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IUPAC's 2025 Top Ten Emerging Chemistry Technologies



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PURE AND APPLIED CHEMISTRY

Why think philosophically? ►
Spotlight on Young Observers ►



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Cover: IUPAC has released its seventh selection of the Top Ten Emerging Technologies in Chemistry. The initiative continues to look into sustainability and circularity, connecting new and innovative ideas towards a greener future, while maintaining a strong interest in the development of methods for the improvement of human health. The selection of the 2025 Top Ten, carefully crafted by a panel of experts from a pool of global nominations, continues to carry the spirit established by the first Top Ten list released in 2019 and that is to highlight the potential of chemistry—and chemists—to provide solutions to the most urgent societal issues. See feature page 6.



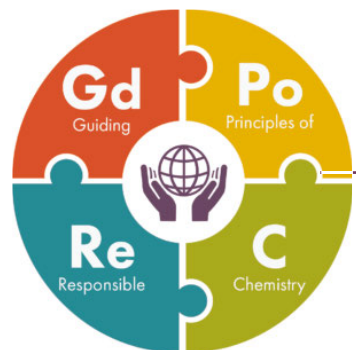
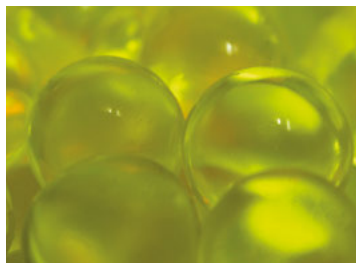
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Chemistry at the Crossroads: Enabling Solutions for a Changing World

by Javier García Martínez

Chemistry stands at a challenging crossroads. We are being asked to decarbonise sprawling value chains, build true circularity, build resilient supply chains, navigate through funding and regulatory whiplash, and rebuild public trust, all at once. And yet, we are a creative community that continues to turn constraints into inventions, such as cleaner processes and fuels, greener solvents, and abundant alternatives for scarce elements.

In the process, the chemistry community does more than solve problems: it creates wealth and quality jobs, improves our health and quality of life, and builds the resilience that a sustainable future demands. This transformative power of chemistry is illustrated each year by the IUPAC Top Ten Emerging Technologies in Chemistry, which showcases how bold ideas and scientific ingenuity can redefine what is possible. But innovation alone is not enough; equally important are data standards, trusted recommendations, and a common language that enable breakthroughs to be safely and reliably scaled across laboratories, industries, and borders; and it is precisely here that IUPAC proves to be essential.

Our recent General Assembly in Kuala Lumpur marked a pivotal moment for IUPAC, as our community came together to make the organization more impactful and effective in addressing today's challenges. Perhaps the moment when this spirit was most visible was the Town Hall meeting, which was held to provide an update on the restructuring of our scientific organization, and that was the result of months of careful analysis and design by the Science Board in close collaboration with dedicated colleagues. The meeting outlined the rationale and options considered and, more importantly, sparked a thoughtful and constructive discussion about the Union's future scientific priorities and the structures needed to support them. The openness and pragmatism in the room were exactly what this moment required, and the feedback shared will inform the next stage of

the design process. Similarly, the World Chemistry Leadership Meeting, entitled 'Trust in Science and the Right to Science', provided an opportunity to reflect on critical issues facing the scientific community. (see more details p 50) The discussions were candid and practical, addressing some of the most critical issues of our time: how to strengthen research integrity, how to open data responsibly, how to communicate clearly with the public and policymakers, and how to ensure that the tools we develop are accessible to all.

Equally powerful was the Presidents' Forum, where leaders of chemical societies from around the world shared activities, resources, and information, allowing us to move forward as one community. Launched in 2023, this initiative is gaining momentum and quickly becoming an integral part of IUPAC's activities.

An important outcome of our meeting in Kuala Lumpur was the admission of Guatemala, Estonia, Singapore, and Peru to the IUPAC family. These new members bring fresh energy and perspectives from Latin America, Europe, and Asia, reinforcing the truly global nature of IUPAC and the momentum that carries us forward. Together, these initiatives, from restructuring to expanding membership, reflect one unifying vision: an IUPAC that is more agile, inclusive, and impactful, prepared to lead chemistry into its next century of service to science and society.

Among the many memorable moments of the World Chemistry Congress, one stood out as especially meaningful: the launch of the **IUPAC Guiding Principles of Responsible Chemistry**. These Principles are already emerging as a foundational document and, even more importantly, as an invitation to reflect on what it truly means to be a chemist today. Green chemistry remains essential; we must reduce our impact on the environment, but it is not enough. Practicing chemistry responsibly also involves embracing safety, diversity, reproducibility, and fair access to data in everything we do. Too often, we focus only on what chemistry *can* do; it is high time to talk about what chemists *should* do. From the beginning of my Presidency, this initiative has been a personal priority that has been masterfully brought to life by a dedicated group of colleagues, chaired by Mark Cesa and Mary Garson. This represents one of the earliest and most significant achievements of our Committee on Ethics, Diversity, Equity, and Inclusion (CEDEI), which, though established only a few years ago, is already making a real difference within our community. Because this initiative is so fundamental and so close to my heart, seeing it take root fills me with pride and hope in the future of the discipline.



Inorganic Chemistry Division meeting in Seattle, Washington, on 13rd August 2006, hosted by Barbara and Randy Coplen. Back row (L to R): Anthony West (Div. II President), Leonard Interrante (Secretary), Tyler Coplen, Luis Oro, Markku Leskelä, John Corish, Alan Chadwick, Kazuyuki Tatsumi (Div. II Vice President and IUPAC President 2012-13) & Norman Holden. Front row (L to R): Sheena West, Tipping Ding, Susan Rosenblatt, Gerd Rosenblatt, Javier García-Martínez (IUPAC President 2022-23), Vita Interrante, Mrs. Chadwick & Mrs. Tatsumi.

