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Science and Survival: Exploring the Papers of Georg and Max Bredig

Top Ten Emerging Technologies in Chemistry ►

The Reality of Electronic Publishing ►

INTERNATIONAL UNION OF
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CHEMISTRY International

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International Union of Pure and
Applied Chemistry (IUPAC)

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Cover: Selection of Immigration Papers from the Bredig Archive (Photograph Courtesy of Nate Raab). An extraordinary archival collection of letters, photographs, and other documents belonging to Georg and Max Bredig, the German father and son chemists of Jewish descent, have been cataloged, translated, digitized, and made publicly accessible by the Science History Institute in Philadelphia. The project *Science and Survival* tells the story of the Bredig family's struggle to survive the Holocaust. See feature p. 6.

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From the Era of Print to the Reality of Electronic Publishing

by Wendy Warr

In 1998, Michael Bowen summarized an ICSU Press workshop on electronic publishing [1]. It is reprinted below (in this issue of Chemistry International) and I have been invited to give a 2023 perspective on its conclusions.* Before I address those conclusions more specifically, it is worth mentioning some electronic publishing advances of the 1990s. Carnegie Mellon University advertised an opening for an "electronic librarian" as early as 1991. Some electronic products predate the World Wide Web (e.g., arXiv preprints which were first emailed using TeX in 1991). The Digital Object Identifier (DOI) was launched in October 1997. SpringerLink, Elsevier's ScienceDirect, and PubMed were all available in 1998. The American Chemical Society (ACS) and Chemical Abstracts Service launched ChemPort in December 1997, in collaboration with seven other publishers. ACS had reinvented its journals for the Web with Articles as Soon as Possible (ASAP), search tools to find specific articles easily, and links to databases, and to cited articles through ChemPort. The scene was clearly set for electronic publishing, and so let's move to the eight 1998 predictions from the ICSU Press workshop.

1. *Electronic journals will become dominant (over conventional paper publishing) in the next 5–15 years*

In 1998, a British librarian reported that his university spent just 10 % of its budget on electronic items [2]. Fourteen years later, a survey found that 76 % of scholarly readings were obtained through electronic means [3]. By 2018, it was reported that virtually all STM articles were available online [4]. A 2019 article indicates that only 8 % of researchers read print articles from a print journal [5]. The ICSU Press workshop prediction was clearly correct.

2. *Peer review and methods to "brand" electronic papers will be indispensable to successful electronic publishing*

Today in 2023, the research community continues to see peer review as fundamental to scholarly communication [4]. Open access journals as well as those behind paywalls recognize peer review as a mark of quality, but alternative approaches to the traditional peer review process are now practiced by some publishers. Journals are still proudly branded by publishers. Major journals continue to report their Journal Impact Factors, but many alternative metrics are in use. Back in 2018, Herman Spruijt of Elsevier said that we must accept that the next generation may want the "article" rather than the journal [2], but 25 years later, both authors and publishers still accept that choice of journal is important; the article is not yet fully freed from its "container." The ICSU Press workshop conclusion is broadly justified but some recent initiatives were perhaps not foreseen.

3. *Electronic publishing may be just as expensive as, or even more expensive than paper publishing*

I am grateful to Alexander Grossmann of HTWK Leipzig for useful discussions on this topic. He published in 2021 a very useful market analysis [6] and welcomes comments on ScienceOpen [7]. (ScienceOpen is a research, networking, and discovery platform that boasts some of the recent initiatives mentioned above.) In the era of print, publishers bore the costs of authoring, submission, initial editorial checking, managing the peer review process, and, after acceptance of an article, copyediting, typesetting, printing, and dissemination of the printed journal issues. In the digital era, there are additional costs for generation of a media-independent electronic version of the text, tagging, reference linking, DOI assignment (plus a fee for Crossref), metadata generation, *etc.,* plus costs associated with the digital infrastructure for content management, peer review, access and rights management, article hosting and long-term archiving. In addition, there are costs associated with maintenance of the IT infrastructure. Further costs would be associated with more sophisticated enhancements such as live graphics. Costs for printing and mailing of physical issues are saved, of course, but these are estimated to be less than 5 % of total costs. It is obvious that creating a digital version must be associated with substantial extra costs.

4. *Publishers have done a poor job explaining to authors and librarians how they have added value to authors' work*

This is a contentious issue. Alexander Grossmann has summarized some of the "nonpublication" costs borne by publishers [6], but opinions vary on how publishers' profit margins are justified in relation to these costs.

* In 1998, Wendy Warr was chair of the IUPAC Committee on Printed and Electronic Publications (CPEP was the predecessor of the current CPCDS) and Mike Bowen was Secretary. It was an advisory function of the committee to keep-up with how the landscape of electronic publishing was evolving.

5. *Gathering detailed information on the searching habits of scientists when they access electronic publications will pose ethical questions for publishers*

When the Committee on Publications Ethics (COPE) was founded in 1997 it was not known that by 2023 our mobile phones would reveal our precise whereabouts and search engines would target us with advertisements based on the data about us that they collect. Artificial Intelligence (AI) is by no means new, but as used in 2023 it raises a host of new ethical issues. The 1998 workshop did not anticipate privacy regulations such as GDPR. There is also no mention of the intellectual property implications of one's search terms being recorded.

6. *The infrastructure that is in place in advanced countries will continue to need maintenance. In some countries large capital investments are essential if citizens are to benefit from services made available via the Internet*

This is still true. Open access (OA) is also a big issue for researchers in many disadvantaged countries and institutions. The big OA movement [8-10] began after 1998. The impacts of AI, social media, mobile technologies, and blockchain on electronic publishing were unforeseen in 1998.

7. *There is an urgent need to maintain archives of electronic publications, but who should be the keepers of the archives?*

Fear of information loss has greatly decreased over the years, though cyberattacks are a new challenge not really considered in the 1990s. Nowadays, IT advances have addressed the issue of hardware failure, mirror sites are maintained, and journal archives are commonly preserved by Controlled LOCKSS (CLOCKSS) which employs an approach to archiving (Lots of Copies Keep Stuff Safe) that was initiated by Stanford University librarians in 1999.

8. *Electronic publishing has reached an exciting stage. The next few years will bring practical knowledge about how current electronic products are used and how much people are prepared to pay*

We now have the reality beyond the excitement, but it seems appropriate to reproduce Dick Kaser's comments reported in my 1998 article [2]: "Think of the potential. In e-Utopia, full text will be set loose, links and citations encouraged, browsing permitted, spontaneous purchases supported, and reuse endorsed. The challenge is to maintain the revenue stream so that we can continue "publishing", to manage in an orderly fashion the movement from print to electronic and to expand readership of the journal." Two issues we now have to address are FAIRness [11] in publication (findability, accessibility, interoperability, and reusability) and how to distribute the costs of OA publishing among the stakeholders as "Plan S" demands widespread open access [12].

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Since January 1992, Wendy Warr <wendy@warr.com> from Wendy Warr & Associates has been supplying business and competitive intelligence services to a broad spectrum of clients in the United States, Europe, Australia, the Middle East, and Asia. (source https://www.warr.com/)

ICSU Press Workshop

First printed in Chem. Int. 1998, 20(5), 140-141.

ICSU Press Workshop on Electronic Publishing in Science, Keble College, Oxford, UK, 30 March—2 April 1998—some observations

This three-day conference, officially titled 'Economics, Real Costs and Benefits of Electronic Publishing in Science—A Technical Study,' was planned to follow up on the Joint ICSU Press/UNESCO Conference on Electronic Publishing in Science that was held in Paris, France, during February 1996 (*Chemistry International* 1996, Vol. 18, pp. 165–169). The Oxford workshop attracted around 50 participants, about half of whom had been present at the Paris conference. Moreover, essentially all the organizations represented in Paris were again represented in Oxford. This useful continuity, together with the smaller size of the Oxford Workshop (50 vs. 150 in Paris) made for an unusually stimulating and interactive three days in the comfortable modern facilities at Keble College's ARCO Building.

Sir Roger Elliott (Chairman of ICSU Press and a former chief executive of Oxford University Press) set the stage for the meeting by challenging the attendees to describe an electronic publishing system for science that would have a number of desirable characteristics: (1) Gives authors' works visibility, with adequate quality control; (2) Can be accessed easily; (3) Preferably costs less than the current system; and (4) Provides adequate incentive and financial return to those (such as publishers) who 'add value.'

Fred Spilhaus, Executive Director of the American Geophysical Union, predicted that the present scientific publishing system was nonlinear, and that substantial, unpredictable changes would inevitably take place. He observed that the boundaries between 'chit-chat' and formal publication were becoming distinctly blurred in the electronic arena and that electronic enhancements will become both more complex and more costly. Anent Parekh, Professor of Physiology at Oxford University, expressed the enthusiastic view of many young academics, that electronic publishing offers users many advantages and relatively few disadvantages. Among the features Parekh found most helpful were currency, ease of access (including access from one's home computer) and the ability to look at and download additional data not usually printed in the paper journal. Donald King (King Research, Ann Arbor, Michigan), Terry Scott (until recently with the American Institute of Physics), and Owen Hanson and Robert O'Shea (Lindsay Ross International, Abingdon, UK), all pointed out that a comparison between the costs of conventional (paper) publishing and costs of electronic publishing must be conducted with great care. King stressed the need for a careful definition of terms, while the others emphasized that many costs (for example, those for peer review) do not disappear in the electronic publishing system and that there is no reason to believe, as some have suggested, that electronic publication is inherently less costly than paper publishing. Indeed, many enhancements in the electronic system—for example hot-linking and graphics display improvements—actually increase cost, they stressed. William Mischo (University of Illinois, Champaign-Urbana) described some of the technical difficulties inherent in archiving electronic journals, including the still substantial cost of archival storage, despite large decreases in storage device costs in recent years. He also raised the disturbing issue of the questionable readability in future years of outmoded storage vehicles such as 5¼-inch floppy disks and current-technology CD-ROMs. Bernard Donovan (Association of Learned and Professional Society Publishers, UK) had surveyed a number of publishers and concluded that substantial costs were incurred by scientific publishers in their conduct of peer review. He estimated such costs as typically between 100–300 GBP per accepted paper. Fytton Rowland (University of Loughborough, UK) challenged the assertion that users would find electronic publications so accessible and easy to use as to render librarians redundant. Indeed, he contended that the librarian and information intermediary functions will continue to be needed as never before, to cope with the variety and rather chaotic arrangement of materials on the Internet. Gary VandenBos and Susan Knapp (American Psychological Association) described a new all-electronic journal published by the APA; this journal has 2500 individual users, currently accessing it for no charge. However, there had been, and continued to be some resistance from potential authors and more resistance than expected from reviewers. Knapp also described an innovative pricing arrangement (still experimental) under which APA members with a print subscription to at least one APA journal could purchase in addition, at a very attractive price, access to a full-text database of all APA journals and/or to the Psychological Abstracts database. Knud Thomsen, a participant in a working group of scientists at fusion energy facilities scattered over many parts of the world, described the characteristics and problems of their system for mutual communication over the Internet. Many of these problems—for example, use of incompatible software versions and different e-mail systems—are extremely germane to electronic publishing on 'the Net.' Abel Packer (Pan American Health Organization, Sao Paulo, Brazil) and Virginia Cano (Queen Margaret College, Edinburgh, UK) explained why scientists in developing countries are attracted to the possibilities of publishing electronically. Fundamentally, this attraction is related to the relatively low barriers inherent in operating a web site, provided that the web host possesses the ability to offer material in English, now the scientific 'lingua franca' of choice world-wide. Visibility can quickly be obtained electronically, but progress is still too often hampered in many countries by poor infrastructure (telephone system) and by a lack of computer availability or literacy. The same points were made by Attlio Bustos and Graciela Munoz (Catholic University of Valparaiso, Chile), who have developed the *Electronic Journal of Biotechnology* in Chile. Vitaly Nechitailenko (National Geophysical Committee, Russian Academy of Sciences) described some of the special problems posed by offering on-line a journal having extensive mathematics, where HTML representation is in some respects deficient.

Summarizing the status of a fast-moving and technologically sophisticated field such as electronic publishing is no mean feat, but workshop attendees attempted it with the assistance of David Pullinger of Macmillan Publishing and of the chairs of three break-out groups to which all attendees had been assigned during the last sessions of the workshop.

The following principal conclusions were among those generally agreed to by participants:

1. Electronic journals will become dominant (over conventional paper publishing) in the next 5–15 years.
2. Peer review and methods to 'brand' (indicate the quality of) electronic papers will be indispensable to successful electronic publishing.
3. Despite widespread expectations that electronic publishing will be less expensive than paper publishing, every evidence to date indicates that it may be just as expensive or even more expensive, depending on the sophistication and cost of electronic enhancements such as live graphics and hot links.
4. Publishers generally have done a poor job in the past explaining to authors and librarians how they have added value to authors' work. (This explains in good part why there exists the wrong expectation described in Conclusion no. 3, above.)
5. The ability to gather detailed information on the searching habits of scientists when they access electronic publications will pose ethical questions for publishers. Users should be informed about any information gathering practices used by electronic publishers.
6. The infrastructure—telephone systems, networks, etc.—that is in place in advanced countries will continue to need maintenance; in developing countries, and even in some developed countries, large capital investments are essential if the citizens in those countries are to share in the benefits of electronic publishing and other services made available via the Internet. Inevitably, government agencies will be looked at as the source of these investments.
7. Everyone agreed that there is an urgent need to maintain archives of electronic publications. But who should be the keepers of the archives? Conferees had little confidence in the willingness or ability of national governments or of commercial publishers to undertake this vital task. Not-for-profit scientific societies—presumably having an obligation to assure access to the record of their various disciplines—were seen as the most logical candidates for this Herculean task.
8. Electronic publishing has reached an exciting stage. There are now a sufficient number of 'products' in the marketplace that the next few years will bring a great deal of practical knowledge about how technical users react to these products, how they use them and—the $64 000 question—how much they are prepared to pay.

Michael Bowen, 4 August 1998

About this article first printed in Chem. Int. 1998, 20(5), 140-141:

In 1998 Michael Bowen was working for the American Chemical Society and was secretary of the IUPAC committee on Printed and Electronic Publications (CPEP); In print, this report is dated 4 August 1998; it is an error and instead it should read 8 April as noted 4/8/98 in the original doc file. Considering the production workflow at that time, it is likely that the American date format was simply not properly converted by the (English) production editor at Blackwell.

Readers interested in reviewing and commenting earlier reports published in Chemistry International, are invited to review the magazine archives <https://archive.org/details/chemistryinternational>

Science and Survival: Exploring the Papers of Georg and Max Bredig

Scientific Papers and Photographs from the Bredig Archive (Photograph Courtesy of Nathan Raab). Another selection of Immigration Papers from the Bredig Archive illustres the magazine cover of this Chem Int issue.

by Patrick H. Shea

Following the death of his parents, George Bredig inherited a large steamer trunk inconspicuously tucked away in the basement of his boyhood home in Oak Ridge, Tennessee. The trunk was old, and upon opening it, a strong musty smell emerged from within. As he reviewed the contents of the trunk, he discovered an assortment of unpublished letters, original photographs, rare pamphlets and small scientific artifacts. His father Max and grandfather Georg were both gifted physical chemists and it did not take long for George to realize that these papers documented their scientific careers in the years preceding their flight from Nazi Germany.

The letters numbered in the thousands, written in many different languages and often scattered with scientific formulas that George struggled to understand. As he combed through the collection, he noticed some names appeared more often than others. Names like Wolfgang Ostwald, Jacobus van't Hoff, Svante Arrhenius, Fritz Haber and Ernst Cohen. These were the leading figures in the European physical chemistry community at the turn of the century, and George's father and grandfather were in the middle of all of it.

Initially, George was unsure what to do with such a trove, but he would later find inspiration in an emotional letter written by Georg to his son in 1937. With the threat of the Nazis confiscating and destroying such a collection, Georg wrote,

> "Yesterday, I sent you volumes I-III of my "Opera Omnia" [complete works] as a package of value… However, my reference library here still contains more interesting letters, including those from van't Hoff and Willstätter… It's very important to me that both copies remain in good hands after my death, as they contain information that could be useful for a necrology. If you cannot keep them, please place them in a university library, preferably a foreign one, or with a trusted friend. I do not want them to be wasted, destroyed, or disposed of under any circumstances. I want my life's work to be available for future reference."

His grandfather's instructions were clear and after taking some time to connect with the items on a very personal level, George set out to find a new home for the collection. With the assistance of Nathan Raab, a Philadelphia area manuscript dealer, that home was found at the Science History Institute.

After years of effort by the Institute's library staff, the collection is now physically accessible in their Philadelphia headquarters and digitally accessible anywhere in the world: see https://digital.sciencehistory.org/collections/qfih5hl.

Each digital file can be viewed in granular detail online or downloaded in high resolution, complete with transcriptions and English translations of the German text.

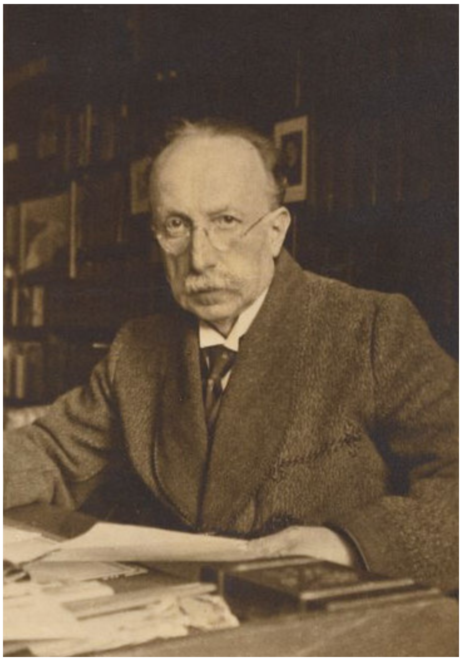
With work complete, the true extent of the collection has revealed itself. It consists of the physical chemistry library and personal archives of Georg Bredig and his son Max during the first half of the 20th century. Prior to 1933, the collection reveals the Bredig's place in a vast network of scientific collaboration and international cooperation. After 1933, however, the contents of the collection take a dramatic shift in tone, as those very same scientific networks were employed to support a desperate flight from Nazi occupied Europe.

The central figure of the story is Georg Bredig, who was born in 1868 to a German Jewish family. He began his university education in 1886, first in Freiburg and soon after in Berlin, where he studied chemistry and physics. In Berlin, Bredig became enamored with the, *Zeitschrift für Physikalische Chemie* (*Journal of Physical Chemistry)*, which had been founded that very year by the famed chemists Wilhelm Ostwald and Jacobus van't Hoff.

Bredig was so enthusiastic about this new border science that he transferred to the University of Leipzig to study directly under Ostwald, whose Physical-Chemical Institute was considered one of the best in the field. Bredig excelled in his studies at Leipzig, eventually earning the coveted spot of Ostwald's student assistant.

Bredig earned his doctorate "summa cum laude" in 1894 and spent the next 18 months studying physical chemistry with some of the leaders in the field including, Marcellin Berthelot in Paris, Svante Arrhenius in Stockholm, and Jacobus van't Hoff in Amsterdam. While in Amsterdam, Bredig also forged a lasting friendship with one of van't Hoff's most devoted pupils, Ernst Julius Cohen.

Cohen obtained his doctorate in chemistry under van't Hoff in 1893, and soon found a close friend in Bredig. The two collaborated on research related to the transition elements and many other topics concerning the chemistry of photography.



