symposium was co-chaired by Michel Iafisco of National Research Council, Italy, and Luciano de Sio of Istituto Italiano di Technologia, Italy.

Plasma and Laser Processing of Bioinspired and Biobased Materials: Highlighted the advances and the challenges in mimicking nature through the use of plasma science and technology and/or laser technology. The symposium was chaired by Hernando S. Salapare III of the University of Côte d'Azur, France, Air Link International Aviation College, and the University of the Philippines Open University, Philippines.

Bioinspired and Biobased Molecular Architectures and their Applications: Focused on cutting-edge basic/applied studies relating to bioinspired and biobased molecular architects and provided deeper understanding of its unique characteristics and potential innovative applications to the chemists and engineers. The symposium was co-chaired by Masanobu Sagisaka and Tomohiro Imura of Hirosaki University, Japan.

Optics and Photonics Symposia

Nonlinear Optics and Complex Dynamics: nonlinear beams, nonlinear waveguides and optical self-structuration, disorder, and nonlinearity

Optical Metrology, Imaging and Sensing: holography, optical fiber sensors, control of light dispersion, and propagation in complex media

Nanophotonics: plasmonics and metasurfaces, silicon photonics, micro-resonators, metamaterials, and photonic crystals

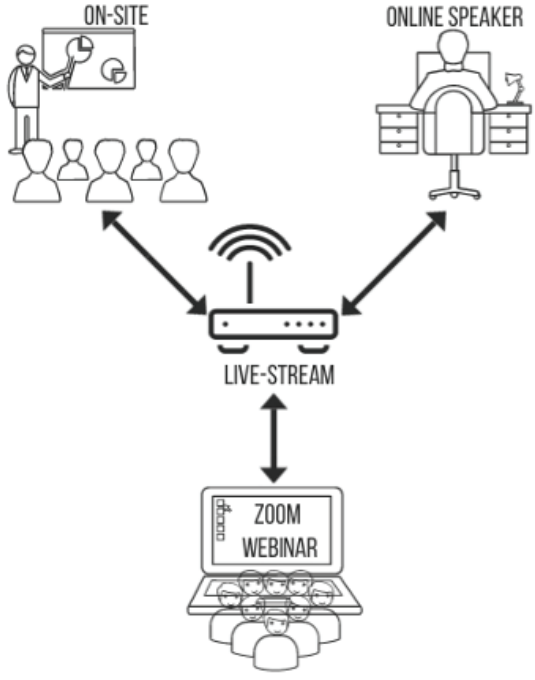
Biophotonics and Biosensors: optical coherence tomography, single-molecule microscopy and multi-photon imaging, bioinspired optical devices, optofluidics, fluorescence, and light-activated techniques

Soft Matter Materials: liquid crystals optics and technologies, colloidal, nanoparticles and active interfaces, organic photonic materials, and light-activated bio-inspired materials

Hybrid Conference Model: Adapting to COVID-19 Challenges

The 5th edition of the N.I.C.E. conference series was held in order to continue advancing science amidst the COVID-19 pandemic. A lot of planning allowed the event to continue and to accommodate all the participants from around the world in different timezones. The decision to pursue the hybrid conference model (on-site and on-line) was made after a wide consultation with major partners and endorsers, namely, IUPAC, MRS, and E-MRS, French Optical Society, CNRS, CEEBIOS, Vacuum Society of the Philippines, and Novachim, as well as with the plenary speakers, invited and keynote speakers, and members of the International Scientific Committee and the International Chair Committee. Constant monitoring of government regulations pertaining to COVID-19 events helped the organizing committee make the decision to hold the hydrid event.

The diagram below shows the hybrid conference model that was applied to the event. All talks, both from on-site and online, speakers were live streamed via the Zoom webinar platform with a unique channel for each of the 6 parallel rooms. This arrangement allowed all the participants whether on-site or online to join the session they were interested in. All the speakers were also given options to either pre-record their presentations or to present live on-site and/or via Zoom. The chair of each session played a very important role in coordinating all the speakers and participants from on-site and online where questions were taken from both the platforms.



To ensure the safety of the on-site participants, constant reminders were given to all the participants. The safety protocols that were imposed are as follows: reminder for constant washing of hands, hydro-alcoholic gels provided inside the venue; no shaking of hands or greeting people with kisses on the cheek; respecting social distancing as much as possible; wearing of masks at all times and reminding participants to replace masks every 4 hours as to maintain the integrity of the masks; reminder to proper wearing of masks, nose and mouth must be covered at all times and no lowering of masks when speaking to someone else; constant disinfection of rooms, materials used in the talks; informing the hotel reception or any of the conference volunteers/staff if someone suddenly felt ill during the event; and reminding the participants that if they intend to attend on-site but they suddenly feel ill or exposed to someone with COVID-19, that they shift their participation from on-site to virtual. No confirmed COVID-19 cases were reported after the event.