Our recent World Chemistry Congress and General Assembly in Kuala Lumpur are yet another powerful reminder of what our community can achieve when we come together. This is why I want to extend my heartfelt congratulations to Datuk ChM Dr. Soon Ting Kueh and his team at the Malaysian Institute of Chemistry for delivering such an exceptional event. The program, attention to details, and warm hospitality left a lasting impression on all of us. No sooner had we returned from Malaysia than the International Advisory Board for the next World Chemistry Congress and General Assembly convened its first meeting, a clear sign of the momentum and commitment that are driving our community forward. I cordially invite you to join us in Montréal, Canada, 8-16 July, 2027, for what I am sure will be another memorable gathering showcasing the best of chemistry.

Next year will mark my twenty years of service to IUPAC. I started as an Associate Member of the Inorganic Chemistry Division (Div II), a Division I have called home for many years. In that time, IUPAC has become an integral part of who I am. The colleagues and friends I have met here have not only inspired me, but also broadened my perspective on how chemistry can help build a better future for all. Through IUPAC, I have learned to think more globally, to listen more openly, and to recognize the true power of chemistry. This community has profoundly influenced how I view my role as a chemist and how I envision the future of our field. It is no exaggeration to say that IUPAC has shaped both my career and the scientist I have become, and for that, I will always be deeply grateful. Now, as my official role at IUPAC comes to an end, I feel a mix of sadness and gratitude, but also a deep

sense of pride in what we have achieved together. I cannot list everyone I would like to thank, but I must acknowledge my fellow Officers, Qi-Feng, Chris, Ehud, Mary, Richard, Zoltan and Wolfram, and I wish Christine and Derek every success. My heartfelt thanks also go to Tammy, Enid, and Fabienne, whose tireless work makes an enormous difference every single day. Much of what they do happens behind the scenes, yet it is essential to IUPAC's success and to the strong sense of community that so many of us value. Perhaps the most important lesson of my IUPAC journey is the extraordinary power of volunteers. It is astonishing how much we accomplish with limited resources and a small staff. That speaks volumes about the dedication of our volunteers and about the strength of our brand, which attracts people from around the World eager to contribute through our Divisions and Committees, our projects, and our conferences. Above all, it affirms that at IUPAC, there is truly a place for everyone.

Serving IUPAC for the past six unforgettable years as Vice President, President, and now Past President has been one of the greatest privileges of my life. Together with many colleagues, I have worked to advance the Union's mission—reshaping its governance to make it more agile, aligning its structure with the evolving trends of chemistry, strengthening our efforts on digital standards, empowering early-career scientists, promoting diversity, and expanding our reach through global initiatives. Yet what I carry with me most are the people: the brilliant minds, generous mentors, and passionate colleagues who reminded me, time and again, that chemistry is ultimately about people and the impact we create together. I have gained far more than I have given, and for that I will always be

Past President's Column

profoundly grateful. Thank you for your trust, your support, and your unwavering commitment to advancing chemistry for the benefit of all. My official role may be coming to an end shortly, but the journey does not stop here. I remain more committed than ever to building connections and working alongside all of you to shape a vibrant, sustainable future for chemistry.

On that note, in my last Column in the April–June 2024 issue, I wrote that integrating the International Younger Chemists Network (IYCN) into the IUPAC structure was one of the most obvious, indeed, inexorable opportunities for our organization. Just a year later, we can already see it happening. Their presence in Kuala Lumpur was felt everywhere: in the many impactful activities they organised at the World Chemistry Congress, in their active participation in our General Assembly, and in the energy they brought to conversations throughout the week. I would also like to highlight the Global Conversation on Sustainability that they organize every year on 25 September 25, and invite you all to participate. It was a pleasure to welcome the Young Observers to the General Assembly. Their enthusiasm and commitment remind us that the strength of IUPAC lies in attracting and empowering the next generation, ensuring that our Union continues to grow in relevance and impact.

Looking ahead, IUPAC's ongoing efforts to have all our output in digital form and to develop international digital standards, an initiative known as "Digital IUPAC", are not merely optional; they are essential to ensuring that our standards remain relevant and effective in a data-driven world. That means ensuring all chemical information is machine-readable, interoperable, and reusable from the outset, so they flow seamlessly between laboratories, publishers, databases, and regulators. Our Committee on Publications and Cheminformatics Data Standards has been building exactly this foundation, curating and advancing digital standards such as InChI, ThermoML, and JCAMP-DX, and our partnership with CODATA has accelerated the work through the WorldFAIR Chemistry case study. Together, we have produced practical guidance like the open FAIR Chemistry "Cookbook" and associated training, and we are now extending that momentum via WorldFAIR+, which focuses on cross-domain interoperability. Embedding the FAIR principles in IUPAC projects and recommendations, so that data and metadata are findable, accessible, interoperable, and reusable by people and machines, will keep IUPAC at the centre of how chemistry is discovered, validated, taught, regulated, and communicated in the years ahead.