Portrait of Georg Bredig (1868-1944) (photo courtesy of Science History Institute, https://digital.sciencehistory.org/works/elyhs6i

After completing his post-doctoral studies abroad, Bredig returned to Leipzig to work as the Assistant to Ostwald. In this role, Bredig produced a series of pioneering works on colloidal metals and their catalytic properties. Most notably, he developed a method for the preparation of colloidal solutions by use of an electric arc. He expanded on this work by studying and comparing the activity of metal colloids and that of inorganic ferments, which he summarized as his habilitation thesis in 1901. These successes led to Bredig's appointment as the first professor of physical chemistry at the University of Heidelberg. Here, he continued to develop his research from Leipzig and most notably achieved the first catalytic synthesis of asymmetric carbon compounds.

While in Heidelberg, Georg married Rosa Frankel. Together they had two children; a son named Max Albert, born in 1902, and a daughter Marianne, born a year later. In 1910 Bredig moved his family to Switzerland where he had accepted a professorship in the Physical Chemistry Laboratory at the ETH Zurich, but he left soon after to succeed Fritz Haber as Director of the Institute of Physical Chemistry at the Technical University of Karlsruhe in 1911. He would remain in that role for the next 22 years.

Among Bredig's students in Karlsruhe was the Hungarian, Elizabeth Rona, who would go on to become a renowned nuclear chemist, training under one of Bredig's best pupils, Kasimir Fajans. Rona described

Laboratory at the University of Amsterdam, 1894. “Wehmann”, Geertruida Wilhelmina Petronella van Maarseveen, Ernst J. Cohen, “Philipps”, “Groshans”, “Moor”, Willem P. Jorissen, “Braskamp”, Georg Bredig, and Viktor Rothmund. (photo courtesy of Science History Institute, https://digital.sciencehistory.org/works/22n5jw1

Bredig as, “very much the authoritative German professor” who was known as “Bredig the Terrible” by his students. But she added that, “under his surface sternness and aloofness, Bredig was a warm and sensitive person devoted to his students’ welfare.”

World War I halted research in Bredig’s lab as both funding and personnel became scarce. Bredig, a staunch pacifist, spent the war as a university administrator and volunteer for the Red Cross. The First World War, however, would come to be known as “the Chemist’s War” and despite not directly contributing to the German war machine, Bredig’s international reputation was tarnished by the sins of his colleagues.

Not only did Germany dominate the chemical industry at the time, but Germany’s chemical warfare program was headed by many of its most esteemed chemists, including Fritz Haber. The use of chlorine gas by the German army at the Second Battle of Ypres in 1915 marked a major turning point in the history of warfare as many felt that the Germans had crossed a moral line. Haber had even personally supervised the first successful gas attack at Ypres. Because of this, German and Austrian chemists were ostracized from the international chemical community after the war. Bredig felt that isolation at his own Institute, which had far fewer international students than were present before the war. That fact weighed heavily on him.

Research collaboration allows scientists to cross both disciplinary and geographic borders. More importantly, it fosters greater knowledge, trust and understanding among the participants. No one understood that fact more than Ernst Cohen who had come to earn a reputation as someone committed to both organizational activities and international cooperation in the chemical community.

When war broke-up that community, Cohen was in a unique position to make a meaningful attempt to restore relations between chemists of recently hostile nations. To this end, he organized a great reunion of chemists in Utrecht in June 1922.[*]

Physical chemists from across Europe and the U.S. participated, with the notable exceptions of the French and Belgians who boycotted the meeting. Many German chemists did attend, however, including Bredig, who was eager to take an important step in repairing international scientific friendships and cooperation. For

1. A group photograph of this major reunion, clearly identifying about 50 participants, is part of the archival collection (https://digital.sciencehistory.org/works/tnrloxm). An autographed dinner menu from the following day, 22 July 1922, is also part of the archival collection (https://digital.sciencehistory.org/works/17mioc8).

Black and white photograph of scientists standing in a laboratory in Leipzig, Germany. (circa 1895-1896) The group of men, many of whom are graduate students studying under Wilhelm Ostwald (1853-1932), surround a table crowded with laboratory equipment, tools, and apparatuses. The scientists pictured from left to right have been identified as Julius Tafel (1862-1918), Georg Bredig (1868-1944), Karl Alfred von Zittel (1839-1904), Arthur Rindell (1852-1936), Ostwald, Robert Thomas Diedrich Luther (1868-1945), and, seated in the foreground, Eduard von Stackelberg (1867-1943). https://digital.sciencehistory.org/works/sdpfe6q. Courtesy of Science History Institute

Cohen, it was an important step in his own pursuit to become the third President of the International Union of Pure and Applied Chemistry in 1925.**

Bredig's pacifist beliefs and promotion of international cooperation endeared him to many in Europe's scientific community, but it also made him a target of nationalist and anti-Semitic attacks in his own country. When the National Socialists seized power in 1933, these attacks only intensified. In one case, one of Bredig's employees wrote to the Ministry of Education and demanded Bredig's immediate resignation to, "put an end to the internationalization and socialization at German Universities." Then, the Nazi government passed the Law for the Restoration of the Professional Civil Service, which, with some short-lived exceptions, banned all Jews from teaching at German Universities. Without fanfare, Bredig was retired on October 1, 1933. A short time later, Bredig received another terrible blow, the death of his wife.

Georg was a proud German and was convinced that the growing indignities imposed by the Nazi regime were only temporary. He refused calls from family and friends to emigrate, but to his son Max, he gave an ominous warning, "My generation is sinking. Now you all must fend for yourselves!"

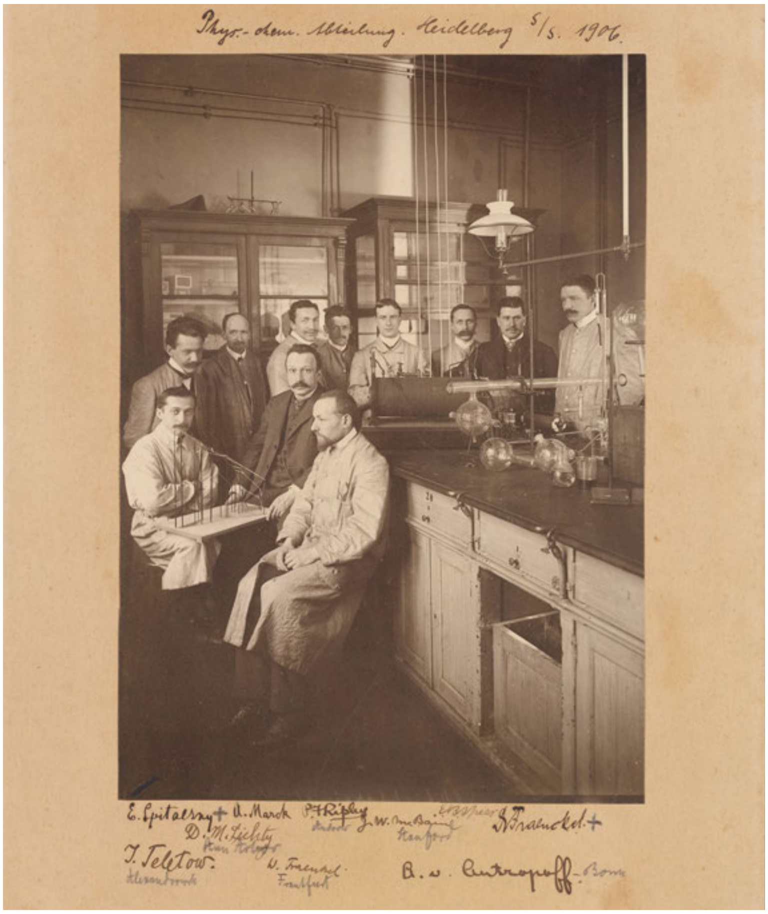
As a boy Max showed an aptitude for chemistry and decided to follow in his father's footsteps. He attended the Technical University in Karlsruhe as an undergraduate, and then moved to the Kaiser Wilhelm Institute in Berlin where he received his doctorate under the direction of Fritz Haber.

Max obtained employment as a research chemist at the Bavarian Nitrogen Works, but when the firm was Aryanized his continued employment was not possible. Max took seriously the warning from his father and fled Germany in 1937.

Staying with colleagues along the way, he travelled first to Sweden, and then to England, before finally arriving at the University of Michigan where he had accepted a fellowship to work in the Department of Chemical and Metallurgical Engineering. That fellowship was arranged by his father's pupil, Kasimir Fajans, who himself had immigrated just a year earlier.

Back in Germany, every day seemed to bring new regulations that restricted some aspect of Jewish life. Then during the events of *Kristallnacht,* a pogrom perpetrated against German Jews in 1938, Georg and about 500 other Jews in the city were arrested, beaten, and publicly humiliated. These events convinced Georg that living out the rest of his years in Germany was not going to be possible. Bredig was not free to move without a moving permit, but was still being forced to give up his home, leaving his fate uncertain. Overwhelmed and desperate, he wrote to

** See also Jorrit P. Smit, "Ernst Cohen and the Challenge of a Truly International Union" Chem. Int. 41(3), 2019, pp. 9-10, https://doi.org/10.1515/ci-2019-0304 and refs therein, and Geert Somsen, "Reconciling Science and Foreign Relations in The Hague" Chem. Int. 45(3), 2023, pp. 16-18. https://doi.org/10.1515/ci-2023-0304.



Black and white photograph of scientists posing in a physical chemistry laboratory at the University of Heidelberg. On the right side table are several glass flasks, beakers, and columns. Georg Bredig (1868-1944) has handwritten the names of the pictured scientists and their locations beneath the photo. The scientists identified in this caption are E. Spitalsky, A. Marck, P. T. Ripley, James Willian MacBain (1882-1953), Ellwood B. Spear (-1943), S. Fraenckel, David M. Lichty, Iwan Serhijowytsch Teletow (1878- 1947), W. Fraenkel, and Andreas von Antropoff (1878-1956). https://digital.sciencehistory.org/works/aysrqhn

Autographed portrait of Ernst Cohen (1869-1944), circa 1900. In 1902, the Dutch scientist became Jacobus van't Hoff's assistant and a professor at the University of Utrecht. He was IUPAC 3rd President from 1926 to 1928 and chaired the IUPAC Congress in The Hague in July 1928. In 1933, like many Jewish scientists and academics, his career was cut short by growing restrictions of Jews in Nazi Germany. In 1944, he was killed at Auschwitz concentration camp. Courtesy of Science History Institute, https://digital.sciencehistory.org/works/s2oya9v

Max, "How we will overcome the extraordinary difficulties of the present time is still doubtful. Will our departure even be possible in today's vast crisis?... Life is so hard these days!"

Georg would find a lifeline from his old friend, Ernst Cohen who sponsored and financially supported his immigration to the Netherlands. Certain that the Nazis would destroy his prized library and archive Bredig packed as much as he could and arrived safely in Amsterdam in November 1939.

Although safe for the time being, the Nazi threat still loomed, and Georg's hardships persisted, writing to Max, "I'm still with my friend Ernst in Utrecht and he's trying to make my difficult life as an emigre easier. I'm still healthy. However, it is uncertain if I will survive here until June 1940… Ernst now lives in cramped conditions and his wife is suffering. Both sacrifice a lot to help me." Max replied with an optimistic note from America, "Even though threats still loom on the horizon, your onward journey seems within reach."

Max knew finding a job for his father in America would improve his father's immigration status, but Georg was approaching the end of his career and academic jobs were proving hard to come by. With the assistance of Hugh S. Taylor, Chair of Princeton University's Chemistry Department, Max devised a way around that problem. Princeton would offer Georg the position of Research Associate on the condition that any payments he received from the appointment would be provided by outside sources and not the University. Max agreed to pay the cost personally, upon which university President Harold Dodds submitted the necessary paperwork to the American consulate to expedite Georg's immigration on a non-quota visa. Cohen and fellow chemist H.R. Kruyt in Amsterdam assisted as well, submitting paperwork attesting to the fact that Georg was indeed still an active chemist.

Max sent word of the good news and assured his father,

> "Please, don't worry about your potential or financial matters. You don't even need to live in Princeton. You will be here with me [in New York City], and you may occasionally be invited to a discussion with your colleagues working on catalysis or in your other specialties. You also don't have to fear language difficulties if there should be such a discussion. Taylor speaks German fluently and I will probably accompany you. In any case, these things don't matter. They know very well who they are dealing with. Taylor worked with Bodenstein for a long time. He even remembers you personally and thought that I resembled you! Moreover, at first, you will have some time to rest, if you have not done so under the good care of the Cohens."

Max Bredig's German Passport, 1937. (photo courtesy of Science History Institute, photo page from https://digital.sciencehistory.org/works/8r00347

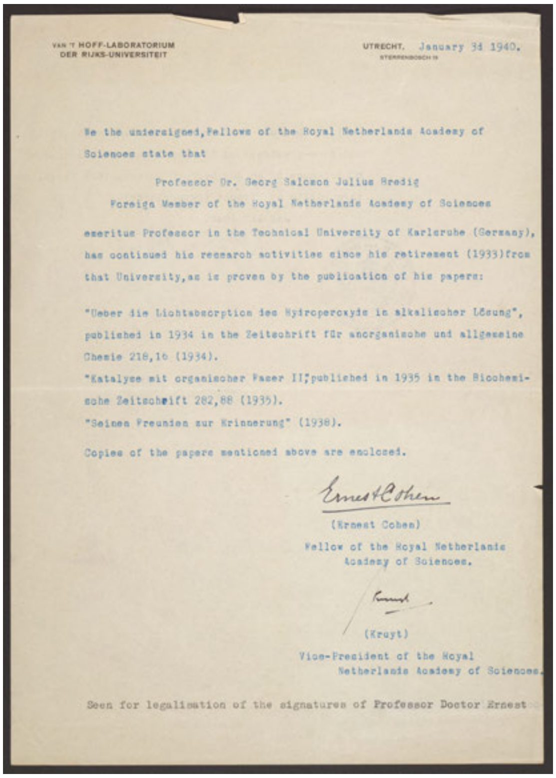
Georg, thrilled to receive the appointment, sent his reply to the president of Princeton in a wonderfully short and succinct telegram in December 1939, which read, "highly honored. Accept. Coming as soon as possible." He arrived in the United States just months later, leaving behind a portion of his scientific library in the van't Hoff laboratory for the remainder of the war.

The Nazi war machine rolled into Amsterdam just five months after Bredig's departure, and Cohen, who was also Jewish, would quickly transition from savior to victim. Cohen experienced many of the same indignities and restrictions as Georg had in Germany, but Nazi policies were becoming increasingly vicious. By 1942 the regime abandoned plans to forcefully migrate Jews from Europe in favor of the "final solution," which was to murder all Jews within reach. Cohen met his fate two years later, when on February 28, 1944, he was arrested on trumped-up charges. A few days later he was deported to Auschwitz where he was gassed on March 6. History would not overlook the bitter and cruel irony surrounding the events of his death.

Georg never quite regained his strength after immigrating to America and would never take up his passion for physical chemistry again. He lived his remaining days with Max in New York, dying on April 24, 1944.

Max continued focusing his efforts to assist his sister's family and many other former colleagues out of Europe. He had several successes, including chemists Alfred Reis and Fritz Hochwald whom he assisted with money, affidavits of support, and in some cases employment. Max also had some tragic losses.

German Identification Card, 1938. As mandated by Nazi Law, Georg was forced to adopt the "Jewish" name, Solomon Julius Georg Bredig. (Science History Institute Archives) page from https://digital.sciencehistory.org/works/925g57t



VAN 'T HOFF-LABORATORIUM
DER RIJKS-UNIVERSITEIT

UTRECHT, January 31 1940.
STERRENBOSCH 19

We the undersigned, Fellows of the Royal Netherlands Academy of Sciences state that

Professor Dr. Georg Salomon Julius Bredig
Foreign Member of the Royal Netherlands Academy of Sciences

emeritus Professor in the Technical University of Karlsruhe (Germany), has continued his research activities since his retirement (1933) from that University, as is proven by the publication of his papers:

"Ueber die Lichtabsorption des Hydroperoxyds in alkalischer Lösung", published in 1934 in the Zeitschrift für anorganische und allgemeine Chemie 218,16 (1934).
"Katalyse mit organischer Faser II" published in 1935 in the Biochemische Zeitschrift 282,88 (1935).
"Seinen Freunden zur Erinnerung" (1938).

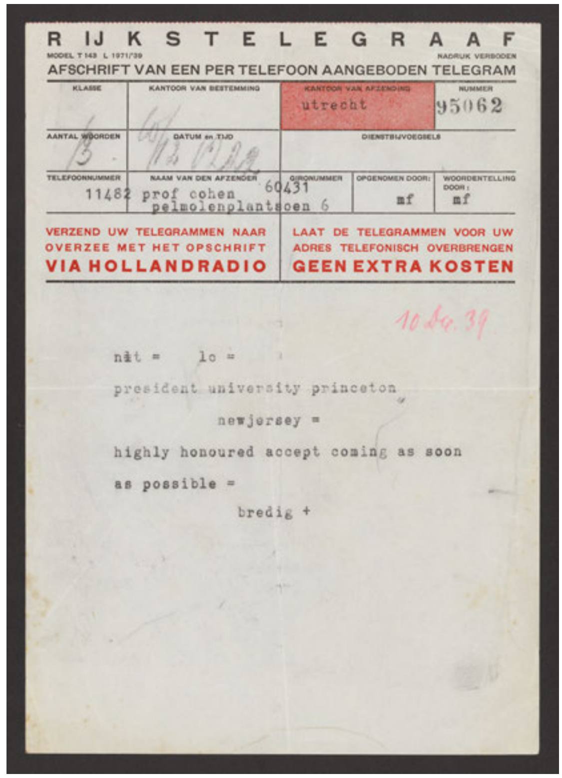
Copies of the papers mentioned above are enclosed.

Ernst Cohen
(Ernest Cohen)
Fellow of the Royal Netherlands Academy of Sciences.

Kruyt
(Kruyt)
Vice-President of the Royal Netherlands Academy of Sciences.

Seen for legalisation of the signatures of Professor Doctor Ernest

Statement from the Fellows of the Royal Netherlands Academy of Sciences regarding Georg Bredig's research activities from 1933-1940. This statementwas needed to help Bredig Immigrate to the United States.Courtesy of Science History Institute https://digital.sciencehistory.org/works/ml2d1fx



RIJKSTELEGRAAF
MODEL T 143 L 1971/39
NADRUK VERBODEN
AFSCHRIFT VAN EEN PER TELEFOON AANGEBODEN TELEGRAM

KLASSE	KANTOOR VAN BESTEMMING	KANTOOR VAN AFZENDING	NUMMER
		utrecht	95062

AANTAL WOORDEN	DATUM en TIJD	DIENSTBIJVOEGSELS
13		

TELEFOONNUMMER	NAAM VAN DEN AFZENDER	GIRONUMMER	OPGENOMEN DOOR:	WOORDENTELLING DOOR:
11482	prof cohen pelmolenplantsoen 6	60431	mf	mf

VERZEND UW TELEGRAMMEN NAAR OVERZEE MET HET OPSCHRIFT VIA HOLLANDRADIO

LAAT DE TELEGRAMMEN VOOR UW ADRES TELEFONISCH OVERBRENGEN GEEN EXTRA KOSTEN

10 Dec. 39

nlt = lc =
president university princeton
newjersey =
highly honoured accept coming as soon
as possible =
bredig +

On 10 December 1939, Georg Bredig writes to Princeton University President, Harold Willis Dodds, to accept a Research Associate position at Princeton University. Bredig's acceptance of this position allows him to immigrate to the United States. (photo courtesy of Science History Institute, https://digital.sciencehistory.org/works/dq1vcry

By 1938 Max's former colleague Alfred Schnell, and his new bride Eva, had fled Nazi Germany to take up residency in The Hague. After the German invasion of the Netherlands, they were ordered to report to a Nazi transit camp. Instead, they went into hiding with the assistance of the Dutch resistance. They found refuge on a farm in Oldebroek, about 40 miles east of Amsterdam, with a widow named Hendrikje Blaauw-Flier. They slept each night underground, in a small hiding space beneath a haystack. Incredibly, while in hiding they sent short messages to Max via the Red Cross. Often writing in code and using aliases to protect their identities, these letters were their only lifeline to the outside world.