As for the organization of the hybrid conference model, it was more challenging than the traditional conference set-up. A lot of preparations and coordination with the speakers were made before and during the actual event. The conference cost was also a challenge since online participants were given registration discounts while the on-site expenses were maintained as with a traditional conference.

Plenary

There were two plenary talks during the event, the first during the first day of the conference from 2018 Nobel Laureate in Physics, Gérard Mourou of École polytechnique, France. Mourou talked about passion for extreme light and its applications to the greatest benefit of humankind. He presented the extreme-light laser as a universal source in providing a vast range of high energy radiations and particles along with the highest field, highest pressure, temperature, and accelerations. He presented the different applications of extreme-light laser in the fields of physics, chemistry, and materials science and engineering.

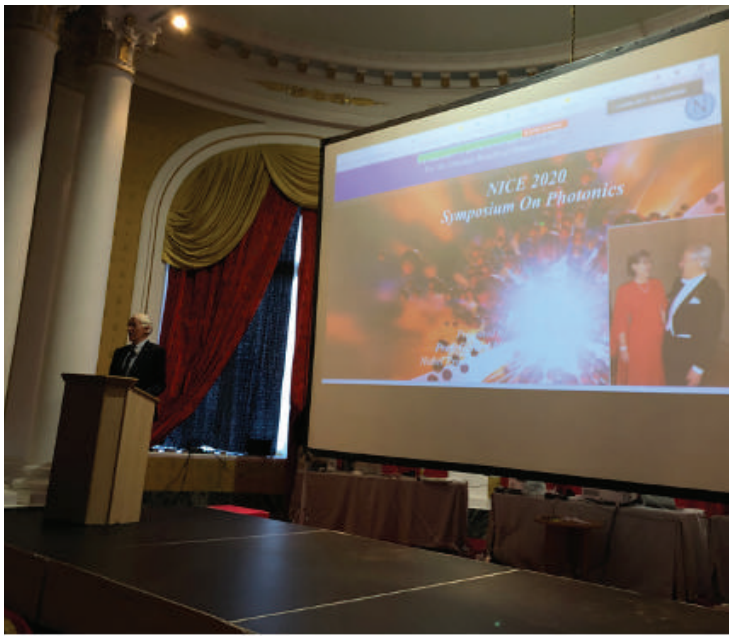
The second plenary talk was delivered virtually by Manijeh Razeghi of Northwestern University, USA. She talked about quantum engineering: building better quantum optoelectronics devices from the atoms up. The talk focused on the atomic engineering of III-V semiconductor optoelectronic materials for a variety of applications important to everyday activities. The applications span many areas, including industrial quality control, public health and safety, and telecommunications.

Invited, Oral, and Poster Contributions

The conference also featured 132 invited talks, 93 oral contributions, and 22 poster presentations. Most of the on-site participants were from European countries as there were no restrictions for travel among European Union nations. The rest of the world from North and South America, Africa, Australia, and Asia joined virtually. The final scientific programme had several changes days before the event due to the time differences of all the participants.

GDR 2088 "BIOMIM": French Network on Biomimicry and Bioinspiration

GDR 2088 "Biomim": Biomimicry and Bioinspiration, established by the Institute of Chemistry of the French National Center for Scientific Research (CNRS) in January 2020 to unite all French actors working in the field of biomimicry and bioinspiration, also held its 1st Annual Meeting in a hybrid format from 13-14 October 2020, jointly with N.I.C.E. 2020. The two-day event discussed the latest developments and research of 92 research groups with 700 scientists, comprising GDR 2088 members, who are working on topics that seek to resolve scientific, societal, and regional challenges in France that are related to biomimicry and bioinspiration. The meeting featured 8 parallel sessions covering: general topics on bioinspiration and biomimicry; movement, mobility, bioinspiration, bio-robotic; biomaterials and bioinspired medical devices; drugs and bioinspired materials of therapeutic value; feeling,



Plenary Talk of Prof. Gérard Mourou, 2018 Nobel Laureate in Physics, delivers a Plenary Talk on the Passion of Extreme Light.

Recipients of the student awards: from left to right, E. Strugovshchikov, E. Vedie, D. Hürlimann, T. Girardet.

experiencing, perceiving; structures in biomimetic systems and perspective applications; and biosensors and chemical sensors. GDR 2088 is also open for international partnerships; the website can be accessed at https://www.gdr-biomim.com.