IUPAC100 celebration in Paris at the IUPAC World Chemistry Congress after the return of the Global Breakfast in 2019. From left: Juris Meija, Christine Dunne, Nnanake Offiong, Javier García Martínez, Supawan Tantayanon, Hooi Ling Lee, Mary Garson, and Laura McConnell

The global activities we launched during our centenary continue to strengthen IUPAC's image as an inclusive and welcoming community. The Global Women's Breakfast has grown into one of the largest and most visible initiatives of its kind, with more than 2,500 events organized so far, reaching over 120,000 attendees across more than 100 countries. Thanks to the leadership of Laura McConnell and Mary Garson and a dedicated network of volunteers from around the world, it is not only opening doors but also building a true global community of scientists and professionals committed to advancing diversity, equity, and inclusion in science. The Top Ten Emerging Technologies in Chemistry has become a widely anticipated annual publication. By showcasing breakthrough ideas with real potential for societal impact, it celebrates the ingenuity of our community and demonstrates how chemistry provides practical solutions to our most pressing challenges. The Periodic Table Challenge has exceeded all expectations in terms of global reach and participation. Hundreds of thousands of students, teachers, and curious minds from over 160 countries have engaged with this joyful activity, turning a symbol of our discipline into a vibrant entry point for learning and discovery. The more recent project to promote chemistry entrepreneurship is already making a significant impact. Through a series of webinars, this initiative has engaged chemists and entrepreneurs alike, creating a platform for sharing knowledge and insights on transforming scientific innovations into successful ventures. The project is now entering a new stage, focusing on providing actionable guidance and fostering collaboration among diverse



The 90th anniversary celebration of the founding of the Spanish National Institute of Physics and Chemistry at, now the “Blas Cabrera” Institute of Chemistry of the Spanish National Research Council (CSIC) in Madrid, Spain, on October 18, 2022, with the presentation of the IUPAC Periodic Table and some significant elements of Spain’s participation in IUPAC in the 1930s.

sectors. Together, these initiatives highlight IUPAC’s ability not only to serve the scientific community but also to inspire society at large, strengthening our role as a truly global and inclusive Union.

Since 2019, IUPAC has undergone a transformation to become more agile and focused on delivering impact. We shifted from meetings of a very large Bureau, often dominated by administrative tasks, to more regular and purposeful meetings of the Executive and Science Board. This restructuring has allowed us to create the time and focus necessary to think and act strategically. While restructuring often brings uncertainty, adapting our structure to meet the evolving needs and opportunities of contemporary chemistry is not just timely; it is critical for ensuring our continued relevance. As part of this evolution, we have intensified our efforts to engage more effectively with external stakeholders, governments, industries, and international organizations. Earlier this year, IUPAC played a pivotal role in drafting the Muscat Declaration on Global Science, a key policy document emerging from the Global Knowledge Dialogue in Oman during the International Science Council meeting. At the same time, we secured a generous \$1 million donation from Raymond Soong, founder of LITEON, to establish the IUPAC-Soong Prize, an annual award celebrating breakthroughs in sustainable chemistry. While these accomplishments mark significant progress, more work is needed to deepen our relationships with international organizations and the chemical industry. Strengthening these connections is essential to amplifying our influence and impact in shaping global science and sustainability efforts.

There are many challenges ahead, yet chemistry has so much to offer, and IUPAC is uniquely positioned to ensure that its full potential is achieved. For this reason, I invite every member of our community, scientists, educators, policymakers, and industry partners, to take an active role. By contributing expertise, sharing perspectives, and working with IUPAC to harness the transformative power of chemistry. Only by working together can we transform challenges into opportunities and ensure that chemistry continues to deliver solutions for society and the planet. Through our standards and recommendations, our projects and publications, our education and outreach, and our ability to connect scientists across borders, we provide the global chemistry community with the tools and platform for discovery and innovation to thrive. In doing so, we are helping chemistry deliver solutions for the benefit of humankind and the world. This is more than our mission; it is our responsibility. Few callings are as urgent or as inspiring as joining together to shape a more sustainable and hopeful future through chemistry. 🌍

Javier García-Martínez <j.garcia@ua.es> is a Professor of Inorganic Chemistry and Director of the Molecular Nanotechnology Laboratory of the University of Alicante, where he leads an international team working on the synthesis and application of nanostructured materials for the production of chemicals and energy. Javier is now IUPAC Past President since January 2024. Previously, he served as President (2022–2023), Vice-President and member of the Executive Committee, and as Titular Member and Vice-President of the Inorganic Chemistry Division. <https://orcid.org/0000-0002-7089-4973>.

IUPAC's 2025 Top Ten Emerging Technologies in Chemistry

by Fernando Gomollón-Bel

Since 2019, the International Union of Pure and Applied Chemistry (IUPAC) has identified the Top Ten Emerging Technologies in Chemistry [1]. This initiative showcases the strategic and innovative contributions of chemistry and chemists to the sustainability and the well-being of society, [2] serving as a platform to promote up-and-coming breakthroughs to catalyse commercial uptake and technology transfer [3]. This year's selection, as usual curated by a team of experts from a pool of proposals submitted by researchers worldwide, includes technologies capable of tackling the climate crisis, transitioning to a sustainable supply chain, and providing promising solutions for better healthcare. Read on to discover the 2025 top ten technologies in chemistry with a transformational potential.