In autumn 1944 Max lost contact with the Schnells. According to eyewitness accounts, they were discovered in their hideout by German soldiers during a raid of the surrounding area and taken to a nearby town for interrogation. They were to be kept overnight and transported the following morning to Poland. But that night, a pair of Dutch Nazis took Eva and Alfred from their cells, along with four other prisoners. They were taken to a park and told to dig six holes. When Eva protested, she was shot. The rest were murdered immediately after.

The consequences of war and the Holocaust weighed heavily on Max. After the war he made a point of distinguishing between former German colleagues he felt were culpable and those he felt worthy of praise. When the *Journal of Chemical Education* published a letter praising the career of Wolfgang Ostwald, Max felt compelled to set the record straight on the son of his father's mentor.

In his own letter to the editor, Max bluntly stated,

> "A considerable number of former European Scientists… remember vividly the swastika which Ostwald used to wear, cautiously on the inside of his lapel before 1933, but proudly in the open in the days of the Hitler regime… Wo. Ostwald was a very good Nazi… Death indeed saved this clever, double-talking propogandist… He was the son of the greater Wilhelm Ostwald who was held in reverent memory by [my] own father not only as an admired teacher and personal friend but – in contrast to the

Max Bredig (1902-1977) seated at a desk in an office at the University of Michigan. Max emigrated from Germany to the United States with the assistance of Kasimir Fajans (1887-1975) to avoid further persecution under the Third Reich and to begin a postdoctoral fellowship at the University of Michigan. (photo courtesy of Science History Institute, https://digital.science-history.org/works/8qew1rb

son- for the honesty which he strove to advance true international understanding and cooperation."

Other German Chemists, particularly Karl-Friedrich Bonhoeffer, received Max's praise and admiration after the war. When Nobel-Prize-winning chemist Harold Urey circulated a letter among Bonhoeffer's colleagues in America to raise money on Bonhoeffer's behalf, more than 50 scientists including Max and Kasimir Fajans answered the call. Max knew Bonhoeffer from his days at the Kaiser Wilhelm Institute in Berlin and was familiar with his illustrious family. Karl's younger brother, Dietrich was an influential pastor, theologian and anti-Nazi dissident. In the closing days of the war, Dietrich and his other brother Klaus, were both executed for their part in the July 1944 plot to assassinate Hitler. Karl developed heart trouble after the war, and Urey's letter helped raise over $1,000 to enable three months' rest in Switzerland.

In 2001 a monument in Zwolle, Netherlands was unveiled honoring the six people murdered on the evening of October 3, 1944.

Max reunited with many other former colleagues who had also found their way to America during the European "brain drain" of World War II. The Hungarian-born theoretical physicist, Eugene Wigner, was Max's senior at the Kaiser Wilhelm Institute, and when he became the director of research and development at Oak Ridge National Laboratory in 1946, he brought Max on to establish an x-ray diffraction laboratory. Max remained at Oak Ridge until 1967 when he retired as Assistant Director of the Chemistry Division.

Max may not be as well remembered as his father or some of his more famous colleagues, but he was without question a first-rate scientist. He published almost 100 scientific papers and is probably best known in the field for his work on the interaction of molten metallic halides with their metals. To this day, the Max Bredig Award is given out by the Electrochemical Society.

Still, few people know about the work Max undertook during the war. Even to his son George, Max rarely spoke of the hardships he endured during the Nazi regime or his efforts to save his father and former colleagues from a horrific fate. It was only after the contents of this archive surfaced that the true extent of the Bredig story has finally been revealed; one of science and survival.

Patrick H. Shea is the Chief Curator of Archives and Manuscripts at the Science History Institute.

IUPAC's 2023 Top Ten Emerging Technologies in Chemistry

by Fernando Gomollón-Bel

This manuscript marks the five-year anniversary of IUPAC's "Top Ten" initiative [1]. The new additions will grow the list of emerging technologies to fifty—all with a powerful potential to make our world more sustainable and all suitable solutions to the current polycrisis [2]. This past summer, the theme of the IUPAC World Chemistry Congress in the Hague was "Connecting Chemical Worlds," which aligns almost perfectly with the goals of the "Top Ten"—multidisciplinary research is key towards transitioning to net-zero and achieving the United Nation's Sustainable Development goals by 2030 [3]. Moreover, the selection this year particularly promotes cross-collaboration in chemistry to create exciting emerging technologies that bridge the gap between academia and industry, while continuing the current competitiveness of chemical manufacturers. From a pool of possible ideas, a panel of experts have selected the following list, covering a range of fields from synthesis and polymer chemistry to health and artificial intelligence. The technology readiness level varies along the different solutions—nevertheless, all show a provocative promise to reimagine our world and our society.

Wearable sensors

In the past years, wearables have witnessed an unprecedented rise, revolutionising how we interact with technology. The COVID-19 pandemic accelerated this trend, and technologies to track and monitor our health flourished [4]. Usually, wearable devices determine data such as fitness metrics, sleep patterns, and they enable seamless communication and navigation. Chemistry adds another layer of valuable information, allowing the real-time monitoring of chemical, biological, and physical inputs—all with high sensitivity performance, but at a low cost [5]. Among the most popular applications is glucose detection in diabetes—wearable sensors have become widely-adopted, and allow quick connectivity with everyday devices, such as smartphones and smartwatches, giving patients unprecedented power and freedom [6]. But beyond glucose, chemical wearable sensors offer an opportunity to detect a wide variety of biomarkers, including pH, lactate, uric acid, ion levels, cytokines, and much more. This provides a platform not only to monitor the progress of patients in real-time, but also to detect and diagnose diseases in-depth, which increases the rapidness and efficiency of classical labwork in medical settings [7].

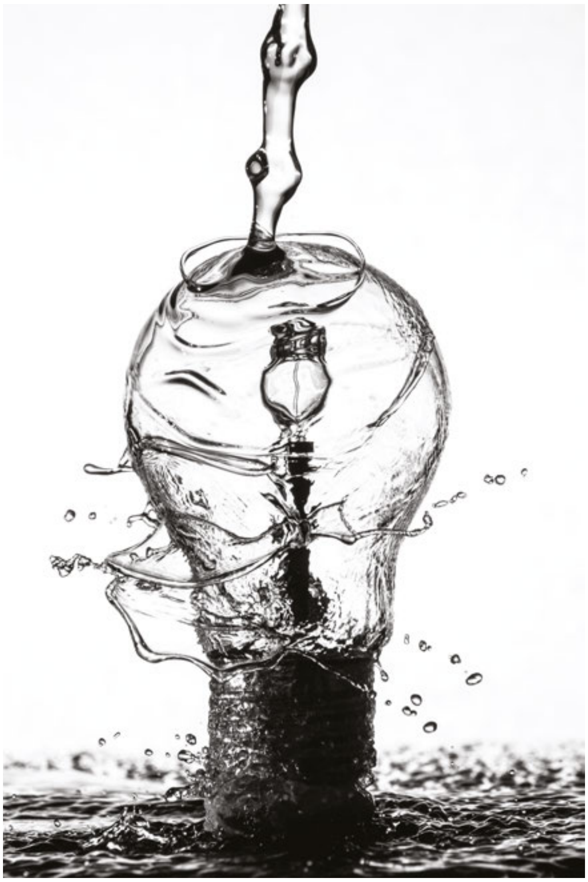
Popular applications is glucose detection in diabetes—wearable sensors have become widely-adopted, and allow quick connectivity with everyday devices, such as smartphones and smartwatches.

Sensors usually convert chemical signals to electrical pulses—however, several solutions explore different detection methods, based on spectroscopic read-outs such as fluorescence, Raman, impedance, and ultrasounds. Beyond finding the features to measure, the real challenge comes from engineering devices with high biocompatibility, flexibility, durability and, of course, comfort [8]. An exciting development comes from the advances in microneedle technologies, which on top of detecting biomarkers could offer options for immediate drug-delivery in response [9]. Another advancement with great promise is pairing wearable sensors with connected devices. Beyond basic read-outs, such connectivity could provide new applications in telemedicine, giving doctors and medical professionals the ability to remotely monitor patients' health conditions with precision and accuracy, promoting timely interventions and tailored treatments. The continuous collection of health data could create new opportunities in drug discovery as well—provided that privacy and anonymity are granted.

Coupled with big data and machine learning, the information from wearable chemical sensors is emerging as a low-cost, non-invasive alternative to classical clinical trials, which often require in-person visits, biopsies, and blood sampling. In the era of multi-omics (genomics, proteomics, metabolomics), chemistry could convey a new revolution [10].

Photocatalytic hydrogen

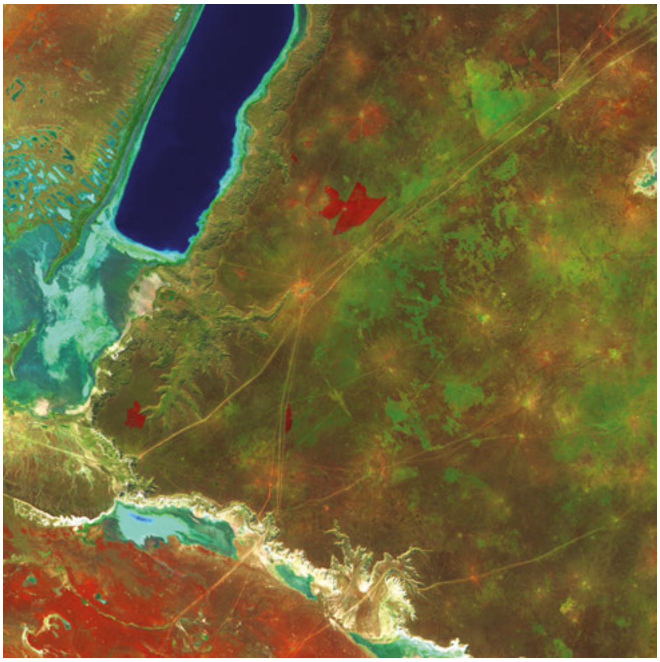
In the past editions of the "Top Ten," the lists highlighted exciting energy innovations, such as sustainable ammonia and liquid solar fuels. Along this line, green hydrogen is clearly emerging as a key-player – both as an alternative to fossil fuels in applications such as transport, industry, and chemical manufacturing, and as a viable vector to safely store and stockpile excess energy from intermittent renewable sources, such as solar and wind. It is estimated that clean hydrogen could cut over 700 million tonnes of carbon dioxide annually [11]. However, 99 % of hydrogen today still stems from fossil fuels—we need sustainable solutions. An attractive alternative is the photocatalytic production of hydrogen, which only requires renewable resources—sunlight and water. However, this technology is still in an early stage, unlike water electrolysis, which has showcased an efficiency of over 30 % with countless cost-effective commercial applications [12]. While still struggling with efficiency, the paramount promise of photovoltaic hydrogen is scalability for safe systems that offer durability and practicality. Recently, researchers demonstrated a photocatalytic production plant of 100 square metres [13], and the field is thriving with published papers and patents growing exponentially. Photocatalytic hydrogen still faces several challenges. For instance, performance is closely connected with the band structure and the bandgap of the catalyst —as well as responsiveness to a wider wavelength range. Narrowing the band gap could boost hydrogen production and reduce the reliance on specific wavelengths, maximising the utilisation of solar energy [14]. Furthermore, scalable systems should safely separate hydrogen, to reduce the risk of explosion. Technologies such as membranes, metal-organic frameworks and, more recently, hydrogels, have emerged as a practical possibility, which could enable applications such as floatable production platforms, with promising potential in large-scale production, sometimes straight from seawater, a sustainable source of hydrogen [15]. Additionally, chemists could collaborate with biologists to boost the efficiency of photo-biological processes to produce hydrogen, thanks to some of the most competent catalysts—enzymes [16]. Biological transformations open the door to the generation of clean hydrogen from water, as well as other renewable sources such as biogas, biomass, and even wastewater [17]. Tools such as the genetic and metabolic engineering of microorganisms, as well as the directed evolution of enzymes (one of the "Top Ten" picks in the first edition of the initiative), could advance the avenues towards a scalable, low-cost, commercial clean hydrogen [18].



99 % of hydrogen today still stems from fossil fuels—we need sustainable solutions. An attractive alternative is the photocatalytic production of hydrogen, which only requires renewable resources—sunlight and water.

Chloride-mediated removal of ocean CO_2

The United Nations consider the ocean our greatest ally against climate change. It absorbs a quarter of all carbon emissions, as well as 90 % of the excess heat generated by greenhouse gases—a big buffer blocking the consequences of the climate crisis [19]. However, the ocean's force is finite, and the excess carbon dioxide accumulated is acidifying seawater and affecting marine life. On the other hand, the excess carbon dioxide could be converted into a capital resource—a carbon reserve free from fossil fuels. In that sense, the electrochemical capture of carbon dioxide from seawater has emerged as an attractive alternative towards net negative emissions, which some venture could provide synthetic fuels and chemical feedstocks at a gigaton per year scale [20]. Nowadays, most systems for electrochemical CO_2 removal rely on bipolar membrane electrodialysis, a technology that presents two important challenges—it is still expensive, and sometimes leaks, which could contribute to additional contamination of the ocean. Now, a new idea bypasses membranes altogether, and could potentially provide an efficient and inexpensive mechanism for ocean carbon removal [21]. This alternative only requires two bismuth-based electrodes, pumps, and gas separation systems, all economical and easy to scale up. It is a cyclic process. The pump provides water to the first electrode, which acidifies it further to free and filter carbon dioxide out. The same mixture travels to the second electrode, featuring a reverse voltage and setup to raise the pH. Regularly, the roles of the electrodes switch to regenerate a continuous flow, cyclic operation, which could cost as little as $56 per ton of carbon dioxide, according to the first technoeconomic studies [22]. It is an early emerging technology, but definitely a promising plan to reduce and reverse the acidification of our oceans.



The electrochemical capture of carbon dioxide from seawater has emerged as an attractive alternative towards net negative emissions, which some venture could provide synthetic fuels.

GPT language models in chemistry

In 2020, artificial intelligence (AI) already made the "Top Ten" selection [23]. Since then, AI models and applications have advanced remarkably, particularly thanks to the release of improved large language models (LLMs) such as OpenAI's ChatGPT, designed and developed to both understand and generate conversations. After meticulous training with a vast amount of data, the AI model learns patterns, grammar, and semantics in language, understands inputs and reasoned responses, which include translation, summarisation, and more. The popularisation of LLMs has equally excited and concerned the scientific community. For example, some feared that fake research papers generated with AI tools could eventually get published—it is relatively easy to trick reviewers, and even simpler to fool specialised tools for plagiarism detection [24]. LLMs have also allegedly started generating peer-review reports, which generates many questions about the solidity and stability of the present-day publishing industry [25]. Nevertheless, many defend LLMs as 'the future of the field.' Because, on top of retrieving responses that look like real-life human discussions, language models have been successfully used in chemistry applications. ChatGPT and other algorithms analyse microscopy images, predict protein structures, and even estimate reaction yields – the possibilities are endless [26]. A novel tool called 'ChemCrow' makes the most of LLMs and is quite capable of accomplishing tasks including planning synthetic routes, controlling robotic reaction platforms, automated analysis, and much more. Additionally, the newest updates include several safety checks to avoid the accidental preparation of potentially harmful products, such as explosives, chemical weapons, and controlled substances [27]. Some studies suggest that LLMs 'understand' complex chemical problems better than tools such as deep learning, expanding the possibilities beyond chatbots [28]. Moreover, LLMs could convey advantages for chemistry education, streamlining literature reviews, information search, and much more. Although some early experiments suggest LLMs still struggle with basic chemistry questions, ChatGPT could rescue students and professors from 'the morass of the mundane, from meetings and memos' [29], freeing time for creativity and constructive conversations.

Synthetic electrochemistry

Electron exchanges drive chemical reactions. Since electricity is our cheapest and greenest source of electrons, it has been used as a powerful tool to transform substances since the discovery of the battery in the early 19th century. The first electrolysis soon ensued the experiments by Alessandro Volta, and just a few years later Michael Faraday performed an electrochemical reaction on an organic compound—the decarboxylation of acetate. The field faded after these famous feats, and briefly resurfaced in the mid-20th century with the discovery of cyclic voltammetry, a technique that enabled a better characterisation of the reaction processes, and was further enhanced later on with the advances in computational calculations [30]. Now, these advances, together with the development and deployment of intuitive and inexpensive equipment, have shed light into a process previously considered a "black box," and synthetic electrochemistry is experimenting a recent renaissance, which has brought benefits such as higher levels of chemo- and regio-selectivity [31]. Now, electrochemistry enables an enormous variety of transformations—the synthesis of ethers, Birch-type reactions, oxidation and fluorination of carbon–hydrogen bonds, and many more [32]. Recently, researchers reported yet another breakthrough in the field—the selective reduction of carbonyl groups, even in presence of other redox-active groups, thanks to alternating current. The team had collaborated closely with chemistry equipment manufacturer IKA to design and develop hardware and software that make the new method accessible to as many laboratories as possible. ElectraSyn is a device designed to democratise synthetic electrochemistry [33]. Electrosynthesis is intimately linked to green chemistry, and shares several key aspects, including high levels of safety, reliability, atom economy, and low energy consumption. These standards have streamlined industrial uptake, with productive processes such as the Baizer process, a method to manufacture adiponitrile, key in the production of nylon, which yields over 300 kilotonnes annually [34]. BASF also uses electrochemistry to synthesize substituted toluenes, making more than 30 kilotonnes of *para*-tolualdehyde and 3.5 kilotonnes of para-metoxytoluene. 3M, Bayer, Johnson Matthey, La Roche, and Sandoz also make the most of electrosynthesis towards key products and intermediates [35]. Currently, many manufacturers embrace electrosynthesis to enhance their production processes, reducing costs and greenhouse gas emissions in the chemical industry. Combined with renewable electricity, electrochemistry emerges as a sustainable and versatile tool for organic synthesis.