Closing Ceremony and Student Awards

During the closing ceremony, Prof. Guittard expressed his sincerest gratitude to everyone who made the event successful, especially for those who attended on-site, amidst the increasing number of cases in France, and for the virtual participants who dedicated their time, even in the wee hours of the night, just to participate in the event. He also thanked the different committees that guided and organized the event. He announced that the 6th edition of the N.I.C.E Conference Series will be held October 2022 in the same venue. After the closing remarks, Prof. Salapare awarded the four student prizes to the following: 2 Best Oral Communications (sponsored by the journal Biomimetics – MDPI) to Evgenii Strugovshchikov of the Institute of Physics, University of Tartu, Estonia, for his work on "Orthogonal chemistry in materials design: Mixed-anion compounds as a case study", and to Elora Vedie of Université de Toulon, France, for her work on *Fabrication and characterization of biomimetic textures for antifouling applications*; Best Poster Award (sponsored by the journal ACS Applied Materials & Interfaces) to Thomas Girardet of Université de Lorraine, France, for his work on *Elaboration of functionalized iron oxide nanoparticles by microwave assisted coprecipitation*; and Best Poster Award (sponsored by ACS Applied Bio Materials) to Dimitri Hürlimann of the University of Basel, Switzerland, for his work on *Bioinspired molecular factories as cell mimics.*

Research and Innovations in Chemical Science: Paving the Way Forward

Experiences and reflections on the month-long IUPAC-endorsed Virtual Conference on Chemistry and its Applications, staged in August 2020.

by Lydia Rhyman, Hanusha Bhakhoa, Nandini Savoo, and Ponnadurai Ramasami

The Computational Chemistry Group of the University of Mauritius (CCUoM) [1] is involved in carrying out research using computational chemistry methods to solve chemistry and interdisciplinary problems. Apart from research work, CCUoM started a virtual conference on computational chemistry and its applications in 2013 (VCCC-2013) [2] and some of us shared our first experience on the organization of the virtual event [3]. After organizing VCCC for three consecutive years, the topics of the virtual conference were extended to other scientific fields using computational methods and thus, an annual virtual conference on computational science (VCCS) was organized for four years. In these virtual conferences, different aspects of a traditional face-to-face conference were maintained, such as a website for the event, call for abstracts, abstract submission, reviewing of abstracts, book of abstracts, presentations, certificate of participation, conference programme, call for full papers, and publication of the proceedings. The salient features of these virtual conferences were that they took place during the whole month of August, there was no live presentation, a nominal registration fee was applicable, free registration was also possible, there was an online platform for scientific interactions, and a virtual cultural day

was held on the last day. There have always been good responses for these virtual conferences with an average of 30 presentations and 100 participants from 25 countries. After each virtual conference, a survey was conducted and the feedback was helpful in improving on subsequent virtual events.

VCCS-2020 was planned for August 2020 but alas, there was the outbreak of COVID-19 in December 2019. On 19 March 2020, the Government of the Republic of Mauritius announced a complete lockdown in Mauritius. In light of this, we decided to apply the experience and feedback that we gathered from our previous virtual conferences and broadened the range of topics to include chemistry and interdisciplinary science subjects so as to promote scientific give-and-take while the world was confined. By broadening the list of topics, we also provided more diverse opportunities for the increasing number of participants that our virtual conferences were attracting over the years. These resulted into the birth of the virtual conference on chemistry and its applications (VCCA-2020). A formal endorsement request was sent to IUPAC. The request was successfully approved which makes VCCA-2020 the first virtual conference that was endorsed by IUPAC. In addition, we collaborated with other international institutions, namely the Organisation for the Prohibition of Chemical Weapons (OPCW), the International Centre for Theoretical Physics (ICTP), Springer, the Royal Society of Chemistry (RSC) and Elsevier, which eagerly supported VCCA-2020 and played an important role in promoting the virtual conference. OPCW sponsored the participation of seventy participants from Sub-Saharan Africa.

As we were preparing for VCCA-2020, the scientific community kept research dissemination and networking ongoing as a result of the surge in virtual conferences [4-6]. In fact, most of the conferences were transitioned to online events [7-10]. Virtual conferences offer possibilities which fit the changing needs of the new era of COVID-19; for instance, researchers may attend a conference while abiding by the travel restrictions and social distancing measures [11]. Moreover, virtual conferences provide a more inclusive platform for scientific discussions whereby researchers from laboratories and institutions with limited funding can participate [12,13].