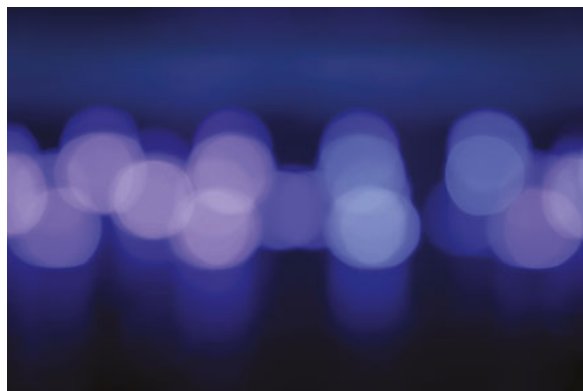
Xolography

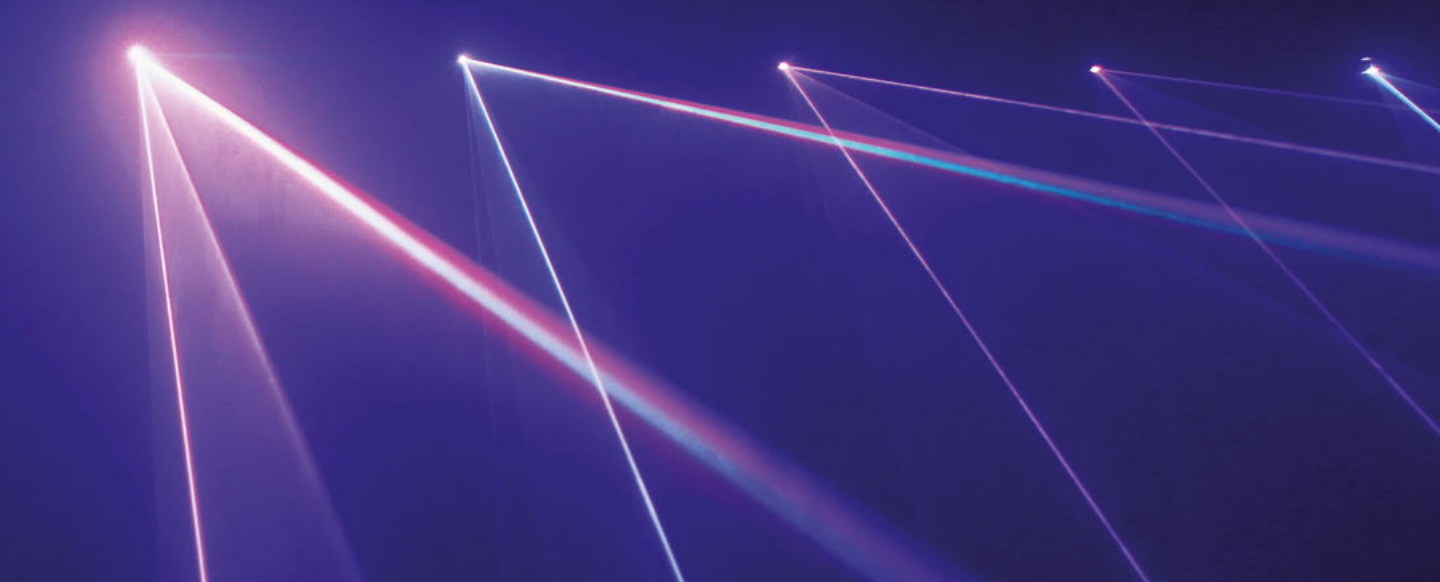
The potential of 3D printing was already highlighted early in the IUPAC Top Ten [1]. Plus, polymers and advances in this broad field often make it into the selection, given the tremendous importance of making manufacturing more substantiable, easier to recycle, and safer by design [4]. In this sense, xolography represents an interesting step forward in innovation and, particularly, in 3D printing. This technique could revolutionise the production of plastics by creating structures with the precision of printing, but without the hassle and time requirements of traditional alternatives, which involve a layer-by-layer approach. First introduced only a few years ago in 2020, [5] xolography combines photochemistry and materials science to print polymers with precision and an unparalleled level of detail. The secret lays in simultaneously using two different wavelengths—one to activate sections of a resin responsive to UV light, and another to quickly cure the activated regions, ensuring the solidification of the structure. Overall, xolography allows the generation and creation

of 3D printed polymers, even complex hollow structures and intricate moving parts, very efficiently and without any extra support scaffolds [6]. Overall, this solution overcomes most of the limitations of the traditional 3D printing of polymers, particularly in the production of interconnected pieces. Beyond precision, xolography offers an impressive speed [7]. Some studies suggest xolography is several orders of magnitude quicker than classic technologies, making structures in just a few seconds that would take layer-by-layer printers more than thirty minutes [8]. Moreover, the most recent advances in the field allow for continuous printing processes [9] and even efficient results under micro-gravity [10]. One of the pioneers of the technology is the co-founded start-up, Xolo, based in Germany, which raised a Series A funding round of eight million euros and applied for several patents, proving the potential of xolography in the manufacturing market [11].

Carbon dots

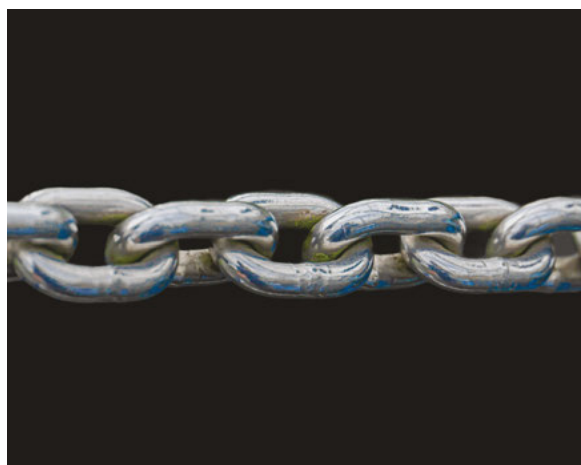
In 2023, the development of quantum dots—colourful, ubiquitous particles used in applications from LEDs to the treatment of tumours—won the Nobel Prize in Chemistry [12]. Carbon dots represent a greener alternative, usually also more biocompatible. Their advantages arise mostly from the possibilities in personalisation, thanks to simple strategies to functionalise