Artificial muscles

Surprisingly, the idea of artificial muscles—or mimicking muscle action with actuators—dates back to the 17th century and experiments by British scientist Robert Hooke. However, it was not until the last 30 years that advances in chemistry and materials science have made the artificial muscles a real possibility. Some state-of-the-art solutions have safely survived in-vivo studies [36], showcasing the promising potential of the field—nevertheless, experts envision clinical trials and applications in humans still lay years ahead. Research on artificial muscles encompasses many materials, a multidisciplinary endeavour examining devices that contract, expand, or rotate in response to different external stimuli, including current, temperature, pH, and light, among others [37]. The challenge is twofold: first, it is about synthesising structures that mimic muscles, then infusing functionality and responsiveness. Researchers have found inspiration in insects, with microfilaments that emulate the movements and micro-structures of myosin and actin, the main muscle proteins in nature; as well as powerful polymers, elastomers engineered to respond to electrical currents, which have shown promise in patients recovering from heart surgery, urinary incontinence, and some side-effects of strokes [38]. Another attractive approach comes from the design and development of composite materials that mimic the natural structure of skeletal muscles. With a combination of liquid crystal elastomers and a matrix of graphene fillers, which mimic myosin and actin in natural fibres, the artificial muscle materials maintain strong mechanical properties and convey conductivity of electrical signals, key for functionalities such as actuation and locomotion. The technology, now patented as "Hercules" fibres, is seeking commercialisation through a Korean spin-off company, and could uncover applications in defence, manufacturing, and medicine, according to the authors [39]. Additionally, artificial muscles have revolutionised robotics, creating highly-adaptable and flexible systems for applications that include prosthetics, exoskeletons, and biomedical devices such as grippers, microsurgery mechanisms, and many more. Thanks to artificial muscles, robots could potentially provide more precise control, as well

Research on artificial muscles encompasses many materials, a multidisciplinary endeavour examining devices that contract, expand, or rotate in response to different external stimuli, including current, temperature, pH, and light, among others.

as improved responsiveness with lifelike movements, making them more suitable and usually safer than current alternatives, especially for delicate tasks [40].

Phage therapy

Phage therapy is a promising approach to combat bacterial infections, in a time when antimicrobial resistance is rising to worrying levels—in 2019 it killed five million people, most of them in low- and middle-income countries. If the trend continues, current calculations estimate that the numbers will double by 2050, which will immediately impact the global economy with costs of one trillion dollars per year [41]. The discovery of bacteriophages (or simply, phages), took place in the early 20th century, simultaneously and independently by Frederick Twort in 1915 and Félix d'Hérelle in 1917. It was the latter who not only extensively studied this type of viruses that specifically target and infect bacteria, but also already recognised the huge potential of phages as a therapeutic tool to treat bacterial infections. In the past years, the field of phages has witnessed a renaissance, a revitalisation that has shown great promise treating bacterial infections, as well as other diseases such as cancer [42]. The differences among applications lay in key structural differences across the phage viruses—the 'lytic' phages infect bacteria and reproduce within, until the crowd of duplicates destroys the host; the 'non-lytic' or 'lysogenic' phage [43], on the other hand, assimilates its genome within the host's, and have found applications in targeted treatments for cancer, stroke, bone defects, and more [44]. But besides biology, chemistry could also complement the characteristics and features of phages—as well as spark uses in drug discovery, diagnosis, and materials science. For example, encapsulation techniques (such as liposomes, nanoparticles, hydrogels, or metal-organic frameworks) could convey controlled delivery of phages, increasing stability, availability, protection from degradation, and advanced active site targeting [45]. Phages have also found use in novel nanomedicine applications, including the study of protein interactions. Recent studies suggest that phages could display peptides and proteins of interest for proteomics analyses—a strategy to discover interesting targets for diagnosis, therapy, and signalling pathways [46]. Last but not least, phages have also emerged as an extremely versatile platform for supramolecular chemistry, a field in the frontiers of chemistry, materials science, and medicine. Phages have formed inorganic nanostructures, platforms for stem-cell differentiation, detected disease biomarkers, and structured scaffolds for applications such as tissue regeneration [47]. The rediscovery of phages could not only create innovative ways of fighting the so-called 'superbacteria', but also stimulate exciting discoveries in supramolecular chemistry and biomaterials.

Biological recycling of PET

Plastic pollution is a persistent problem [48]. Recent reports have shown plastics and microplastics appearing in the most improbable places—Antarctic krill, freshly fallen snow, even human blood samples [49]. The Organisation for Economic Co-operation and Development (OECD) is concerned that, while the world has doubled its production of plastic waste in the past

An especially exciting development in recycling is an enzyme that hydrolyses PET back into its building blocks, with excellent yield and productivity.

twenty years, only 9 % of plastic is properly recycled, and 22 % of waste is mismanaged and incorrectly disposed [50]. Once again, chemistry could come to the rescue, bringing better solutions for sustainability, providing a hopeful new model based on the reutilisation of resources and the reduction of waste and by-products [51]. The discovery and characterisation of enzymes that could naturally hydrolyse and degrade polymers and plastics opened a world of new possibilities for repurposing and recycling [52]; and soon the expansion of directed evolution (awarded with the 2018 Nobel Prize in Chemistry and selected as one of IUPAC's "Top Ten" Emerging Technologies in 2019) has further driven the promises in this field [53]. An especially exciting development is an enzyme that hydrolyses polyethylene terephthalate (PET) back into its building blocks, with excellent yield and productivity. The traditional techniques for PET recycling result in an incremental loss of mechanical properties. However, the evolved enzymes eventually produce PET with the same properties as petrochemical PET—contributing to circularity and reducing waste in landfills and the environment [54]. And the good news is commercialisation is close. French green chemistry company, Carbios, is currently building a plant that will implement this innovation industrially and, by 2025, it will be ready to recycle 50 kilo tonnes of PET per year—the equivalent to 2 billion PET bottles [55].

Depolymerisation

We have already reviewed the problems of plastic pollution. Moreover, back in 2019, we explored some solutions based in biotechnology to break polymers back into basic building blocks—monomers. Now, we are revisiting this approach to recycling, with additional angles on upcycling, circularity, and sustainable design. Different tools could provide interesting ideas for repurposing plastic waste into valuable resources. Chemically cutting polymers into monomers is an especially suitable solution for polycondensation polymers such as PET, polyamides, and polyurethanes. Similarly, high-temperature processes like pyrolysis and gasification convert polymers such as polyethylene and polypropylene of smaller molecular fragments—not monomers, yet interesting feedstock for recycling. Several start-ups and companies have successfully implemented chemical recycling processes for various waste products, including PET packaging, bottles, textiles, as well as polyurethane and polystyrene streams [55]. Finding the right approach to chemical recycling can significantly contribute to a circular economy for plastics and aid in achieving carbon neutrality within the plastics value chain. Two priorities towards more productive depolymerisation include the rational design of polymers and macromolecules and the reduction (or removal, if possible) of additives acquired during plastic processing. All efforts towards re-engineering the production of polymers and plastics could mitigate some of the problems of pollution [56]. Some exciting examples include polydiketoenamines, a family of strong and powerful polymers that bring us closer to closed-loop, zero-waste plastics. The covalent bonds in polydiketoenamines are easy to recycle and upcycle with simple mechanochemical methods [57]. Another attractive

Different tools could provide interesting ideas for repurposing plastic waste into valuable resources. Chemically cutting polymers into monomers is an especially suitable solution for polymers such as PET, polyamides, and polyurethanes.

alternative is microwave-assisted depolymerisation, which is already scaled-up for the recycling of PET. Recently, Swiss firm Gr3n announced a new plant that will recycle 40 kilo tonnes of PET annually using this method, which will open in 2027 [58]. Beyond biodegradability, chemists could create polymers and plastics safe and sustainable by design. For example, the latest advances in molecular modelling could help anticipate and predict possible pollution problems, degradation side-effects, and the viability of recycling reactions. Moreover, comprehensive life-cycle analyses would help us better understand the impacts beyond waste, including factors such as economics, carbon emissions, and product-life. In this sense, policies such as REACH [59] and new digital product passports, already implemented in the EU, could catalyse change towards the circular economy [60].

"Low-sugar" vaccinations

Glycans—namely oligo- and polysaccharides—cover most biological structures, including nucleic acids, lipids, proteins, and cells in general. Glycans' sugar coatings contribute to a variety of functions - immune responses, receptor recognition, as well as communication, signalling, and interactions between cells. Understanding glycans and the "glycome" is vital for developing vaccines, studying diseases, and advancing biomedical research [61]. The role of sugars was key in the development of vaccines and treatments for SARS-CoV-2, the virus that causes COVID-19. Researchers demonstrated that glycans played a key role in the recognition process of the spike protein, contributing to a more effective infection [62]. And more recently, another advancement related to sugar chemistry conveyed an interesting steppingstone towards better and broader vaccines against SARS-CoV-2, with enhanced effectiveness against new variants. In this case, however, removing the sugar skin of the spike protein seems to provide a powerful protection against infection. Deleting some of the sugars exposes the most common and conserved regions of the virus, which leads to stronger and broader immune responses, including both neutralising antibodies and T-cells. This "sugar-free" vaccine showcased many advantages *in vitro*, however further studies will need to corroborate the results *in vivo*, and then examined further by clinical trials [63]. A similar solution, "glycan trimming," has also shown promise in the development of more effective vaccines against HIV infection. The modifications in the glycoprotein improve the immune response in animal models, helping better recognise the HIV virus despite its evasive envelope—a glycan coating that tricks antibodies and T-cells [64]. Although the technology is still in a very early stage, some biotechnology and pharmaceutical companies have already attained agreements to further develop and commercialise the idea.

The 2023 "Top Ten" Emerging Technologies in Chemistry represent a diverse selection all around—from very early-stage ideas to industrialised innovations, in many different fields of chemistry, including synthesis, materials science, energy, biomedicine, and education. Perhaps instead of considering chemistry the "central science," we should consider it the "connecting science"—one that catalyses collaboration across disciplines and encourages industrial innovation. Similarly, sustainability remains a universal subject throughout the "Top Ten" selections—the uttermost purpose of the initiative is still to ensure a sustainable future, advancing our society, and improving our quality of life [65]. We need creative chemistry solutions for a better world, therefore let us work together to identify the most imaginative ideas and innovations and guarantee growth, as well as access to basic rights—including renewable energy, fuels, food, and pharmaceuticals for all.

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IUPAC Announces the 2023 Top Ten Emerging Technologies in Chemistry

IUPAC has released the 2023 Top Ten Emerging Technologies in Chemistry. The goal of this initiative is to showcase the transformative value of chemistry and to inform the general public about the potential of chemical sciences to foster the well-being of Society and the sustainability of our planet. The Jury* —an international panel of scientists with a varied and broad range of expertise- reviewed and discussed the diverse pool of nominations of emerging technologies submitted by researchers from around the globe and selected the final top ten, covering a range of fields from synthesis and polymer chemistry to health and artificial intelligence. These technologies are defined as transformative innovations in between a discovery and a fully-commercialized technology, having outstanding potential to open new opportunities in chemistry, sustainability, and beyond.

The 2023 finalists are (in alphabetical order):

- Artificial muscles
- Biological recycling of PET
- Chloride-mediated removal of ocean CO_2
- Depolymerisation
- GPT language models in chemistry
- Low-sugar vaccination
- Phage therapy
- Photocatalytic hydrogen
- Synthetic electrochemistry
- Wearable sensors

This year in particular, the selection promotes cross-collaboration in chemistry to create exciting emerging technologies that bridge the gap between academia and industry, while continuing the current competitiveness of chemical manufacturers. The technology readiness level varies along the different solutions—nevertheless, all show a provocative promise to reimagine our world and our society. The new additions grow the list of emerging technologies to fifty—all with a powerful potential to make our world more sustainable and all suitable solutions to the current polycrisis.

The 2023 Top Ten Emerging Technologies in Chemistry are further detailed in a feature article published in the October issue of *Chemistry International (CI)* [see page 14]. Fernando Gomollón-Bel, the author of that feature concludes by suggesting that “instead of considering chemistry the “central science,” we should consider it the “connecting science”—one that catalyses collaboration across disciplines and encourages industrial innovation.” He also noted that “sustainability remains a universal subject throughout the “Top Ten” selections—the uttermost purpose of the initiative is still to ensure a sustainable future, advancing our society, and improving our quality of life. We need creative chemistry solutions for a better world, therefore let us work together to identify the most imaginative ideas and innovations and guarantee growth, as well as access to basic rights—including renewable energy, fuels, food, and pharmaceuticals for all.”

The first selection of the Top Ten Emerging Technologies in Chemistry was released in 2019 as a special activity honoring IUPAC’s 100th anniversary. The results were published in the April 2019 issue of *Chemistry International*, 41(2), pp. 12-17, 2019. The results of subsequent editions and the related articles in CI can be accessed at: https://iupac.org/what-we-do/top-ten/.

The search for the next Top Ten Emerging Technologies in Chemistry has already begun and is being led again by Michael Droescher. For more information on the search for the Top Ten Emerging Technologies in Chemistry go to: https://iupac.org/what-we-do/top-ten/.

*The following comprised the panel of judges for the 2023 Top Ten Emerging Technologies in Chemistry: Chair, Michael Droescher, (German Association for the Advancement of Science and Medicine), Jorge Alegre-Cebollada (Centro Nacional de Investigaciones Cardiovasculares, Spain), Mamia El-Rhazi, (Université Hassan II de Casablanca, Mohammedia, Morocco), Javier García Martínez (Universidad de Alicante, Spain), Ehud Keinan (Technion, Israel), Rai Kookana (CSIRO Land & Water, Australia), Molly Shoichet (University of Toronto, Canada), Zhigang Shuai (Tsinghua University, China), Juliane Sempionatto (Caltech, USA), Natalia P. Tarasova (D. I. Mendeleev University of Chemical Technology, Russia), and Bernard West (Life Sciences Ontario, Canada).

Awardees of the 2023 IUPAC-Zhejiang NHU International Award for Advancements in Green Chemistry

The 2023 IUPAC-Zhejiang NHU International Award for Advancements in Green Chemistry was announced and presented during the 49th IUPAC World Chemistry Congress in The Hague, The Netherlands. We congratulate Xile

Hu from the Swiss Federal Institute of Technology, Switzerland as the experienced chemist award winner, and Mirabbos Hojamberdiev from Technical University Berlin, Germany, Jiayu Peng from Department of Materials Science and Engineering, Massachusetts Institute of Technology, USA, and Zhe Zhuang, Department of Chemical and Systems Biology, Stanford University, USA as the young award winners.

The IUPAC-Zhejiang NHU International Award for Advancements in Green Chemistry is presented every two years. Each time, one award is presented to an experienced chemist (10000 $US), and three awards are given to three young chemists (2000 $US each) for their significant contributions to the field of green chemistry. The previous awards were presented in 2019 and 2021, respectively.

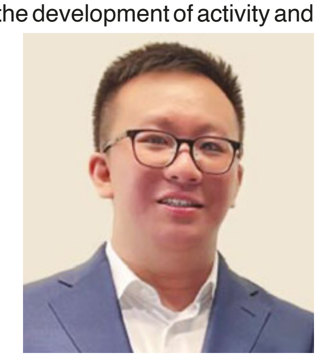
Professor Xile Hu has been invited to deliver a plenary lecture at the 10th IUPAC International Conference on Green Chemistry, 25-29 October 2024, Beijing, China, and the three young award winners have been invited to give invited lectures at this conference. In addition, each of the award winners is expected to write a short critical review for *Pure and Applied Chemistry.*

Main achievements of the winners

Professor **Xile Hu's** group has made many outstanding scientific discoveries in the field of Green Chemistry, particularly in Green Catalysis and Green Energy. In the area of green catalysis, they have developed new catalytic methods and catalysts that are based on earth-abundant elements for organic synthesis. In the area of green energy, Hu and his team have developed a number of novel earth-abundant electrocatalysts for the hydrogen and oxygen evolution reactions (HER and OER), which are the two half-reactions for water splitting, the main route to green hydrogen. They have made significant contributions to highly active earth-abundant catalysts for the hydrogen oxidation reaction, the key cathodic reaction in fuel cells. They have also invented superior anion exchange membranes (AEMs) for next-generation membrane water electrolyzers and fuel cells. They have demonstrated record-setting efficiencies in AEM electrolyzers and fuel cells. His group has made breakthrough catalysts and systems for CO_2 and CO electroreduction. Their work is not only of fundamental value but has significant potential in industrial applications. For example, a startup company, NovaMea SA, has been founded based on their work in green energy. Follow his work at https://orcid.org/0000-0001-8335-1196

Mirabbos Hojamberdiev works on the development of strategies to synthesize mixed-anion compounds for artificial photosynthesis. He explores perovskite oxynitrides as one of the promising photocatalysts for water oxidation due to their absorption of visible light, small bandgap energy, good stability, and nontoxicity. He has significantly enhanced water oxidation performance of perovskite barium tantalum oxynitride by modulating the key parameters, such as photon absorption, charge generation, charge separation, charge transport, and surface properties, by engineering the morphology and textural parameters, stability, and electronic, crystal, and defect structures. His innovative strategies have allowed the synthesis of perovskite oxynitrides with less defect density at lower temperature and shorter time. The systems that he developed have exhibited high efficiency and stability, which are important for the application of solar water-splitting reactions to generate green hydrogen in the future. Green hydrogen generated from solar water splitting may play an important role in achieving sustainable development goals. Follow his work at https://orcid.org/0000-0002-5233-2563

Jiayu Peng works on the development of activity and stability design principles for catalyst optimization. His research tackles the scientific question—how to understand, control, and engineer catalysts on the atomic scale to have optimal activity and stability for diverse renewable technologies. Combining electrochemistry, physical chemistry, and materials science, he has developed physics-driven catalyst design principles for



activity and stability optimization. He has identified one of the first-ever sets of stability design principles for preventing catalyst degradation in acid, where modulating the electronic structure of transition metal oxides and nitrides stabilizes them against dissolution in acidic electrolytes. Furthermore, he has shown that tuning the electron-withdrawing capability of heterometal substituents in transition metal oxide catalysts can optimize their bonding properties, reaction barriers, and catalytic activity for boosting electrochemical water splitting to produce hydrogen fuels. Such principles highlight a physically meaningful framework with quantitative predictive power for accelerating catalyst design to combat the most recalcitrant, urgent societal challenges in sustainability and decarbonization, including climate change, environmental pollution, energy poverty, and food insecurity. Follow his work at https://orcid.org/0000-0003-3696-770X

Zhe Zhuang works on advancing the field of C–H functionalization reactions of native substrates using practical oxidants and catalysts. He has developed a range of C(sp^3)–H functionalization reactions that utilize inexpensive and industry-compatible oxidants, namely tert-butyl hydrogen peroxide and sodium percarbonate, with the potential for large-scale manufacturing. In contrast to traditional multi-step synthesis approaches, his methodologies enable the streamlined, one-step synthesis of biologically significant scaffolds from readily available starting materials, such as aliphatic carboxylic acids and amines. The utility of these protocols has been demonstrated through their applications in late-stage functionalization of natural products and pharmaceutical compounds, as well as in total synthesis endeavors. For example, he has developed a method for the direct synthesis of β-lactones from readily available aliphatic acids. This approach yields a versatile intermediate for constructing diverse compound library in medicinal chemistry and serving as a covalent warhead in drug discovery. The use of inexpensive and practical tert-butyl hydrogen peroxide in water, combined with the ease of product purification without the need for column chromatography, render this reaction scalable and potentially amenable to tonne-scale manufacturing.

The IUPAC-Zhejiang NHU International Award, managed by the ICGCSD, is presented every two years. Look for the announcement of the next call in 2024 ahead of the 2025 IUPAC World Chemistry Congress that will take place in Malaysia. For further information about the IUPAC-Zhejiang NHU International Award, see https://iupac.org/what-we-do/awards/.

Empowering Future Chemists: IChO and IUPAC Work together to Inspire New Chemistry Vocations

The 55th edition of the International Chemistry Olympiad (IChO) was held from 16-25 July 2023 in Zurich, Switzerland. The alpine country hosted the competition for the first time, bringing together 350 students from 89 different countries. Despite the competitive spirit, the friendship among all participants was the main characteristic of this international event. The IChO is an annual competition for some of the most talented secondary school chemistry students. Participating countries send a team of four students who compete in two separate exams, a practical laboratory exam and a written theoretical exam. The mission of the IChO is to promote friendly relations between young people from different countries, encouraging cooperation and international understanding. Indeed, the IChO 2023 had a very fitting motto: "Let's find solutions together!"