The starting points of VCCA-2020 were the setting up of the international advisory committee and the website (https://sites.uom.ac.mu/vcca2020/). The international advisory committee consisted of twenty-two members from twenty-one countries. Four Nobel Laureates, namely Robert Huber (1988 Nobel Prize Winner in Chemistry), Sir Richard Roberts (1993 Nobel Prize Winner in Physiology or Medicine), Ada Yonath (2009 Nobel Prize Winner in Chemistry) and Jean-Pierre Sauvage (2016 Nobel Prize Winner in Chemistry), accepted our invitation to participate in VCCA-2020. We also extended our invitation to prominent scientists who agreed to participate and they were considered as keynote speakers. Simultaneously, we proceeded with a call for abstracts.

Ponnadurai Ramasami poses with a picture of Erwin Rudolf Josef Alexander Schrödinger, who was celebrated with a series of events during the virtual conference

The deadline for the submission of abstracts was 22 June 2020 and a total of 194 abstracts were obtained from 46 countries. These abstracts were reviewed and 190 of them were accepted. The corresponding authors were then notified about a decision on their submitted abstracts. They were also aked to complete their registration and submit their presentations by the 20 July 2020. The registration fee was kept nominal and the major costs were associated with logistics and administrative purposes. It is worth pointing out that compared to our previous virtual conferences, we reduced the registration fee in order to broaden participation so as to keep the momentum going in terms of scientific collaboration and stay up to date on the latest research as the world was on lockdown. Nevertheless, a participant could register for free and access all the contents.

The participants were encouraged to submit video presentations of 20-30 minutes and guidelines were provided, although presentations in PDF and PowerPoint formats were also accepted. Ultimately, there were fifty video presentations. To the best of our knowledge, most of the virtual conferences consist

of live presentations and we wanted to overcome the geographic limitation and technical challenges. Thus, we did not host any live presentation during VCCA-2020 and all presentations were available on the website as from the first day of the virtual conference. As such, VCCA-2020 can be considered as flexible as participants were able to view or download presentations at their own convenience.

Christopher Brett, president of IUPAC, was the first speaker of VCCA-2020 with a presentation entitled *IUPAC: Its Global Role and Activities* (view recording at https://youtu.be/1fgVj_2XNsg). The virtual conference was concluded with two keynote presentations entitled *An Inclusive Chemistry Community* by Ale Palermo from RSC and *Supporting Research Continuity: Elsevier Research Solutions* by Khalid M. Shalan from Elsevier.

Based on our previous experience with virtual conferences and our technical know-how, we used the free Web Wiz platform for the online discussion although several virtual conferencing software are now readily available with significant cost. Once a participant posted a question, query, or comment on the Web Wiz platform, all other participants were notified by email. All the posts on the online discussion platform were moderated to better control the flow of discussion. However, questions/comments/queries which were not relevant were not approved and therefore, not posted. In such cases, we privately contacted the participant to inform them the reasons. It was important for us to moderate the posts so as to avoid insignificant notifications which were sent by emails to all registered participants.

As part of VCCA-2020, 12 August 2020 was marked as Schrödinger Day. We also marked the International Youth Day. The events were celebrated as part of the 75th anniversary of the United Nations. Schrödinger Day is in recognition to Erwin Rudolf Josef Alexander Schrödinger for his birth anniversary. Erwin Schrödinger was born on 12 August 1887 and he bagged the 1933 Nobel Prize in Physics for the formulation of the Schrödinger equation. One of the aspects of Computational Chemistry involves solving the Schrödinger equation numerically.

International Youth Day is commemorated every year on 12 August and the theme for 2020 was "Youth Engagement for Global Action." The programme of the day was held online using Zoom with 300 participants. In the morning session, The Vice-Prime Minister, Minister of Education, Tertiary Education, Science and Technology, Honourable Leela Devi Dookun-Luchoomun addressed the participants and focused on the need for capacity building. Jean-Pierre Sauvage, 2016 Nobel Prize Winner in Chemistry and Hayat Sindi, Scientific Advisory Board Member of the United Nations also intervened in the morning session. The afternoon research capacity building session was conducted by Lydia Rhyman from the Computational Chemistry Group and Khalid M. Shalan from Elsevier Africa. Participation for the event on 12 August was free but participants had to register and a certificate of participation was provided through an automated process. The participants were also offered complimentary access by Elsevier to use Reaxys for one month. A survey was conducted, and most appreciated the event although some mentioned that the afternoon session should extend for more than one day.