and decorate these carbon structures to convey applications in sensing, bioimaging, drug delivery, catalysis, solar cells and energy storage, among others [13]. The structure of carbon dots varies, depending on the preparation process. Some feature a crystalline core, such as a few layers of graphene fragments (*i.e.* carbon *quantum* dots), while others count on a core of amorphous graphite (*i.e.* carbon *nano* dots) or carbonised pieces of polymer (*i.e.* carbon *polymer* dots). Overall, whatever synthetic strategy is used, the value of carbon dots lies in sustainability, stability, solubility and, most importantly, low toxicity [14]. The latter, together with tuneability, makes carbon dots an attractive alternative for applications in biology and medicine. Thanks to strategic structural modifications, chemists are able to tune and tailor the fluorescence of carbon dots for easy identification, as well as modify them with linkers and tags to direct them to specific structures in biological systems, such as antibodies, organelles, and cells [15]. This is extremely useful in sensing and imaging for the detection of diseases and defects in biological tissue, for example, but is also useful for treatment. Carbon nano-dots could carry cargos for drug delivery and potentially provide solutions for therapeutic applications, including phototherapy and chemotherapy [16]. Recently, carbon dots derived from citric acid showed promise in the treatment of base burns, reducing the recovery period. Perhaps more interestingly, the processes for producing carbon dots often rely on sustainable syntheses and inexpensive, abundant resources such as biomass, in line with the principles of green chemistry. Last, but not least, the possibilities of personalisation have led to the discovery of chiral carbon dots, which open new avenues in the sensing of structures, including drugs, DNA, amino acids, sugars, and other biomolecules and bioactive compounds. Moreover, chiral carbon dots present unique opportunities in catalysis, including photocatalysis, electrocatalysis, click chemistry, and even as an alternative for the site-selective cleavage reactions of CRISPR gene editing [17]. Although still

mostly in the realm of research, carbon dots could make it to the market soon, partly thanks to several start-ups and spin-offs around the world. An interesting example is Qarbotech in Malaysia, a company that created a carbon dot solution to boost the efficiency of photosynthesis, pioneering applications in agriculture.



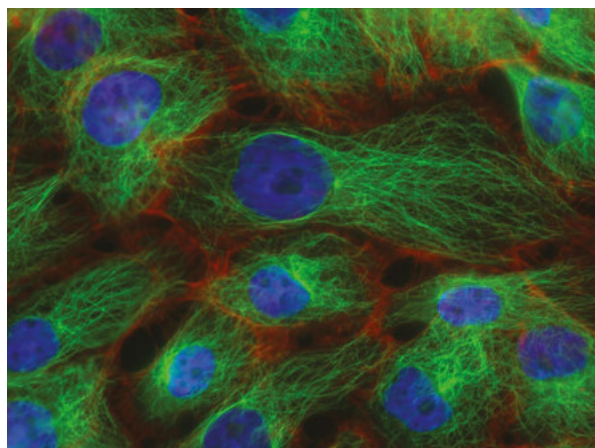
Nanochain biosensors

Nanotechnology has been present in the Top Ten selections since the initiative was created, representing an estimated ten percent of the technologies. In this same spirit, nanochains could provide a promising solution for biosensing. Since the start of the current century, the modification of one-dimensional nanostructures has been explored as a strategy to selectively and sensitively detect molecules, particularly small molecules and biomolecules, with a combination of electrical, electrochemical, optical and mechanical methods. The recipes rely on a variety of products, including gold nanoparticles, carbon nanotubes, and silicon nanowires, among others. Decorated with different “detectors,” such as enzymes, antibodies, proteins and DNA fragments, these nanosensors reached limits below pico- and femtomolar concentrations, in some situations spotted

even a few single molecules [18]. This surpasses the limits of most microscopy techniques and opens the door to innovative solutions—among them nanochains. Nanochains were inspired originally by research in magnetic nanoparticles, which very easily assemble into sequenced, stable structures, also identified and isolated in some living organisms. Today, researchers prepare nanochains on-demand, decorated with a variety of fragments for applications in catalysis, imaging, and drug delivery [19]. The versatility of nanochains allows not only for different uses, depending on the surface modifications, but also sparks solutions in microfluidics and “lab-on-a-chip” devices, where the nanostructures serve as a strategy for separating and selecting substances, as well as serving as a solution for mixing the reagents—if applied as a nanoscale stirring rod. Imagine minuscule magnetic filaments, made of smaller particles, all coated in reactive probes, such as antibodies [20]. Additionally, another virtue of nanochains lays in an ability to amplify scattering signals, expanding the limits of detection of optical microscopes from two hundred down to fifty nanometres, which allows the direct observation of viruses. This inspired researchers to create more sensitive tests for pathogens such as SARS-CoV-2, H1N1, and H3N2, which cause diseases like COVID and the flu. In this case, the nanochains consist of carefully synthesised non-metallic nanoparticles, modified with the relevant biomarkers ready to detect the different diseases [21]. Other studies present nanochain biosensors for heart diseases, kidney infections, migraines, and some examples of tumours. Some nanochains are easily dispersed in solutions, which facilitates the fabrication of printed biosensors, almost “à la carte.” It may still seem a bit early for commercial applications, but nanochain sensors have found a niche in personalised point-of-care tests and could soon start a revolution in treatments after some success in therapies for hard-to-treat cancers [22].