IUPAC is a long-standing partner of IChO. In 2007, the two organizations signed a Memorandum of Understanding (MoU). IUPAC provides some financial support to enable the participation of students from low-income countries and to contribute to the promotion of IChO's goals and activities. The MoU was renewed in May 2022 which ensures the continuation of the strong partnership between these two international chemistry organizations that share not only their commitment to inspiring and empowering young students, but also their passion for chemistry, education, and international cooperation.

During the first two days of IChO 2023, the students explored the beautiful city of Zurich and the ETH (Swiss Federal Institute of Technology), where the exams were held. The initial shyness on the first day vanished as the participants engaged in enjoyable activities together. The environment in the student hotel was also lively. The building's clubhouse was packed with people chatting, playing games and, of course, solving chemistry problems! The exams lived up to their reputation of being challenging, leading to high nerves before the first exam. The competition included a total of 5 hours of practical

Some of the students who took part in the IChO 2023 and IUPAC President, Prof. Javier García Martínez, during the visit to Lucerne.

lab exercises and 5 hours of theoretical problems, covering various topics from organic chemistry to physical chemistry. A real chemistry marathon over two days that required all participants to give their best.

For the participants, IChO 2023 was a unique opportunity to make new friends that share their passion for chemistry and discover new places in Switzerland. Carmen Fuentes Campos, a student from Sevilla, Spain, was very positive about the Olympiad: "As an IChO participant, this experience has not only allowed me to test myself by putting my knowledge into practice in the different tests, but also to realize how much I still have to learn. This has really increased my interest to get to the deepest and most complex part of chemistry and to become a researcher in the future to go as far as possible. It was a life-changing experience that many of these students will never forget."

The IChO 2023 was possible through the efforts of 300 volunteers, including team guides, mentor guides, exam authors, scientific assistants, and the members of the scientific committee. They were always recognizable by their colourful T-shirts. These volunteers embodied the best part of the IChO: generosity and hope for the next generation of chemists. They skilfully managed and maintained a tight schedule throughout the 10-day event, which is no small feat when coordinating over 600 people, while the scientific committee not only put together the exams, but also managed to correct them in record time.

In addition to the exams, the participants had the opportunity to explore the country during the weekend. On Saturday, they visited Lonza in Visp, where they learned how chemistry helps to improve our daily health. In the afternoon, they went on an exciting self-guided tour of Bern. As you would expect in Switzerland, there was also a chocolate tasting on the train between Visp and Bern. A delicious trip! On Sunday, they visited Lucerne, crossed the lake by boat, and climbed Mount Rigi for a spectacular view. There, IUPAC President Javier García Martínez addressed all participants, telling them how they can help create some of the solutions we need to address our most pressing challenges, and how we at IUPAC are working to provide the chemistry community with the resources, data, and standardized methods to accelerate chemical discovery, improve chemistry education, and make science more impactful, useful, and inclusive.

On Monday, 24 July, the Tonhalle concert hall in Zurich was filled with hundreds of students eager to find out if they would be awarded one of the 2023 IChO medals. A wave of excitement and friendship filled the air as national flags flew in the recently restored hall. It was clear to all in attendance who heard the shouts of support for the medallists that friendship, not competition, was the star of the IChO 2023 Closing Ceremony. For those who received a gold medal, IUPAC President Javier García Martínez presented them with a signed IUPAC Periodic Table, which they will surely treasure for years to come.

IChO 2023 Closing Ceremony at the Tonhalle Concert Hall; gold medalists fly their flags as all participants show their support.

IUPAC and the International Chemistry Olympiad have joined forces to promote new vocations in chemistry. The importance of this mission cannot be overstated. By promoting excellence and recognizing talented students, the IChO inspires the next generation of chemists to pursue careers in this vital scientific field. Encouraging young people to explore and embrace chemistry is paramount, as it lays the foundation for future discoveries and innovations that can address pressing global challenges ranging from sustainable energy solutions to environmental protection and medical breakthroughs. The combined efforts of IUPAC and IChO contribute significantly to the advancement of chemistry and its critical role in shaping a better and more sustainable world for generations to come. Let's meet again at the 56th International Chemistry Olympiad in Ryad, Saudi Arabia, in July 2024.

https://www.icho2023.ch/

Report prepared by Víctor Sabanza <victor.sabanzagil@epfl.ch> a PhD candidate at the École Polytechnique Fédérale de Lausanne (EPFL) and a volunteer during the IChO 2023 in Zürich.

WorldFAIR month 12 deliverables

In June 2023 CODATA announced that all the WorldFAIR month 12 deliverables have been submitted to the *EC HORIZON* agency and are available in their Zenodo community:

- WorldFAIR Project (D3.1) Digital recommendations for Chemistry FAIR data policy and practice: https://doi.org/10.5281/zenodo.7887283

This report reviews some of the critical and persistent issues around documentation of chemical information. These were identified through a series of webinar panels on the theme: "What is a chemical?", and through other conferences, workshops, and ongoing collaborative projects run as part of the WorldFAIR project and IUPAC (the lead organisation of WP03). See IUPAC Project 2022-012-1-024

- WorldFAIR Project (D4.1) Nanomaterials domain-specific FAIRification mapping: https://doi.org/10.5281/zenodo.7887341
- WorldFAIR Project (MS6) Geochemistry Scientific Content Component: https://doi.org/10.5281/zenodo.7977116
- WorldFAIR Project (D7.1) Population Health Data Implementation Guide: https://doi.org/10.5281/zenodo.7887385
- WorldFAIR Project (D8.1) Urban Health Data – Guidelines and Recommendations: https://doi.org/10.5281/zenodo.7887523
- WorldFAIR Project (D9.1) Data standard for sharing ecological and environmental monitoring data documented for community review: https://doi.org/10.5281/zenodo.7849241
- WorldFAIR Project (D12.1) Disaster Risk Reduction Case study report: https://doi.org/10.5281/zenodo.7887557

- WorldFAIR Project (D13.2) Cultural Heritage Image Sharing Recommendations Report: https://doi.org/10.5281/zenodo.7897244

This is a fantastic achievement and there is a lot of really important work described and communicated in these deliverables. The external reviewer commented on the quality and readability of the outputs. That reflects the efforts of the primary authors, but also of all the internal reviewers and the considerable editorial and proof-reading. The process is essential to ensuring the quality of the outputs and that they will be read and have impact. Congratulations to all involved and to the authors for their hard work and for helping the project stick to the deadlines.

WorldFAIR, a global initiative to advance implementation of the FAIR data principles within and across research domains, is funded by the EC HORIZON-WIDERA-2021-ERA-01-41 Coordination and Support Action under Grant Agreement No. 101058393. Visit WorldFAIR online at http://worldfair-project.eu

Actions Taken by IUPAC Council, The Hague, Netherlands, August 2023

On 23 and 24 August 2023, the 52nd IUPAC Council was held in The Hague Netherlands along with the IUPAC General Assembly and the 49th World Chemistry Congress, IUPAC|CHAINS.

The Congress and General Assembly both were a huge success, and IUPAC thanks the Royal Netherlands Chemical Society for their hospitality throughout the event.Of the 13 motions presented, Council passed 11 in a productive meeting. The list of all the motions that were presented are below; the online version includes embedded links to access background information.

Motion 1: Minutes of the 51st Council Meeting, which was online only, are approved.

This motion was passed with a show of hands.

Motion 2: Council ratifies all decisions taken by the Bureau and Executive Committee, since those approved by the Council at its 51st meeting in Montréal, Canada (online).

This motion was passed with a show of hands.

The corresponding minutes and list of decisions made are linked below.

Council Special Meeting: 4 June 2022, online

110th Bureau Meeting: 24 April 2023, online

109th Bureau Meeting: 4-6 November 2022, Frankfurt, hybrid

108th Bureau Meeting: 9 April 2022, online

107th Bureau Meeting: 20 November 2021, online

106th Bureau Meeting: 1 September 2021, online

162nd Executive Committee Meeting: 27 March 2023, online

161st Executive Committee Meeting: 16 February 2023, continued on 6 March 2023, online

160th Executive Committee Meeting: 6 November 2021, online

Motion 3: Council formally adopts the Recommendations approved by the Interdivisional Committee on Terminology, Nomenclature and Symbols (ICTNS) and published, or scheduled to be published, in *Pure and Applied Chemistry* from August 2021 to August 2023.

This motion was passed with a show of hands.

Motion 4 concerned the applications for IUPAC National Adhering Organisation membership for Honduras and Jordan. Each of these countries would enter IUPAC with a National Subscription of US$1000 and with one vote at Council Meetings.

Motion 4a: Council approves the National Autonomous University of Honduras as a National Adhering Organization effective 1 January 2024.

This motion was passed with a show of hands.

Motion 4b: Council approves the Jordanian Chemical Society as a National Adhering Organization effective 1 January 2024.

This motion was passed with a show of hands.

Motion 5 concerned proposals for changes to the Statutes and Bylaws of the Union. These were voted on by delegation, *i.e.* by show of cards, and each needed a two-thirds majority of the total number

of votes available (on 22 and 23 August 2023: 157, including Jordan and Honduras) to pass (Statute 16.3).

Motion 5a: Changing "National Adhering Organization" to "Council Member Organization".

This motion was not *passed.*

Motion 5b: Changes related to financial status: The Union shall be under no obligation to support the involvement of individuals whose Council Member Organization is more than twelve months in arrears (S9.2).

This motion was not *passed.*

Motion 5c: Voting at Council meetings: Membership has been adjusted to allow voting on admission (B1).

This motion was passed with a show of cards.

Motion 6 concerned the incorporation of the International Younger Chemists' Network (IYCN) as an IUPAC Committee. At their online meeting on 24 April 2023, the Bureau approved the incorporation of the IYCN as an IUPAC Committee with retention of the name IYCN and with autonomous management of their external communications, with the details of the incorporation to be determined by the Science Board. US$2000 of the proposed 2024/2025 budget is to be allocated to IYCN operational expenses, as for other IUPAC Committees.

Motion 6: Council approves the IYCN as an IUPAC Committee with retention of the name IYCN and with autonomous management of their external communications, with the details of the incorporation to be decided by the Science Board.

This motion was passed with a show of cards.

Motion 7 concerned the election of the Officers and Council-elected members of the Executive and Science Boards. According to Statute 5.7.2, the Council must elect the Officers of the Union, and the Elected Members of the Executive Board and the Science Board. All nominations for elections taking place at the 52nd Council meeting were received within the due date specified by Bylaw 2.2.2.1. New incumbents for the following positions had to be elected: Vice President, Secretary General, six Elected Members of the inaugural Executive Board and, as decided by the Bureau on 22 August 2023, five Council-Elected Members from the chemistry community at large of the inaugural Science Board (Statute 8.2 specifies that Council may elect up to five members for the Science Board).

Note that the current Vice-President, Ehud Keinan, and the current President, Javier García Martínez, will start their terms as President and Past President, respectively, on 1 January 2024. The term of the current Treasurer, Wolfram Koch, will run until the end of 2025.

The following people were elected by secret ballot, by delegation *(i.e.* with weighted vote):

Vice President
Mary Garson (Australia)

Secretary General
Zoltan Mester (Canada)

Elected Members of the Executive Board
Hemda Garelick (UK)
Richard Hartshorn (New Zealand)
Bonnie Lawlor (USA)
Christine Luscombe (Japan)
Bipul Saha (India)
Zhigang Shuai (China/Beijing)

Council-Elected Members of the Science Board
Eva Åkesson (Sweden)
Pierre Braunstein (France)
Alejandra Palermo (UK)
Peter Schreiner (Germany)
Chi-Huey Wong (China/Taipei)

Motion 7: Council ratifies the election of the new Vice President, Secretary General, Elected Members of the Executive Board and Council-Elected Members of the Science Board at the 52nd Council Meeting in The Hague, Netherlands.

This motion was passed.

Motion 8: The Czech Republic and Slovakia joint bid for Prague as host of the 55th General Assembly and the 52nd World Chemistry Congress from 18—24 August 2029 *was passed* by Council in a secret ballot with a simple majority.

Motion 9: Council approves the IUPAC Guidelines and the four policies presented by the Committee for Ethics, Diversity, Equity and Inclusion.

This motion was passed with a show of cards.

The policies in question are:
IUPAC Guidelines (April 2023)
IUPAC Social Media Policy
IUPAC Harassment Policy
IUPAC Conflict of Interest Policy
IUPAC Privacy Policy

Motion 10 concerned an adjustment to the national subscription fees for the NAOs to IUPAC, according to a decision at the Virtual Council Meeting of 31 July 2018 that the Member Subscriptions should be subject to a review ahead of the 2024 cycle. To take into account unrelentingly high inflation worldwide, a general annual correction of 7 % was proposed, to be implemented as follows:

Adjustment for countries below target is the general correction or 3 %, whichever is bigger, in this case 7 %.

Adjustment for countries on target is the general correction, in this case 7 %.

Adjustment for countries above target is the general correction less 3 %, in this case 4 %.

Motion 10: Council approves the proposed adjustments to the national subscription calculation to safeguard IUPAC's financial future and to ensure that IUPAC's income from national subscriptions reaches the amount forecast by the calculation sooner.

This motion was passed with a show of cards.

Motion 11 concerns the budget proposal for the 2024/2025 biennium. The presentation was somewhat different from that of previous biennia, in that the prior liabilities incurred by projects approved in past years were made explicit. The purpose of this was to sensitise IUPAC Committee members and Council delegates to the fact that project monies are not sequestered upon project budget approval, but are written up as liabilities against IUPAC's future income, a situation that has contributed to financial uncertainty within IUPAC. It was emphasised by the Treasurer that a careful review of IUPAC's overhead expenses will be conducted in the new biennium as a matter of priority.

Motion 11: Council approves the recommended 2024-2025 Budget.

This motion was passed with a show of cards.

Motion 12 concerned the approval of Division and Committee arrangements. Officers of these bodies listed below.

Motion 12a: Council reauthorizes the Commission on Physicochemical Symbols, Terminology and Units, the Commission on Isotopic Abundances and Atomic Weights, and the IUBMB- IUPAC Joint Commission on Biochemical Nomenclature (JCBN).

This motion was passed with a show of cards.

Motion 12b: Council approves the suggested changes in rules for Division V (Analytical Chemistry).

This motion was passed with a show of cards.

Motion 12c: Council approves the results from elections of Division Committee Officers.

This motion was passed with a show of cards.

Motion12d: Council receives the results (status on 27 July 2023) from elections of Titular Members of the Division Committees and the thus far known members of the Science Board.

This motion was passed with a show of cards.

Motion 13: Council approves the Composition and Terms and References of the Committee on Ethics, Diversity, Equity and Inclusion.

This motion was passed with a show of cards.

See online for details and links to background
https://iupac.org/actions-taken-at-iupac-council-the-hague-2023/

An International Decade of Sciences for Sustainable Development

On Friday, 25 August 2023, the United Nations General Assembly proclaimed 2024-2033 as the International Decade of Sciences for Sustainable Development.

On Friday 25 August 2023, during its 96th Plenary meeting of its 77th session, the United Nations General Assembly adopted a resolution declaring the International Decade of Sciences for Sustainable Development. co-sponsored by Andorra, Argentina, Armenia, Bangladesh, Belarus, Belgium, Bosnia-Herzegovina, Bulgaria, Cambodia, China, Croatia, Cuba, Cyprus, Dominican Republic, Egypt, Equatorial Guinea, Guatemala, Greece, Honduras, Hungary, Indonesia, Italy, Kazakhstan, Kenya, Kiribati, Kyrgyzstan, Latvia, Lithuania, Malaysia, Maldives, Malta, Republic of Moldova, Monaco, Montenegro, Morocco, Kingdom of the Netherlands, Pakistan, Peru, Philippines, Poland, Portugal, Russian Federation, Senegal, Serbia, Singapore, Slovenia, South Africa, Spain, Syrian Arab Republic, Tajikistan, Thailand, Timor-Leste, Turkey, United Kingdom, United Republic of Tanzania, the Bolivarian Republic of Venezuela, Viet Nam, and Zimbabwe.

All stakeholders of the International Year of Basic Sciences for Sustainable Development fully support this resolution.

The International Science Council noted that "by proclaiming the International Decade of Sciences for Sustainable Development, the United Nations General Assembly signals the need to shift towards a transformative era of science-based collaboration and progress. It stands as the recognition, at the higher international level, that achieving sustainable development requires a global transdisciplinary and multidimensional approach—one that bridges science disciplines, all forms of knowledge, and the realms of science, policy, and action. Rooted in the 2030 Agenda, this Decade seeks to harness a more effective and inclusive global approach to sustainability based on the synergic cooperation of all sciences and all knowledge forms in an integrative and transformative way to inform policymaking and the implementation of the SDGs." (from https://council.science/current/news/international-decade-of-sciences-for-sustainable-development/)

The full text of the resolution here https://digitallibrary.un.org/record/4019134

The Video record of the session is available as https://youtu.be/dTd_UaS28wY

2024 IUPAC-Richter Prize in Medicinal Chemistry

The 2024 IUPAC-Richter Prize will be presented during the XXVIII EFMC International Symposium on Medicinal Chemistry (September 1-5, 2024) in Rome (Italy) and the recipient will also give a lecture on the subject of their research at the 38th ACS National Medicinal Chemistry Symposium (June 23-26) in Seattle, WA, United States.

The prize is to be awarded to an internationally recognized scientist, preferably a medicinal chemist, whose activities or published accounts have made an outstanding contribution to the practice of medicinal chemistry or to an outstanding example of new drug discovery.

The Prize of USD 10000 has been has been established by a generous gift from the Chemical Works of Gedeon Richter, Plc. (Budapest, Hungary) to acknowledge the key role that medicinal chemistry plays toward improving human health.

Applicants should be received by NOMINATION only, with just one person needing to serve in that capacity, although a total of five (5) individuals should be listed as referees overall. The package must be submitted electronically and should contain a complete resume, a professional biography of not more than two pages, and a one-page summary of what the individual considers to be their activities, accomplishments and/or publications that have had the most significant impact upon the field of Medicinal Chemistry.

For further information please contact Prof. Janos Fischer, Member of the IUPAC Sub-committee on Drug Discovery and Development, by email at j.fischer@richter.hu

Nomination materials should be uploaded by **15 December 2023**

<https://iupac.org/2024-iupac-richter-prize-call-for-nominations/>

Design for International Standards for Chemistry Education

by Mei-Hung Chiu

Over the past 30 years, Johnstone's (1982, 1993) famous triangle of learning levels (macro, submicro, and representation) has played an influential role in chemistry education. Professional chemists work well inside the triangle and can manipulate all three components simultaneously and efficiently because of their descriptive and functional (macroscopic level), representational (symbolic level), and explanatory (microscopic level) skills. However, it can be a challenge for learners who lack the skill to connect and transform these components to learn chemistry, especially, when they are unfamiliar with these three components and have limited capacity to manipulate them mentally (Johnstone, 2000). Other researchers argue there are limitations to these three levels of teaching and learning chemistry and modified the triplet in chemistry by adding terms (such as experiences, models, visualization in Talanquer, 2011), by emphasizing the interaction between the three components proposed by Johnstones (Taber, 2000, 2013), and by introducing new elements (such as human element by Mahaffy, 2006; native languages by Chiu, 2012).