VCCA-2020 reached a successful end on 31 August 2020. A total of 401 participants registered for the virtual conference. To mark the one-month long event, on the last day, we hosted a virtual cultural day on the Web Wiz forum where participants were encouraged to share videos highlighting the culture, music, food and interesting places from their respective countries. Moreover, there was the announcement of three best presentations which were decided by independent juries. Cash prizes were offered and sponsored by the organizing committee of VCCA-2020 and ICTP. Springer also offered book vouchers to the winners. The awardees for VCCA-2020 are:

Y. Ganga-Sah; *Synthesis of Sterically Congested Chiral 2,2'-Bi(adamantyl)-Based Alcohol and Amines*O. Holtomo; *Radiative Forcing Efficiency of the Stereoisomers cis- and trans-CHCl=CH-CF_3 in the DFT Framework*S. Kundu; *Synthesis of N-Methylated Amides Utilizing Methanol*

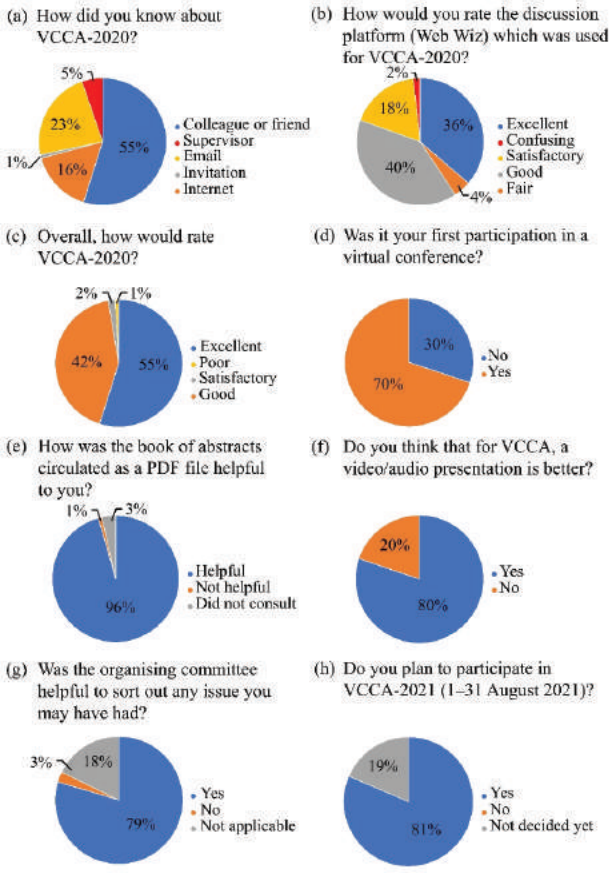
After the end of VCCA-2020, a survey was carried out among the participants to gain feedback (previous page) and 25 % of them responded. According to the survey, most of the participants came to know about VCCA-2020 through peers, email, and the internet, which indicates that VCCA-2020 was well advertised and promoted. The overall feedback about the Web Wiz forum was positive, while 2 % of the participants found the forum confusing. We thus deduced that scientific discussions through the Web Wiz forum were effective. In general, the feedback for VCCA-2020 was positive. 70% of the participants attended a virtual conference for the first time, which reflects the rise of virtual conferences in the COVID-19 era. A majority of the participants qualified the book of abstracts which was circulated and the organizing committee as helpful and considered video and presentations with audio to be better. Of all the participants who responded, 81 % are interested to participate in VCCA-2021, while the rest have not decided yet.

We noted an increased interest to participate in a virtual conference and this paradigm shift may soon be an integral part of scientific interaction. However, some universities and funding bodies are still reluctant to support and recognize participation in a virtual conference. Another factor that benefits effective and efficient participation in a virtual conference is the technical skill which is required for better virtual presentation and interaction.

The virtual conference was followed by a call for full papers for the conference proceedings. These will be peer-reviewed and will be part of a special issue for *Pure and Applied Chemistry* and a book to be published by De Gruyter. Currently, the full papers are under review and publications are expected to be completed by mid March 2021.

On a concluding note, the organizing committee would like to thank all the international advisory members, reviewers of abstracts, participants, sponsors and juries for the success of VCCA-2020. The facilities from the University of Mauritius are fully acknowledged.

The committee is planning for VCCA-2021 which will be held in August 2021.



Based on positive responses to a post-conference survey, organizers are enthusiastic about future virtual events.

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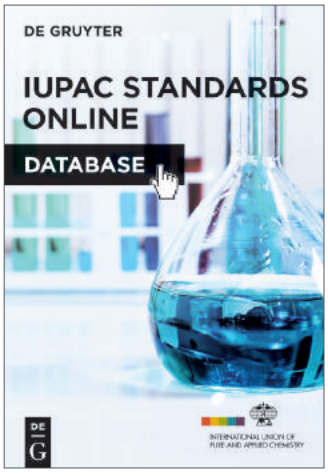

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