Synthetic cells

Everything is chemistry—including our own cells. And, for years using different approaches, chemists and biochemists have tried to recreate our own cells in the lab [23]. On the one hand, our synthetic cells could serve as “simulations” or simplified models to study and understand processes such as gene expression, metabolism or molecular communication in biology. On the other hand, our synthetic cells could provide pioneering applications in biotechnology and medicine, for use in research, diagnostics and therapeutics, with totally-tailored properties, including examples such as the synthesis and selective release of drugs [24],



or even technologies for the capture and utilisation of carbon dioxide [25]. Generally, the creation of such synthetic cells is classified as either “top-down” or “bottom-up.” The former implies the simplification of an existing living structure, removing any parts strictly non-essential to tailor the cell’s composition. This is the idea followed by a team in the J. Craig Venter Institute in the US, credited with the creation of the “first minimal synthetic cell,” reducing the original genome of a specific bacteria to half its usual length, while still staying viable as an organism [26]. These synthetic structures can shed light into the secrets of life, as well as provide a platform for personalised gene expression, which could create “cell factories.” Similar to genetically-engineered bacteria, these structures could enhance the efficient production of chemicals, biofuels and drugs [27]. “Bottom-up” methods make a cell from scratch, usually using lipid vesicles to encapsulate other biomolecules, including nucleic acids, proteins, enzymes, and even simplified versions of organelles. This approach simplifies the issues related to genetic engineering and expression, and makes the creation of cells simpler, faster, and ready for large scale development. The applications of artificial cells range from drug synthesis and delivery to bioreactors and biological “computers.” [28] Indeed, the current complexity expands from expressing genes, with examples that change shape, move around, and communicate [29]. Although still in early stages, researchers stay positive about the potential of synthetic cells. Some specialists even consider applications such as the mRNA COVID-19 vaccines, as well as other drug formulations using liposomal encapsulation, as a simple example of “bottom-up” structures, resembling synthetic cells, demonstrating the possibilities of this technology. Overall, synthetic cells could provide a better understanding of life and, simultaneously, solutions to boost our health.

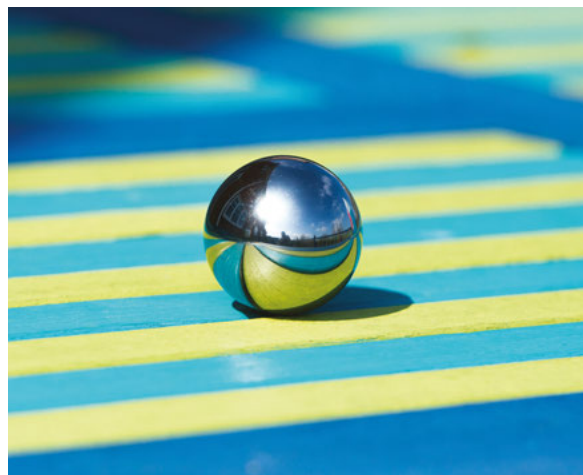
Single atom catalysis

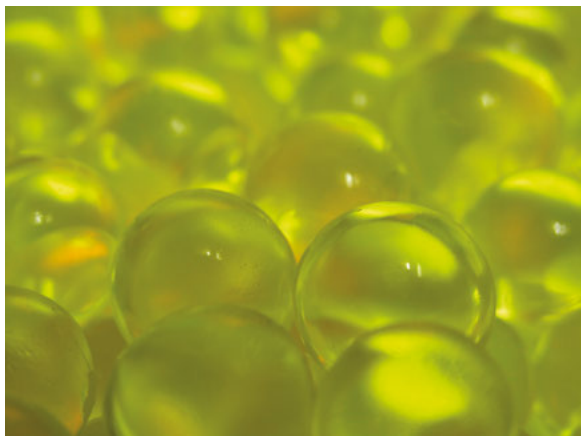
Heterogeneous catalysts have continuously dominated the market. Traditionally, metals make the active sites, dispersed on supporting structures such as activated carbon and ceramic materials. However, at the beginning of the current century, chemists envisioned an exciting idea for more efficient and sustainable catalysis in industry, which could combine the capabilities of heterogeneous catalysis with the precision and selectivity of enzymes—single atom catalysis (SAC) [30]. Instead of supporting clusters of catalyst atoms or nanoparticles, SAC uses isolated, single atoms, attached to a supporting surface. Therefore, every catalytic site stays exposed to the reagents, which consequently conveys a theoretical atom efficiency of 100%, maximising reactivity and, perhaps most importantly, sustainability. This is due not only to the higher efficiency, but also to the reduction in required amounts of metal and increased recyclability—SACs have demonstrated a sustained state of activity after several recovery and recycling reactions [31]. In the past two decades, researchers have reported results with SACs across the periodic table, including not only with the more traditional platinum, palladium, and rhodium, but also with the more abundant alternatives such as iron, nickel, and copper [32]. The latest, for example, has emerged as an exciting catalyst for the electrochemical conversion of carbon dioxide into value-added products [33]. Additionally, SACs sometime showcase interesting and unique catalytic activity, different from bulk heterogeneous options. The different coordination environments which, in turn, also prompt tuneability and modifications, create a special electronic structure in the active sites, affecting selectivity and stopping undesired reactions. The reactivity of SACs has been reported as “unique and multi-faceted.” [34] This has

become increasingly attractive for researchers working in energy solutions such as CO₂ valorisation into chemical fuels, water splitting, and the synthesis of green ammonia [35]. SACs have also successfully catalysed commercial reactions, such as Suzuki couplings [36], and now progressively advance towards more scalable, resilient solutions, ready for the mass market. Catalyst companies such as Johnson Matthey are reportedly working on sustainable solutions using single atom catalysts, and commercial suppliers often offer preparations with SACs for reactions in energy conversion, petrol refining, and advanced synthesis. Now, the most likely next frontier is chiral catalysis. Some studies have explored the possibilities to perfect the “final frontier” of catalysis even further, replicating the selectivity and specificity of enzymes while keeping the attractive commercial capabilities of SACs [37].