The purpose of this study was to identify and specify the chemistry literacy that elementary and secondary school students need to develop during their school years (K-12) via analyzing international chemistry curriculum standards across different countries. It aimed to compare the international chemistry curriculums and recommend teaching and assessment materials for researchers, educators, and policy makers. Several existing documents were used as the foundation of the study, for instance, globalization of science education (Chiu, 2012; Chiu & Duit, 2011), findings of TIMSS and PISA outcomes (OECD, 2013), and the chemistry education triangle approach (Johnstone, 1991, 2000; Mahaffy, 2006; Talanquer, 2011). Research has shown that most chemistry teaching focused on the factual knowledge and observable phenomenon. As a result, therefore students are lacking of the competence on bridging the phenomenon at macroscopic level to submicroscopic level. Also, teachers rarely help students build bridges to comfortably move between the three levels, macroscopic, microscopic, and symbolic levels in chemistry education (Talanquer, 2011; Treagust, Chittleborough, & Mamiala, 2003). Therefore, in order to propose International Standards for Chemistry Education (ISCE), several international chemistry education researchers from the IUPAC Committee on Chemistry Education collaborated and analyzed curriculum standards of chemistry education in different countries from grades 1-12 based upon the perspectives of phenomenon (*e.g.,* testable, measurable, and sensible), structure (*e.g.,* atomic and/or molecular models), and symbols (*e.g.,* formulas or icons) in order to make international comparisons.

There is no single curriculum standards set for promoting chemistry education in emerging and developed countries but there are so much to learn from different cultures and societies for improving chemistry education and providing insights for educational reforms in the future.

ISCE Framework—Terms definition

To adopt the relevant research in our study, we used the three epistemological aspects to analyze the standards of chemistry curriculum which include macroscopic, microscopic, and symbolic representations. Each definition of the three categories is stated below:

1. The macroscopic level is the observable chemical phenomena (or via human sensors) that can include experiences from students' everyday lives such as color changes, observing new products being formed and others disappearing. In other words, the characteristics of this aspect are dealt with concrete, observable, operational experience of scientific phenomenon which include descriptive knowledge of chemical phenomena
2. The microscopic level of representations, developed by chemists, which are descriptive, explanatory, and predictive, such as the particulate theory of matter, is used to explain the macroscopic phenomena in terms of the movement of particles such as electrons, molecules, and atoms for explaining macroscopic phenomenon.
3. Symbolic representations: In order to communicate about these macroscopic phenomena and underlying mechanism of the phenomena, chemists commonly use the symbolic representations to describe or explain the relations of components of a system. The symbolic representations include pictorial, algebraic, physical and computational forms such as chemical equations, graphs, reaction mechanisms, analogies and model kits. Symbols for electron, ions, molecules, chemical formula, chemical equations are used.

Coding process

- Step 1: To confirm which grader (ages) do the standards belongs to.
- Step 2: To confirm the national standards according to the contents, practices or application.

The task group at work, from left: Mustafa Sözbilir, Masahiro Kamata, Jan Apotheker, Mei-Hung Chiu, Michael Droescher, and Suzanne Boniface

- Step 3: To use Table of Contents of Atkins' General Chemistry textbook as the key concepts for analysis.
- Step 4: According to the statement of standards to distinguish the three epistemological elements of the framework:
  - Phenomenon (macro): observable, measurable
  - Structure (micro): model, atomic and molecular structure
  - Symbolic (representation)

  (See Figure 1, top)
- Step 5: Meetings for consensus on the coding scheme and then started to code individually
- Step 6: Coded and discussed
- Step 7: Finding examples from local textbooks according to macro/micro/symbolic representation.

Results

The results show that in general, curriculum standards for students' progressive development from phenomena in the lower grades (before 6th grade), to symbolic descriptions linked with the preliminary structures in the middle grades (grades 7-9), and finally to move to in-depth descriptions at the atomic and molecular levels (microscopic) of the structures with symbols at grades 10-12. However, standards for grades 10-12 in senior high schools tend to be decontextualized and focus on chemical theories.

As for emphasis of curriculum standards in different countries, the results show that first, Chile and Turkey had more emphasis on microscopic and symbolic levels and few emphases on the integrations of the three aspects in their curriculum standards. Second, although Japan had the chemistry curriculum standards linking between each two aspects of the triangle elements respectively, there were missing the integrations of the three aspects. Third, as for Malaysia, more emphases of the standards on the use of symbols in chemistry learning and few emphases on the linkage between phenomenon and symbols. Finally, there were three countries showed their curriculum standards integrating the three aspects together, namely, Israel, New Zealand, and Taiwan.

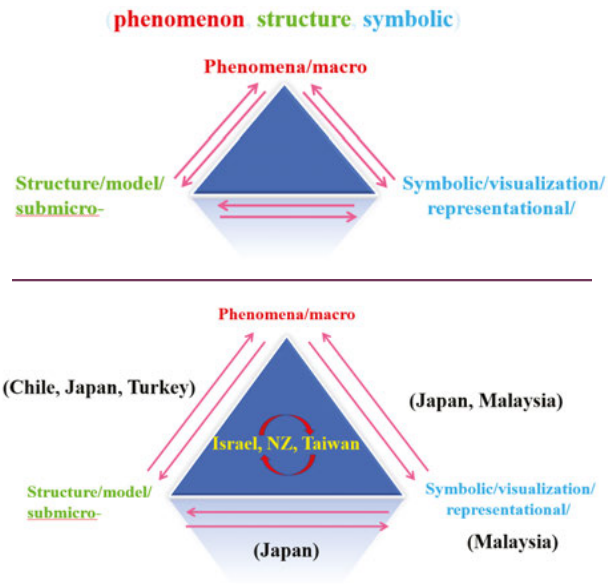


Figure 1: (top) The three epistemological elements used in the coding process. (bottom) Qualitative focus emphasized by specific national curriculum

To summarize, first, Chile, Japan and Turkey emphasized more on the linkage between phenomena at macroscopic level and structures of matters at microscopic level. Second, Japan and Malaysia focused more on the linkage between phenomena at macroscopic level and symbolic representations of matters and compounds, while there were three countries integrating macroscopic, microscopic, and symbols in their curriculum standards to present a relatively holistic framework for chemistry learning (Figure 1, bottom).

Conclusions

With well-designed curriculum standards, teachers can develop appropriate learning materials and strategies to cultivate students' understanding of chemistry and then apply their knowledge of chemistry in problem solving and authentic situations. The analyses of this study might provide an avenue for designing chemistry curriculum standards and further for chemistry education reforms.

We are faced with a great challenge in teaching chemistry, but it is also a great opportunity for us, as chemistry education researchers, to reflect on why we do the work we do and where our research could lead us to the next stage for future generations. While learning chemistry is a challenge for most students, research has shown that certain approaches can effectively promote learning through the use of sense-making materials and strategies (such as modeling-based text, conceptual conflict scenario, systems thinking, and innovative technology). Yet, more evidence-based research is needed to guide us on improving the quality of chemistry education both locally and globally. This goal cannot be easily achieved without researchers' and policymakers' persistence and passion for chemistry education.

Note:

Research findings were presented at various international conferences, such as the 23rd International Conference on Chemistry Education in Toronto, Canada, 2014; International Conference on Network for Inter-Asian Chemistry Educators (NICE) in 2015, and 24th International Conference on Chemistry Education 2016. Some of the participating countries might launch new curriculum standards ever since. Further analysis might be needed to investigate the progressive development on curriculum standards in chemistry across countries.

Acknowledgement

The author and chair of the project (2013-022-2-050) would like to take this opportunity to thank the following collaborators and task group members for their great support and involvement in the project. The study could not have been accomplished without their effort. They are Jan Apotheker (The Netherlands), Suzanne Boniface (New Zealand), Michael Droescher (Germany), Richard Hartshorn (NZ), Masahiro Kamata (Japan), Leontina Lazo Santibañez (Chile), Rachel Mamlok-Naaman (Israel), Mauro Mocerino (Australia), Hannah Sevian (USA) and Mustafa SÖzbilir (Turkey).

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Capacity Building of Teachers on Chemistry Hands-on Small-scale Experiments in High School in Asia: Nepal

by Supawan Tantayanon, Jyoti Giri, Rajesh Pandit, Rameshwar Adhikari, Supakorn Boonyuen and Zuriati Zakaria

Capacity Building of Teachers on Chemistry Hands-on Small-scale Chemistry [Kathmandu, 19-20 October 2022]: The capacity building of high school government science teachers were envisioned by the IUPAC Committee on Chemistry Education by introducing

Photographs of Dignitaries at Opening ceremony and participants in working in technical session

chemistry practical education at the high school level on a small scale. In the same connection, the IUPAC Project 2022-004-1-050 was planned in such a way that it could be sustainable for the future as well, therefore it was planned in four different segments:

- Phase 1: workshop in Nepal, 19-20 October, 2022, NAST
- Phase 2: video competition to select 10 best teachers who participate in PACCON 2023, 15 November 2022, Online
- Phase 3a: Networking & workshop in PACCON 2023, 21 January 2023, MaeFah Laung University
- Phase 3b: Training for trainers, 22 January 2023, Sann Hotel

As per project theme, the two-day workshop was conducted at the Nepal Academy of Science and Technology (NAST), Saatdobato, Lalitpur, Nepal for 100 government high school science teachers selected from 7 different provinces of Nepal. The workshop was organized by the Chemical Society of Thailand (CST), Bangkok Bank with financial collaboration and local organizing partner Nepal Polymer Institute (NPI). Locally the program was hosted by NAST and teachers out-reach partner Science Teachers Association, Nepal (STAN).

The workshop was the lightning bolt to all the participants; chemistry and science teachers who are responsible for teaching chemistry for high school students in theoretical and practical aspects inside the classroom. 100 permanent teachers from government high school were selected using a google form for application and selection was done on the basis of their answers to the questions and gender equity. Out of total 147 applicants 100 were selected: 22 participants from Province 1, 8 participants from Madhesh Province, 20 participants from Bagmati Province, 19 participants from Gandaki Province, 14 participants from Lumbini Province, 8 participants from Karnali Province, and 9 participants from Far Western Province. Of the 100 participants, only 3 were female teachers.

The workshop was conducted by 11 dedicated trainers came from Thailand

1. Supawan Tantayanon, *Chulalongkorn University*
2. Vudhichai Parasuk, *Chulalongkorn University*
3. Noppavan Chanunpanich, *King Mongkut's University of Technology North Bangkok*
4. Supakorn Boonyuen, *Thammasart University*
5. Boonnak Sukhummek, *King Mongkut's University of Technology Thonburi*
6. Thitinat Sukonket, *Suan Dusit University*
7. Sudkanueng Singto, *National Nanotechnology Center*
8. Chayawin Chomngam, *Prachinratsadornamroong School*
9. Jiraphan Charoensinvorakul, *Doing Sciences Co., Ltd.*

Chotima Nooprick, *Office of the Basic Education, Ministry of Education*Zuriati Zakaria, Institute Kimia Malaysia, was also involved in training the teachers during the workshop.

The local organizing members were Rameshwar Adhikari, Jyoti Giri, Rajesh Pandit from NPI, Rabindra Dhakal from NAST and Devendra Karn from STAN facilitated the complete local arrangements.

The trainers from Thailand and Malaysia with 100 small scale experimental kits on 17 October, 2022 were warmly welcomed by local organizers. The due preparations were with experimental kits were completed on 18 Oct with all trainers and volunteers from local organizers.

The official opening of the workshop was conducted in the presence of very inspiring dignitaries

- **Rameshwar Adhikari** (Chair of Local Organizing Committee)
- **Supawan Tantayanon** (Director, Small Scale Chemistry Center, and CCE IUPAC)

- **Vudhichai Parasuk** (President, Chemical Society of Thailand)
- **Khil Kumar Pradhan** (President, Science Teachers Association of Nepal (STAN))
- **Chartsiri Sophonpanich** (President, Bangkok Bank Public Company Limited)-virtual
- **Indu Bikram Joshi** (Associate Secretary, Ministry of Education, Science and Technology, Nepal Government)
- **Marietjie Potgiete**r (Chair, Committee on Chemistry Education, IUPAC) —virtual
- **Sunil Babu Shrestha** (Chief Guest, Vice-Chancellor, Nepal Academy of Science and Technology)
- **H.E. Vosita Vorasaph** (Special Guest, Ambassador of Thailand to Nepal)

Before entering the technical workshop, all participants gave the online pretest about their real knowledge on small scale experiments. The technical session started with brief introduction of small-scale and all nine experiments that they were going to learn in those two days by Supawan.

On the first day (19 October) 3 experiments were practiced among the participants followed with question answer session.

- Experiment 1: Interdiffusion of gases
- Experiment 2: Electrochemical separation of copper
- Experiment 3: Solubility of ammonia

All participants were enthusiastic to learn different techniques they could apply to their chemistry teaching chemistry practice. On the second day (20 October) the rest of six experiments were practiced:

- Experiment 4: Titration of a strong acid with strong base
- Experiment 5: pH indicators
- Experiment 6: Electrolysis of water
- Experiment 7: Reactions of acid and carbonates
- Experiment 8: Property of oxygen gas
- Experiment 9: The law of conservation of mass

After completing all nine experiments participants, gave the post-test which clarified the knowledge they gained in this workshop. Moreover, they were also explained about video competition process to select ten best teachers among them who could participate in training the trainers and networking on 21-22 January in Chiang Rai, Thailand.

The closing ceremony of the workshop was conducted in the presence of member secretary of NAST, Mahesh Kumar Adhikari. Trainers and Trainee both shared their experiences that they gathered in the workshop.

A post workshop meeting was also held among all organizers to make the workshop more sustainable for the future as well.

The second phase of the project was a video

All dignitaries, mentors, organizers, and volunteers pose for a picture at the closing ceremony of the two-day workshop on chemistry education. It was washeldat the Nepal Academy of Science and Technology (NAST), Saatdobato, Lalitpur, Nepal for 100 government high school science teachers selected from 7 different provinces of Nepal.

Group photograph of teachers from five countries during training the trainers

competition where teachers need to submit their innovative experiment designed video of 5 minutes for small scale chemistry practical using their local resources and submitting it to before 15 November 2022.

Among 40 videos submitted from Nepal, the best 10 videos with small-scale concept using local resources were selected by the expert team of Chemical Society Thailand as follows:

- Govind Bahadur Dhami: *Preparation of Carbon dioxide Gas*
- Hari Ram Devkota: *A Popping Sound from Hydrogen Gas*
- Janak Raj Pant: *Study of Chemical Kinetics for the Evolution of Hydrogen Gas*
- Lokendra Subedi: *Generation of Gas from the Reaction between Acid and Metal*
- Matrika Timilsina: *Handy Preparation of Carbon dioxide Gas to Observe Fire Extinguishing Property*
- Narendra Rawat: *Sublimation Technique for Separation of Volatile and Non-Volatile Mixture*
- Prameshwor Sharma: *Distillation Flask Setup from Locally Available Materials*
- Rohini P. Lohani: *Kitchen Materials for Generation of Carbon dioxide and Study Its Properties*
- Uttam Subedi: *Convenient Electroplating of Copper on Iron Nail*
- Yubaraj Ghimire: *Low Cost Convenient Construction of Galvanic Cell*

These ten teachers were nominated to participate Phases 3a and 3b of the project on 21-22 January in Chiang Rai, Thailand.

Ten selected teachers from Nepal travelled to Thailand on 19 Jan 2023 to accomplish the third and fourth phases of the project. On 20 Jan 2023, teachers joined the banquette dinner in Mae Fah Luang University, Chiang Rai, Thailand, with all PACCON 2023 delegates. On 21 Jan 2023, the Chemistry Teachers networking session was organized at the E4 building in Mae Fah Luang University.

In the program, 63 participants actively participated in the networking session, among them 10 from Nepal, 30 from Thailand, 6 from Vietnam, 8 from Cambodia, and 9 from Indonesia. As the program was focused on building the networking between the teachers, participants, experts, and mentors from each country introduced themselves briefly. One special video lecture was displayed by Robert Worley, the high school teacher as a safety expert of CLEAPPS from United Kingdom. The lecture was mainly focused on safety and cost reduction aspects of small-scale chemistry as well as the challenges faced in the implementation of small-scale chemistry techniques in schools.

After the lecture, all the participants were divided into two groups with blue and red circles. Each group was further divided to fill ten tables arranged to make two circles. Five tables in each circle housed five experiments which need to be completed in ~15 minutes. Participants were instructed to conduct experiments and shuffled to another table to conduct the next experiment. The shuffling of tables was carried out to ensure that every participant will meet new people each time they conduct new experiments. Participants carried out each experiment by interacting and sharing their idea with each other in the group which increased their networking capacity. The five experiments performed in networking session were given follows:

1. Indicator colors at different pH and making a universal indicator. An introduction to small-scale chemistry
2. Chemistry of Transition Metals—Iron
3. Spectator ions: Using small-scale to challenge misconceptions
4. Diffusing Precipitate Reactions
5. Solubility Rules: Using small-scale for an investigation

At the demonstration site, experimental stalls were set up by all participants to display their winning experiments. The experimental display was visited by PACCON 2023 delegates, the main attraction being the presence of Nobel Laureate David W. C. McMillan along with Vice President (President-Elect) of IUPAC, Ehud Keinan. The participants had the opportunity to interact with prominent chemists at the conference. The participants observed each other's experiments and interacted to share their knowledge and expanding their networking. The exciting part was when the organizer announced that there will be an award for one participant from each country with the highest networking.

On the second day (22 Jan 2023), the Phase 3 of the program was conducted at 9:00 am at Sann Hotel with a short introduction from Niwat Srisawasdi, Faculty of Education, Khon Khaen University, Thailand who gave lecture on "Competency-based chemistry education for new generation learners" focusing on both trainers and trainees to conceptualizing research based high impact learning and teaching strategies. Based on the lecture, nine high impact teaching strategies were practiced:

1. Supporting visual generation
2. Supporting content producer
3. Receiving immediately feedback and rewards
4. Receiving challenge to level up
5. Learning as game playing
6. Presenting isolated facts
7. Disconnecting to present daily living
8. Linkage of multiple representations
9. Disconnecting nature of the scientific inquiry

In the training the trainers workshop, the participants were separated in 9 groups for the task assignment. Each participant had selected one topic in which they wanted to be an expert from the above 9 topics. After selection of specific topic, each participant moved to each table from 1 to 9, where they could exchange and learn a certain strategy from each expert. Each expert group discussed in detail their respective topics for 20 minutes and shared the information gained from the expert in group discussion.

After discussion, they correlated the strategies which were relevant to the small scale experiments performed by them on 21 Jan. Each group prepared a PowerPoint presentation on the related strategy and small scale experiments for their proposed learning activities within the provided time frame. The technical session ended with a lecture on "Applications on low-cost simple colorimeter for education" by Supakorn Boonyuen to instruct the participants how to correlate strategy in small scale experiments.

At the end of the program, the best networking awards were announced for every country:

- Dang Thi Houng Giang, Vietnam,
- Surangkana Srisawet, Thailand,
- Neav Navy, Cambodia
- Mohammad Wahyudi, Indonesia
- Hari Ram Devkota, Nepal

The Vice President of Bangkok Bank Public Co., Ltd. distributed certificates to awardees and all participants in Singha Park. The award giving celebration was conducted with cultural program from each participating countries in group performance. Supawan Tantayanon motivated all the participants to spread the knowledge they gained among their colleagues in their country for small scale chemistry experiments and network with other teachers in Asia. The CST and Bangkok bank also gave a set of small-scale distillation set for individual participant to carry to their workplace making them more equipped.