Thermogelling polymers

Often, polymers and plastics appear in the IUPAC Top Ten lists. Since the beginning of the 20th century, these materials have become ubiquitous and offer solutions to remediate environmental pollution. Innovations in polymer science usually boost the materials' sustainability, as well as unveil unforeseen applications. Thermogelling polymers present the perfect example. These smart materials transition from liquid to gel with the pull of a single trigger—temperature. There is no need for chemical crosslinkers or supplementary stimuli. This property has catapulted applications in cosmetics, medical imaging, drug delivery, and bioengineering—particularly in the production of artificial tissues for regeneration [38]. Most of these applications stem from the versatility of thermogelling polymers, often designed with biocompatibility in mind. Normally, temperature triggers the transformation of linear copolymers into micelles first, then into more complex networks, which eventually evolve into a stable gel. A key advantage for biomedical applications is injectability. As liquids, or *sols*, these substances are easily inserted into the body, where they spontaneously, but progressively transition into the gel state. In drug delivery, for example, the gels enable the sustained release of active ingredients into the affected zones, with very promising results in complex diseases, including cancer [39]. The starting state as *sols* also enables interesting uses in 3D printing, an ideal platform to prepare biocompatible scaffolds for wound regeneration, cell cultures or organoid growth [40]. Perhaps the most promising and positive result in the field is related to the versatility of thermogelling polymers for real-life reparation of tissues in the eye. Until recently, the vitreous





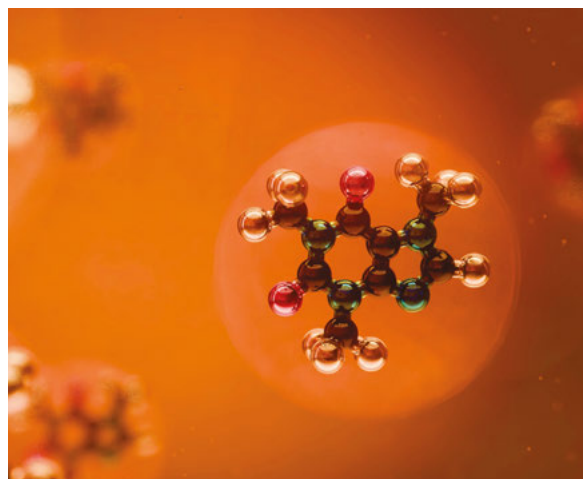
humour was considerable irreparable and irreplaceable if damaged. This issue caused retinal diseases and even detachment, often resulting in permanent blindness. However, researchers crafted a solution to repair retina detachments, mimicking the special structure and characteristics of the vitreous humour with thermogelling polymers of similar viscosity and transparency. In time, the gel stimulates and supports structures naturally present in the eyes, such as collagen, fibrillin, and vitrin, overall reducing the complications associated with retinal surgery [41]. Nowadays, some start-ups investigate the possibilities of these polymers in clinical and commercial applications, while researchers explore areas such as 3D bioprinting, soft robotics, and environmental sensing [42].

Additive manufacturing

It is usually said that Renaissance artist Michelangelo simply “saw” his statues inside blocks of marble, then stripped the excess away to create pieces of art such as his statue of David in Florence, Italy. Additive manufacturing is the exact opposite process. It consists of creating objects layer by layer, in an additive manner, minimising material waste. Often, “additive manufacturing” means 3D-printing, because of the possibilities of polymer and plastic printing in manufacturing, but other techniques also have an additive approach at the core and could count in the same category [43]. Chemistry is crucial to increasing the sustainability of additive manufacturing even further. This involves innovations in materials science to produce printable polymers, ceramics, and biobased materials with better biodegradability and recyclability. It also involves the development of sustainable solutions in inks, resins, and filaments to make manufacturing itself more resilient and energy efficient [44]. These discoveries have driven developments such as additive manufacturing of metals, using composite polymers and metal powders. This increases

the efficiency compared to current alternatives, as well as reduces the production of waste, since the unused solution is easily recycled. Moreover, the most recent advances in 3D-printing open possibilities in the production of hollow, yet strong structures, such as scaffolds and lattices. The optimisations in engineering could contribute to the creation of lighter components, especially useful in the manufacturing of machinery. In this scenario, additive manufacturing would boost sustainability by reducing the amount of materials needed, as well as making lighter cars and planes, cutting carbon emissions throughout the lifetime of the product [45]. This technology could increase the sustainability of chemistry itself, by creating applications for researchers and innovators in the lab. Additive manufacturing could contribute to the creation of more sustainable lab equipment, as well as accelerate scale-up with the 3D-printing of low-cost prototypes and developmental demonstrations. Moreover, most designs for parts are published in repositories in open access, fostering not only a quicker implementation of innovation, but also a more collaborative ecosystem for chemists worldwide [46]. Large companies such as Evonik, Airbus, and Carbon have reportedly started working in additive





manufacturing, contributing to cutting CO₂ emissions and catalysing commercial uptake.

Multimodal foundation models for structure elucidation

Artificial Intelligence (AI) has become a buzzword, in some cases carrying negative connotations because of its impact on the environment. Nevertheless, some interesting applications of AI could make chemists' lives easier, by accelerating analytic processes as well as reducing the hindrance of repetitive tasks, which opens up time for creativity, as discussed in the Top Ten selection of 2020 [47]. This is exactly the case of molecular models for structure elucidation, a technology that makes the most of machine learning, deep learning, and artificial intelligence to holistically study spectra from different sources, such as infrared, nuclear magnetic resonance, UV spectroscopy, and mass spectrometry, among others. In contrast, common approaches previously focused on single spectroscopic techniques. The "multi-modal" approach presents several advantages, rooted in the interconnectivity of data to provide the algorithms with a structural understanding of molecules and materials. For example, this could cut costs in laboratories with limited access to expensive equipment and databases, since simple experiments, such as infrared measurements, would suffice for structure elucidation. The model would match the selected spectra with available datapoints, comparing across complex patterns and accelerating assignment of an optimal structure [48]. Besides democratising elucidation, these multimodal models could also accelerate drug discovery and materials innovation, as well as optimise processes in pollution monitoring, quality control, and forensic analysis. The models use publicly-available databases, including patent data, to train the algorithms

with standardised sources [49]. Although incipient, the idea has already attracted the interest of companies such as IBM. The existing models still lack the reasoned and creative approaches of trained chemists, but the investment in innovation, including better interpretation of structures with standards such as InChI and SMILES, will only make models better. Soon, AI will also reduce the struggles of structural elucidation.