All the participants of the small-scale workshop agreed that this was a very fruitful and sustainable program for Nepal.

Bookworm

Books and publications hot off the press.
See also www.iupac.org/what-we-do

Accreditation and Quality Assurance

A Special Issue in Memory of Paul De Bièvre (1933–2016) in ACQUAL Journal. June 2023, Guest Editor: Franco Pavese

Reviewed by F. Pavese

In 2021 I proposed to the Journal ACQUAL, the one founded by Paul De Bièvre, a Special Issue in memory on the 5th anniversary of his death, and it was readily accepted. Then, its preparation was quite slow, also due to a change of the Chief Editor of the Journal, and now it is published also in its paper form, with 8 contributions, including such authors as: M. Filomena Camões, A.G. Chunovkina, Steven Emmerson, Alistair Forbes, Jeremy Frey, Richard Hartshorn, Pascal Heu, Manfred Gröning, Juris Mejia, Franco Pavese, Antonio Possolo, Gary Price, Martin Quack, A.V. Stepanov, and Timothy J. Wallington.

I will not repeat here the excellent Obituary written by Hendrik Emons in 2016 (ACQUAL; https://doi.org/10.1007/s00769-016-1213-0), but will quote from it:

> "For me Paul was one of the most prominent ambassadors for metrology in chemistry. He devoted his professional life, which definitely did not stop after his official retirement from the European Commission (did he retire at all?) to promote the comparability of measurement results and the common understanding of metrology among scientists. For that purpose, he was a global traveler, missing only very few countries of the world, and an invited speaker at many conferences and seminars. Paul was always keen to stipulate what he called "clear thinking." This gained him in my eyes the label "Mister Terminology," in the combination of creating and promoting terms as well as underlying concepts. His contributions to the development of the International Vocabulary of Metrology (VIM) are certainly the most visible, but not the only signs of these efforts."

I met Paul more than 30 years ago, having the need for my research, on thermodynamic properties of condensed gases, to have directions about the possibility to get sound mass spectrometer measurements. Since then, I had many occasions to meet him also within IUPAC activities and by correspondence, and we both realized that we had a quite similar type of personal character, very resilient in respects to our

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Paul De Bièvre was born in Blankenberge (Belgium) on 7 July 1933 and he passed away on 14 April 2016 in Leuven (Belgium).

ACQUAL June 2023

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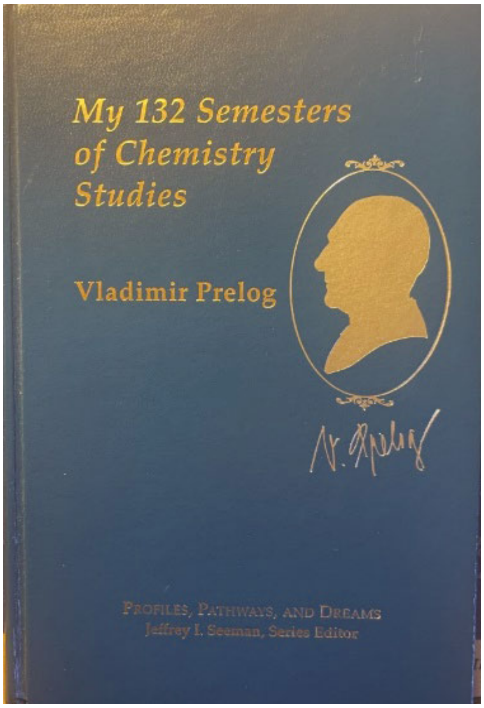
A Nobel support of Professor Thomas Hudlicky

by Leiv K. Sydnes

The readers of this and other chemical magazines should be well aware of the turmoil Thomas Hudlicky caused more than three years ago when he published an essay in *Angewandte Chemie* on factors influencing the progress of organic synthesis in the last 25 years [1]. In his mind, eight factors were relevant to consider, of which five only had had a negative impact on the development. The immediate outcry the essay generated was for the most part due to a factor Hudlicky called *Diversity of the work force*, but his discussion of *Transference of skills* did indeed create harsh and inappropriate reactions as well [2].

The reaction to the latter factor is surprising. A central part in the training of chemistry students in general, but students of synthetic chemistry in particular is devoted to learning practical skills. To master the unit operations used in synthesis is indeed a tedious process; first students have to be exposed to the techniques, and then the operations have to be perfected through repetitions and supervision from more experienced chemists, well beyond what traditional university courses give nowadays. In his discussion of this aspect, Hudlicky used the relationship between a master and an apprentice, so familiar from vocational training and most art disciplines, to describe how to teach students the practical skills and all the tricks required to excel in synthesis [1,3]. The point is that it is time consuming, it requires patience, and the long hours invested do not guarantee that the required level of competence has been acquired.

In my opinion, the reference to work as an apprentice is an excellent description of the working conditions for graduate students in organic synthesis, as long as Michael Polanyi's expression "an unconditional submission of the apprentice to his/her master" [4], which Hudlicky refers to, is limited to the educational activities belonging to the chemical profession, taught in a transparent environment, and practiced in a healthy and respectful way. But Polanyi and Hudlicky are not the only scientists comparing graduate studies in chemistry with the training students of vocational disciplines are exposed to. A firm supporter of such a comparison was Nobel Laurate Vladimir Prelog. In his interesting biography *My 132 Semesters of Chemistry Studies*, published in 1991 in Jeffrey I. Seeman's excellent series of *Profiles, Pathways, and Dreams; Auttobiographies of Eminent Chemists* [5, Figure], Prelog describes his devotion to chemistry, which brought him to Prague where he enrolled as a student at the age of 18 at the Czech Institute of Technology in 1924. He obviously disliked organic chemistry at the outset because as "presented in the second year, organic chemistry



Vladimir Prelog (1906-1998) was a Croatian-Swiss organic chemist, who was educated in Prague (graduated 1929) and worked in a Czech chemical company (1929-1935) and at the University of Zagreb (1935-1941) before he started to work at the Swiss Federal Institute of Technology (Eidgenössische Technische Hochschule, ETH) where he became full professor in 1952. In 1975 he obtained the Nobel Prize in Chemistry "for his research into the stereochemistry of organic molecules and reactions." [9]

In 1991 his concise biography *My 132 Semesters of Chemistry Studies* was published.

seemed to consist of endless details, compounds, and reactions without connection." [6] But that changed when he was hired as assistant to Rudolf Lukes, who conducted the laboratory course in organic chemistry and later advanced to professor at the institute. Prelog became an apprentice: "Lukes needed a co-worker; thus I became his apprentice." [6] This apprenticeship influenced Prelog profoundly; not only did he decide to shift focus to organic chemistry, he also reached the conclusion that being an apprentice is the best way to study science. "I have more than once expressed my view that the best way to study science is as an apprentice to a master who is a model both in his field and in his personal characteristics. Through this collaboration, I learned that, in the beginning, it was important for a chemist to be confronted with reality and that sometimes it is better to follow the maxim "Work now, understand later". [7]

What a Nobel support of Thomas Hudlicky, who passed away on 10 May last year during a visit to Prague where he was born 73 years earlier [8].

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. (All websites were visited 10 March 2023.)

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8. For an obituary, see Trond V. Hansen, Yngve Stenstrøm, Rolf Carlson, and Leiv K. Sydnes, Professor Tomáš Hudlický in Memoriam, Kjemi 2022, (5), 23-25. https://www.kjemidigital.no/dm/5-2022/22
9. The website for the Nobel Prize; https://www.nobelprize.org/prizes/chemistry/1975/prelog/facts

Leiv K. Sydnes (leiv.sydnes@uib.no) is Professor emeritus at University of Bergen, Norway. He was president of IUPAC 2004-2005 and chaired the CHEMRAWN committee in 2008-2015. He also chaired the ICSU Committee for Freedom and Responsibility in the Conduct of Science 2013-2018. He is currently a member of UNESCO's Committee on Ethics in Science and Technology (COMEST).

Bookworm (cont. from p. 39)

respective positions (often quite similar), in several scientific respects. One example in that sense was one of the last of his papers, which we liked to share (F. Pavese, P. De Bièvre, Fostering diversity of thought in measurement, 2015, in ISBN 978-981-4678-61-2; https://doi.org/10.1142/9789814678629_0001).

We also became good friends personally. I have rarely met another people with so wide a range of interests and high level of competence, demonstrated by the wide range of his activities, and of formal positions that he performed, namely in IUPAC, with excellence until his very last days. In particular, he was an excellent metrologist (I am a full metrologist), in the frame of his own research and of the research in metrology worldwide, and an important and competent contributor to one of the basic metrological documents, the International Vocabulary of Metrology, 3rd Edition.

In Memoriam, members of the IUPAC Commission on Isotopic Abundances and Atomic Weights recalled

> "Paul had a penchant for philosophy of science and he believed that great measurements start with great thinking. His writings on metrology in chemistry appeared frequently in *Accreditation and Quality Assurance* (Springer) of which he was the Founding Editor-in-Chief (1995). He was a straightforward, cheerful person and his colleagues fondly remember his passion for science." (https://www.ciaaw.org/debievre.htm)

We will remember for a long time the contributions of Paul De Bièvre to science and to metrology, not only in Chemistry, and as a very special person and scientist.

Franco Pavese, former Research Director in Metrology (Thermodynamics), National Research Council of Italy, member of the IUPAC Commission on Physicochemical Symbols, Terminology, and Units (Commission I-1).

https://link.springer.com/journal/769/volumes-and-issues/28-3

POLY-CHAR [Auckland] 2023

by Jianyong Jin , Conference Chair

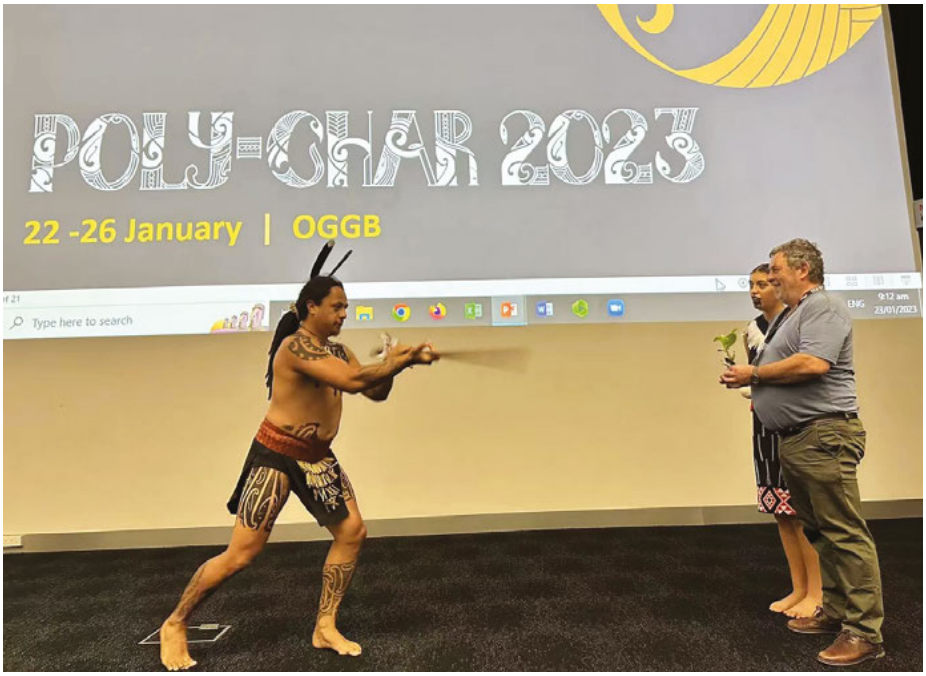
The **2023 Annual World Forum on Advanced Materials**, POLY-CHAR [Auckland] 2023, was held 22-26 January. The University of Auckland, New Zealand, hosted the event under the auspices of the POLY-CHAR Scientific Committee. This was an IUPAC-endorsed conference and sponsored by Groupe Nutriset (Platinum Sponsor), Netzsch (Workshop Sponsor), Anton Paar (Exhibitions Sponsor), 100% Pure New Zealand (Marketing Sponsor), with Photon Factory and the University of Auckland School of Chemical Sciences as Conference Sponsors.

After postponement from January 2021, POLY-CHAR [Auckland] 2023 was the first live conference to be hosted after the two purely digital events of POLY-CHAR [Venice] 2021 and POLY-CHAR [Halle-Siegen] 2022. The local organising committee chair, Prof. Jianyong Jin, reflected "it is really pleasing that offline conference has resumed. The POLY-CHAR regular attendees and newcomers are able to gather in-person after years of suspension during the pandemic." The scientific and organising committees of POLY-CHAR were extremely grateful for the participation of 178 scientists from 29 countries: a total of 7 plenary speakers, 15 showcase speakers, 27 keynote speakers, 43 oral speakers and 19 poster presenters. The four-day conference plus one-day pre-conference workshop covered nine technical themes ranging from traditional polymer physics and characterisation, synthetic polymer chemistry, and biological functional polymers, to cutting edge research areas of polymers additive manufacturing (3D/4D printing), aggregation induced emission mechanisms, biomedical imaging, photovoltaic materials, porous polymers for separation membrane, and double network gels.

POLY-CHAR is a non-profit, non-governmental organisation fostering a friendly environment for sharing information, establishing student exchange, and strengthening international cooperation. The conference series provides an inclusive platform for scientists from all over the world working in the fields of materials science and, in particular, polymer characterization and polymer materials science and technology. POLY-CHAR is driven by ground-breaking polymer research from synthesis all the way to applications. An important goal of POLY-CHAR is offering a forum for PhD students and young researchers to create their own scientific networks and experience a vested scientific community. POLY-CHAR will always be committed to improving our world through education and distribution of knowledge.

POLY-CHAR has the tradition of a full-day pre-conference Short Course for PhD students and early-career polymer chemists. POLY-CHAR 2023 was no exception. On Sunday the 22nd of January, seven prestigious researchers delivered graduate-level tutorial presentations on the following topics:

- Thermal Analysis and Rheology in Polymer Additive Manufacturing – Natalie Rudolph (virtual)



Opening ceremony of POLY-CHAR 2023 in the Sir Owen G Glenn Building of the University of Auckland.

The iconic building stands as a place of convergence for business, academia and government, and through traditional Māori culture, it stands as symbolic links between manuhiri or visitors, students and staff, between the past and the present and the North and South Islands.

- What is Science? - Jean-Marc Saiter
- Polymer Crystallization and its Kinetics – Alejandro J. Müller
- Rheology and Thermal Characterization of Polymer Systems – Michael Hess
- Dynamic Light Scattering: Basics, Rules, and Application to Polymer Science – Sergej Filippov
- Thermodynamics of Polymer Solutions and Blends – Volker Abetz
- 3D printing with polymers – Domagoj Vrsaljko

On the morning of 23 January, POLY-CHAR 2023 officially began with a Māori welcoming ceremony called pōwhiri. The opening remark was delivered by the president of POLY-CHAR, Jean-Marc Saiter. Michael Hess gave an overview of IUPAC and polymer division activities. Obituaries for deceased colleagues and SciComm members were read during the opening ceremony: Melissa CHAN Chin Han, Raj Pal Singh and Dusan Berek were remembered. The first plenary presentation was given by Volker Abetz on the topic of polymer membranes and vitrimers, which set the stage for the engaging days to follow. The first day concluded with a welcome reception featuring New Zealand wine and beers.

Besides the intense technical programme, all delegates enjoyed a half-day conference excursion to explore the beautiful west coast of Auckland on Tuesday the 24th of January. The huge waves of the Tasman Sea and thousands of gannet birds nesting at Muriwai Beach were spellbinding.

On Tuesday evening, the POLY-CHAR scientific committee annual meeting was held at the historical Old Government House, which was completed in 1856 and played an important part in the government of New Zealand until 1865, when the capital was moved to Wellington. The international Scientific Committee of POLY-CHAR elected Ricardo Manríquez-González (University of Guadalajara, Mexico) and Costas S. Patrickios (University of Cyprus) as new members.

Another key social event was the conference dinner at the Hilton Hotel on the Wednesday night of January 25th. Warm conversations, delicious food, music and a selection of New Zealand wines filled the unforgettable evening. Ralph Cooney delivered a banquet talk on New Zealand nature, science, history and economy.

At the closing ceremony on Thursday the 26th of January, outstanding researchers were honoured with POLY-CHAR awards, named in honour of three distinguished Nobel Laureates: The **Richard Robert Ernst Award** went to Marian A. GÓMEZ-FATOU Rodríguez, Instituto de Ciencia y Tecnología de Polímeros, CSIC, Madrid, Spain. The **Jean-Marie Lehn Award** was awarded to Domagoj VRSALJKO, University of Zagreb, Zagreb, Croatia. The **Pierre-Gilles de Gennes Award** was awarded to Melissa CHAN Chin Han, MARA University of Technology, Selangor, Malaysia.

Three **POLY-CHAR Awards for the best oral presentations from students and young scientists** were awarded: to Chris Bainbridge, The University of Auckland, Auckland, New Zealand, for the presentation entitled "RAFT-based networks as a 4D polymer platform"; to Patakorn Pilasen, Chulalongkorn University, Bangkok, Thailand for the presentation entitled "Thermoplastic starch vitrimer through thermoreversible Diels-Alder"; and to Kawaljit Kaur, University of Siegen, Siegen, Germany for the presentation entitled "Towards spatially targeted eradication of antimicrobial-resistant bacteria: Novel polymer-based antimicrobial photodynamic therapy."

The **IUPAC Prizes for the best poster presentations**, including a one-year free membership to IUPAC, were awarded to Sebastian Balser, Goethe University Frankfurt, Frankfurt a.M., Germany, for the poster entitled "Preparation and characterization of highly conductive and biorepulsive Polypyrrole/Polyglycerol Surface Films"; to Pawel Grzybek, Silesian University of Technology, Gliwice, Poland for the poster entitled "Alginate composite membrane filled with silver and nickel nanowires—characteristic and application in pervaporation dehydration of ethanol"; and to Patrick Imrie, The University of Auckland, Auckland, New Zealand for the poster entitled "Direct-ink-write 3D printing of "living" polymer hydrogels via type I photoinitiated RAFT polymerization."

The **POLY-CHAR Awards for the best poster presentations from students and young scientists** were awarded to Lakshmi Mukundan, Indian Institute of Technology Kharagpur, Kharagpur, India for the poster entitled "Polycaprolactone encrusted bioactive glass antibiotic nanohybrid through drug mediated surface initiated polymerization: An overcoat approach for modulated burst release"; to Krishnendu Nath, Indian Institute of Technology Kharagpur, Kharagpur, India for the poster entitled "Facile preparation of light-weight biodegradable and electrically conductive polymer-based nanocomposites for superior electromagnetic interference shielding effectiveness"; and to Devon Bryant, The University of Auckland, Auckland, New Zealand for the poster entitled "Novel conducting polymer sensor for the detection and analysis of biothiols."

This year, there have been additional **POLY-CHAR [Auckland] 2023 awards for the best poster presentation from students and young scientists, sponsored by The University of Auckland**, that were awarded to Liam van Mechelen, The University of Auckland, Auckland, New Zealand for the poster entitled "Harakeke Reinforced Furan Bio-Composites"; to Danny McDougall, The University of Auckland, Auckland, New Zealand for the poster entitled "What makes mussels stick?"; and to Mahdieh Ghofrani, Victoria University of Wellington, Lower Hutt, New Zealand for the poster entitled "Towards the methylation analysis of heparan sulfates".

The approaching POLY-CHAR conference, "POLY-CHAR [Madrid] 2024: Polymers for our Future", will take place in Madrid, Spain, 27-31 May 2024.

Sustainability and Inclusivity: An Interdisciplinary Conversation

by Liana Vaccari, Kristin A. Bennett, Ana Ferreras, Danniebelle N. Haase, Jennifer E. Lansford, A. Ester Sztein, and Vivian U

No individual discipline alone can solve the issues of sustainability and inclusivity. These are complex interconnected problems with both physical and societal implications around the globe. For the 2023 IUPAC Global Women's Breakfast (GWB) and in recognition of the International Year of Basic Science for Sustainable Development, the National Academies of Sciences, Engineering, and Medicine of the United States hosted on 14 February an interdisciplinary conversation to build connections across fields and share best practices in support of progress towards sustainability and equity, particularly for women. This event, coordinated by the National Academies' Board on International Scientific Organizations, consisted of a panel with representatives of four fields and U.S. National or Liaison Committees to IUPAC, the International Union of Pure and Applied Physics (IUPAP), the International Union for Crystallography (IUCr), and the International Union of Psychological Science (IUPsyS), moderated by Dr. Ester Sztein.

Each panelist touched on what sustainability means for their field and related Sustainable Development Goals. Danniebelle Haase, Dow Chemical Company, spoke to her work supporting energy efficiency and considering environmental and health impacts across the lifecycle of products that improve quality of life as well as the contribution of chemistry to zero hunger, good health, and other environmental and health challenges. Similarly, Kristin Bennett, KB Science, addressed crystallography's contribution to drug discovery, work in clean energy, and water quality and sanitation. Jennifer Lansford, Duke University, highlighted the importance of psychology in good health, education, and understanding behavior and ramifications of climate action. Vivian U, University of California, Irvine, emphasized the importance of good health and well-being as well as gender parity for the strength of the field of physics while astrophysicists look to far-flung galaxies and black holes to understand how the phenomena evolved.

IUPAC has supported the GWB annually since 2019 and along with IUPAP participates in a cross-union effort on reducing the Gender Gap in Science. Every three years since 2002, IUPAP has held an International Conference on Women in Physics originating from the eponymous Working Group. IUPAC and IUCr have also recently established internal committees addressing equity and diversity. While there are common goals and challenges across these disciplines, the panel also discussed issues unique to each field and current efforts or best practices. For example, field work in certain disciplines can put women in vulnerable and isolated situations. For psychology, there is gender parity, if not a high proportion of women, but this has not meant that a) women are equally represented in positions of authority, or b) that there has been equitable representation across countries. IUPsyS efforts of late have aimed to be more inclusive of global research and perspectives and reduce the overemphasis on U.S.-centered psychology.

Suggested best practices for promoting inclusivity in scientific societies and communities included:

- Require inclusion, quota for keynote speakers, panelists, presenters, and symposium organizers at conferences
- Work towards inclusivity at all levels of authority
- Make use of anonymous proposals where applicable to reduce the effect of biases
- Partner with communities affected by your science to understand their needs
- Support scientific literacy
- Use metrics to demonstrate real progress towards equitable inclusion
- Support hybrid meetings for improved accessibility and environmental sustainability

One emergent common theme, relevant to both sustainability and inclusivity, was the importance of developing situation specific solutions with measurable outcomes that are also scalable. Lansford described efforts in psychology to study implementation science, aimed at improving the outcomes of interventions that take place outside of laboratory or experimental settings. Understanding what circumstances will support change and acceptance is vital for taking technical solutions developed by physical and life scientists and enacting them for the good of the broader society. This underscores the importance of continued conversation between disciplines, sharing best practices and complementary efforts. We are grateful for the IUPAC Global Women's Breakfast platform for this opportunity to have this conversation and contribute these insights.

Liana Vaccari and Ana Ferreras are from the U. S National Academies of Sciences, Engineering, and Medicine, Washington, DC; Kristin A. Bennett is from KB Science LLC, Boston, MA; Danniebelle N. Haase is from Dow, Collegeville, PA, Jennifer E. Lansford is from Duke University, Durham, NC; A. Ester Sztein is from the Geological Society of America, Washington, D.C.; and Vivian U is from UC Irvine, Irvine, CA

The opinions expressed here are those of the authors and do not necessarily represent positions of the U.S. National Academies of Sciences, Engineering, and Medicine.

Javier Garcia Martinez with professors and students of the Faculty of Chemistry, University of Bucharest, Romania.

Creating stronger bonds—Highlights of the visit of IUPAC President to Romania

by Mihaela Florea, Mihaela Matache, and Aurelia Visa

IUPAC plays a vital role in furthering the United Nations (UN) Sustainable Development Goals (SDGs) by fostering global collaboration. While currently IUPAC membership is limited to a select number of countries, the organization is committed to expanding its reach to involve as many nations as possible. With this in mind, Javier García-Martínez, President of IUPAC, has paid a visit to Romania in May 2023. During the days he stayed with us, he had fruitful and important meetings with representatives of the Romanian Academy and Romanian Chemical Society. In addition, he delivered an enlightening lecture to students, researchers, and academic staff at the University of Bucharest and he also delivered a plenary lecture at the 8th International Workshop of Materials Physics at the National Institute of Materials Physics, Magurele, Romania.

On 15 May 2023, Javier García-Martínez met Marius Andruh, Vice-President of the Romanian Academy, Bogdan Simionescu, President of the Romanian Chemical Society (RCS), and other eminent scientists from chemical institutions of Romania. García-Martínez provided an overview of IUPAC activities, such as networks, projects, and actions, and introduced the contribution of IUPAC and the field of chemistry to the achievement of the UN SDGs. In particular, he emphasized the importance of expanding the number of IUPAC Adhering Organization to countries that currently

From left: Mihaela Florea, Vlad Chiriac, Marius Andruh, Bogdan Simionescu, Javier Garcia Martinez, Corneliu Radu, and Mihaela Matache.

are not affiliated to IUPAC. He also commented on the importance of expanding the network around the globe and the key role of chemistry education, with special emphasis on IUPAC projects such as *"Systems Thinking in Chemistry for Sustainability: Towards 2030 and Beyond."* He also stressed the importance of attracting young chemists as new members of IUPAC. The Vice-President of the Romanian Academy, the President of the Romanian Chemical Society, and other representatives of the RCS welcomed the idea of reconnecting Romania to IUPAC and getting more involved in IUPAC programs. It is important to note that the RCS was affiliated to IUPAC in 1921 and organized the 6th IUPAC Congress in Bucharest in 1925. The representatives of the Romanian Chemical Society were pleased to learn about the first steps of Romania's readmission to IUPAC.

On 16 May 2023, the President of IUPAC was warmly welcomed at the University of Bucharest, Faculty of Chemistry, and delivered an insightful lecture, chaired by Mihaela Matache, on "*How to reinvent our relationship with the planet at molecular scale,*" based on his research conducted at the Inorganic Chemistry Department, University of Alicante, Spain. In addition, he introduced IUPAC and its main mission and activities and talked about solving global challenges with the tools that science provides and how the IUPAC contributes to this global effort.

In particular, he emphasized that chemistry education is about people, and that science is and will always be a common language for all, regardless of nation. Both the visit and the theme of his lecture were timely since we are still in the UNESCO International Year of Basic Sciences for Sustainable Development (IYBSSD) that started in 2022. He also mentioned some existing outreach activities funded by IUPAC, including the Periodic Table Challenge and the Global Women's Breakfast, and invited Romanian senior and young scientists to be an active part of such events. The academic staff, researchers, and students had the great pleasure to listen to his lecture and discuss the possibility of creating a sustainable future for everyone.

On 17 May 2023, the IUPAC President payed a visit to the National Institute of Materials Physics (NIMP) which fell within the occurrence of the 8th edition of the International Workshop of Materials Physics (IWMP). The main topic "*Advanced Materials and Methods for Heterogeneous Catalysis*" was chaired by Mihaela Florea, Lucian Pintilie, and Cristian Mihail Teodorescu. The aim of the workshop was to share the latest scientific results related to advanced materials and characterization techniques with an emphasis on heterogeneous catalysis. The most exciting recent experimental and theoretical developments in materials synthesis, characterization, and potential applications were presented and discussed. Javier García-Martínez also delivered an invited talk on "*Materials at order-disorder boundary: defect engineering for superior catalytic performance*" during this important workshop, and interacted with professors and students.

The short, but intense visit of the IUPAC President to Romania not only raised the awareness of IUPAC's significance and mission among academic staff and students but also marked the first step to reintegrating Romania into the IUPAC. Furthermore, he also shared the recent advances in the field of Molecular and Materials Chemistry for building a sustainable society with scientists and students. Finally, we sincerely hope that our country will soon rejoin IUPAC and continue to the advancement of chemistry and chemistry education in the world via active involvement in different activities and programs of IUPAC.

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ICCE 2024
Pattaya, THAILAND

BUU
BURAPHA UNIVERSITY
WISDOM OF THE EAST

IUPAC

Website: www.icce2024thailand.com
E-mail: icce2024@gmail.com

The 25th Annual Meeting of the Israel Analytical Chemistry Society and ISRANALYTICA

ISRANALYTICA 2024 will be held 16-17 January 2024, in Tel Aviv, Israel

The Israel Analytical Chemistry Society (IACS) was established in 1998 with the goal of promoting analytical chemistry in Israel, in both research and education. The Society believes that working towards this goal will bring additional people to the field of analytical chemistry and widen its popularity. The Society is also working towards close contact with leading analytical companies active in Israel, ensuring the connection between the academy and the industry in the field, and allowing the free flow of information between them.

IACS Annual Meetings are organized at the ISRANALYTICA Conference and Exhibition, arranged by the Bioforum company www.bioforum.org.il. Israel Schechter, current IACS President, wrote in his welcome letter, inviting participation in ISRANALYTICA 2024, that the ISRANALYTICA conference accompanied by the large exhibition has become the most prestigious analytical chemistry meeting in Israel. Traditionally, this meeting attracts more than 3000 participants from the academy, the chemical industry, laboratories, and companies. The conference has been recognized as an international event, attracting analytical chemists from all over the world.

Six biannual IUPAC/CITAC Workshops on metrology, quality, and conformity assessment in analytical chemistry were organized in conjunction with the ISRANALYTICA events:

- Human Errors and Out-of-Specification Test Results (2013);
- Human Errors and Quality of Chemical Analytical Results (2015);
- Validation of Test Methods, Human Errors and Measurement Uncertainty of Results (2017);
- Quality of Test Results for Conformity Assessment of a Chemical Composition – What is Good and What is Bad? (2019);
- Metrology, Quality and Chemometrics—Correlation of Test Results and Mass Balance Influence on Conformity Assessment (Zoom webinar 2021); and
- Metrology, Quality and Conformity Assessment (2023).

These workshops discussed the IUPAC/CITAC Guides in the field of metrology in chemistry at different stages of their development and use, published in *Pure and Applied Chemistry* (PAC), open access:

- Kuselman, I. and Fajgelj A. IUPAC/CITAC Guide: Selection and use of proficiency testing schemes for a limited number of participants—chemical analytical laboratories (IUPAC Technical Report) *PAC* **82/5**:1099-1135 (2010), https://doi.org/10.1351/PAC-REP-09-08-15;
- Kuselman, I., Pennecchi, F., Burns, C., Fajgelj, A. and de Zorzi, P. IUPAC/CITAC Guide: Investigating out-of-specification test results of chemical composition based on metrological concepts (IUPAC Technical Report) *PAC* **84/9**:1939-1971 (2012), https://doi.org/10.1351/PAC-REP-11-10-04;
- Kuselman, I., Pennecchi, F. IUPAC/CITAC Guide: Classification, modelling and quantification of human errors in a chemical analytical laboratory (IUPAC Technical Report) *PAC* **88/5**:477-515 (2016), https://doi.org/10.1515/pac-2015-1101;
- Kuselman I., Pennecchi F.R., da Silva R.J.N.B., Hibbert D.B. IUPAC/CITAC Guide: Evaluation of risks of false decisions in conformity assessment of a multicomponent material or object due to measurement uncertainty (IUPAC Technical Report) *PAC* **93/1:**113-154 (2021), https://doi.org/10.1515/pac-2019-0906;
- -Pennecchi F.R., Kuselman I., Hibbert D.B. IUPAC/CITAC Guide: Evaluation of risks of false decisions in conformity assessment of a substance or material with a mass balance constraint (IUPAC Technical Report) *PAC* in press (2023), *https://doi.org/10.1515/pac-2022-0801*

The scientific program of ISRANALYTICA 2024 will cover a large variety of modern topics in analytical chemistry. Leading researchers from the academy, from the industry and from government agencies will present their recent achievements and will discuss the most exciting developments and innovations. The program will consist of several plenary lectures by international top scientists, oral presentations (in parallel sessions) featuring speakers from Israel and abroad and a large poster session. The exhibition will take place in a central location.

In addition, the ISRANALITICA is a pleasant social event, allowing for meetings with old friends and colleagues and making new acquaintanceships. Looking forward to seeing you at the 25th Annual Meeting of the Israel Analytical Chemistry Society, ISRANALYTICA 2024 Conference and Exhibition. More details about important dates, topics, accommodation, contacts, etc., are on the website, https://2024.isranalytica.com/.

Mark Your Calendar

Upcoming IUPAC-endorsed events
See also www.iupac.org/events

2023

From 1 Nov

12-16 Nov 2023 - Phosphorus Chemistry - Ningbo, China
The 24th International Conference on Phosphorus Chemistry (ICPC24)
Chair: Yanmei Li, Tsinghua University, Haidian District, Beijing, P. R. China; icpc24@nbu.edu.cn or info@icpc24.org • https://icpc24.org/contact.html

12-14 Dec 2023 - Bioinspired and Biobased Chemistry & Materials – Nice, France
International Conference on Bioinspired and Biobased Chemistry & Materials – NICE winter 2023
Organizing chair: Frédéric Guittard; contact@nice-conference.com • https://www.nice-conference.com/

18-20 Dec 2023 - Bioorganic Chemistry - Singapore
13th International Symposium on Bioorganic Chemistry (ISBOC-13)
Chair: Bengang XING, Chemical Engineering and Biotechnology (CCEB), Nanyang Technological University (NTU), Singapore, Bengang@ntu.edu.sg

2024

27 Feb 2024 – Catalyzing Diversity in Science – Virtual
IUPAC Global Women Breakfast
https://iupac.org/gwb/

27-31 May 2024 - Polymers for our future - Madrid, Spain
POLY-CHAR 2024, Co-chairs: Araceli Flores and Peter Shuttleworth, poly-char2024@fgua.es https://www.poly-char2024.org/ Co-chair: Aldrik Velders, Wageningen University; ecb@tfigroup.com https://www.ecb2024.com/

30 Jun - 3 Jul 2024 - Biotechnology - Maastricht, The Netherlands
19th International Biotechnology Symposium - "Biotechnology for the Grand Challenges of our Society", joint with the 19th European Congress on Biotechnology (ECB2024) and the Annual Dutch Biotechnology Meeting (NBC-24)
Co-chair: Aldrik Velders, Wageningen University; contact: ecb@tfigroup.com • https://www.ecb2024.com/

24-28 Jun 2024 - Polymers for Sustainable Future – Prague, Czech Republic
85th Prague Meeting on Macromolecules – Polymers for Sustainable Future
Program co-chairs: Hynek Beneš, and Zdeněk Starý, Institute of Macromolecular Chemistry, Czech Academy of Sciences; pmm85 @imc.cas.cz • https://www.imc.cas.cz/sympo/85pmm

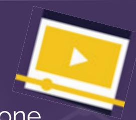
1-4 Jul 2024 - MACRO2024 - Coventry, UK
50th World Polymer Congress—Sustainability: improving lives whilst preserving our planet
Chair: Dave Haddleton, University of Warwick, Coventry, UK, d.m.haddleton@warwick.ac.uk https://www.macro2024.org/

15-19 Jul 2024 - Chemistry Education - Pattaya, Thailand
27th IUPAC International Conference of Chemistry Education (ICCE2024) - The Power of Chemistry Education for Advancing SDGs
Chair: Supawan Tantayanon, Faculty of Science, Chulalongkorn University, Supawan.T@chula.ac.th; Contact: icce2024@gmail.com • https://www.icce2024thailand.com

11-16 Aug 2024 – Novel Aromatic Compounds - Toronto, Canada
20th International Symposium on Novel Aromatic Compounds
Chair: Dr. Thomas Baumgartner (he/him) York University, Toronto, ON, Canada; isna2024@outlook.com https://www.isna2024.com/

POLYMER VIDEO COMPETITION

IUPAC



The Subcommittee on Polymer Education (SPEd) invites YOU to be part of our the Polymer educational series on the IUPAC's YouTube Channel!

You can take part by creating and submitting a short (3 min) video where you EXPLAIN or DISCUSS one of the topics from the list provided. Anyone can submit a video, however you must follow certain rules:

You are currently a:

- highschool student
- undergraduate student
- postgraduate (Master, PhD)
- Early career researcher*

The video content is based on the list of concepts and themes provided in the competition guidelines.

see below

Depending on the age/group category, you can submit either as an individual or in groups.

For certain categories, an IUPAC document must be the main reference used.

01 CATEGORIES & TEAM COMPOSITION

MONOMER — **HIGHSCHOOL** students (groups up to 3 people and a tutor/teacher to supervise)

MACROMOLECULE — **UNDERGRADUATE** students (up to 2 people, 2 students or a student and a tutor/teacher

POLYMER — **POSTGRADUATE** students (masters, PhDs) and ECRs* (up to 2 people, 2 students or a student and a tutor/teacher).

**ECR = less than ten years after receiving a PhD*

02 VIDEO CONTENT & TOPICS

MONOMER / **MACROMOLECULE**

- **Basic polymer concepts**
- **Polymer history**
- **Polymer experiments**

POLYMER

- **Advanced polymer concepts**
- **Polymer experiments**
- **Polymer nomenclature**

Examples :

Tell us about an interesting polymer-discovery or an application or what your polymer-related research project is about!

OR

Explain through a video a poly related concept or some nomenclature rules from the li provided.

The videos can be in any language but MUST include english subtitles.

03 JUDGING CRITERIA & PRIZES

A panel of 4 judges from **IUPAC's Polymer Division** and the S**ubcommittee on Polymer Education** will be evaluating the videos; taking into account :

scientific content, artistic/technical quality, creativity & originality and impact

A final selection of **9 videos** (3 from each entry group) will be made from the best noted. These videos will be showcased in the next IUPAC meeting or MACRO conference and will be uploaded on the IUPAC Youtube Channel. Other prizes (depending on entry group) will receive:

lectronic certificates of participation will be given to all individuals who partake in the competition.

MONOMER

- **Certificate** & set of IUPAC goodies for each team member
- **1 invitation** for a virtual presentation at the next IUPAC World chemisry or MACRO conference

MACROMOLECULE / **POLYMER**

- **Certificate** & set of IUPAC goodies for each team member
- **1 invitation** as IUPAC Young observer to the next IUPAC World chemisry or MACRO conference, AND
- **1 travel fund** (1000 USD) to atte

To ensure equa oppor un es, we ave prepare a st o use ul links to licence-free materials to help you make the best videos you can!

SUBMISSION DEADLINE: 31 MARCH 2024

@IUPACPolymer

For more info go to: https://iupac.org/project/2022-003-2-400/

Submit your video here: bit.ly/polymervids

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IUPAC2025

KUALA LUMPUR, MALAYSIA

50th World Chemistry Congress (50WCC)
13 - 18th July 2025

53rd IUPAC General Assembly (53GA)
11 - 15th July 2025

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