Direct air capture

We must tackle the climate crisis with every available alternative. And, although often discredited as a temporary patch, direct air capture (DAC) is widely recognised as a strategic solution to reduce the concentration of carbon dioxide in the atmosphere and mitigate the effects of climate change [50]. Chemistry is central to solving the principal problem of DAC—successfully sequestering a substance present as the smallest atmospheric proportion of four hundred parts per million. This concentration is enough to cause climate alterations, but sufficiently minuscule to make materials efficient enough for carbon capture. To overcome this, chemists encountered two complementary courses of action. The first relies on reactive adsorption, using basic compounds such as hydroxides, oxides, borates, and amines to "trap" carbon dioxide, usually in the form of carbonates and similar salts. In most cases, the main downside is the demand of energy needed for regeneration, a process that requires really high pressure and temperature. The second idea counts on a technology from the original Top Ten list in 2019—metal organic frameworks (MOFs). Structured like miniaturised sponges, MOFs are porous materials with an extremely high adsorption surface, which makes them ideal to selectively store gases, included CO₂. Usually, the efficiency trapping carbon dioxide is lower for physical than chemical sorbents, but regeneration is easier and smoother, which in turn makes MOFs more





attractive for industrial implementation. Of course, chemists have also studied a consolidated solution – decorating the extensive surface of metal-organic frameworks with reactive structures, such as amines. This strategy improves the adsorption capacity, as well as makes MOFs even more selective towards carbon dioxide versus other gases in the atmosphere [51]. Most MOF-based solutions have progressed to pilot plants, even industrial demonstrations [52]. And, in general, DAC has already established itself as an alternative for carbon capture worldwide. There are several industrial infrastructures with high levels of maturity, that have cut the cost below \$100 per ton of CO₂ surpassing the most optimistic predictions by the International Energy Agency. However, some studies suggest that the solutions lack scalability and resilience [53], supported by news of closures and cuts among leaders such as Climeworks and Ørsted. While carbon capture could contribute to our climate-neutral targets, the technology still needs further development and improvement to become competitive [54].

Electrochemical carbon capture and conversion

While DAC offers an opportunity to capture carbon dioxide directly from the atmosphere, electrochemistry enables an extra step—using CO₂ as an alternative source of carbon, converting it into chemicals, fuels, and other value-added products. The first examples of electrochemical carbon capture date back to the 1960s and 70s, when they were used as a tool to complement the methods based in adsorption. Using electricity as the driving force usually reduces cost and enables coupling

with clean sources of energy, such as solar, wind, and hydrothermal. Additionally, electrochemical processes tend to surpass the performance of traditional thermochemical alternatives, reducing the overall impact and making them an attractive alternative to DAC [55]. Additionally, electrochemistry enables efficient liberation of CO₂ gas, which is less energetically demanding than desorption processes. Moreover, electrochemistry offers the chance to seamlessly couple capture with conversion and utilisation. Once trapped, carbon dioxide serves as a source of carbon towards key chemical feedstocks, including carbon monoxide (CO), formate, methanol, ethylene, as well as longer hydrocarbons [56]. In the past few years, an increasing number of studies showcased the limitless possibilities of electrochemical carbon dioxide reduction reactions, usually referred to as eCO₂RR [57]. Since the first example of eCO₂RR, published in 1985 [58], the advances in catalysis, materials science, and engineering have perfected the processes to prepare small feedstock molecules, breaking ground for more challenging reactions, such as the synthesis of hydrocarbons [59]. In this area, electrocatalysts made of abundant metals such as copper and nickel have shown great promise, converting carbon dioxide to both linear and branched hydrocarbons with chains of up to six carbon atoms [60]. As a relatively recent field, eCO₂RR is still far from competitive to the traditional thermochemical processes in oil refining. However, the reliance on electricity as the sole source of energy increases sustainability, as well as democratizes and delocalises access to chemicals. Despite its early stage, far from scalability and industrial applications, the electrocatalytic conversion of

carbon dioxide is still regarded as a promising alternative to produce value-added chemicals in a sustainable manner [61]. Overall, electrochemistry is an emerging technology for both capture and conversion of carbon dioxide. Nevertheless, its promise to promote sustainability and circularity, mitigating the impact of climate change, is clear. Further research will undoubtedly unveil and uncover interesting innovations to transform CO₂ from waste into feedstock, making it a key starting material for manufacturing in the chemical industry [62].

Conclusions

In its seventh consecutive year of operation, the IUPAC Top Ten Emerging Technologies in Chemistry initiative continues to look into sustainability and circularity, connecting new and innovative ideas towards a greener future [63], while maintaining a strong interest in the development of methods for the improvement of human health. Overall, the selection of the 2025 Top Ten, carefully crafted by a panel of experts from a pool of global nominations, continues to carry the spirit established by the first Top Ten list released in 2019 and that is to highlight the potential of chemistry—and chemists—to provide solutions to the most urgent societal issues. The initiative attempts to highlight diverse technologies from around the world that are in early stages of development in order to boost their visibility and eventually facilitate technology transfer and market uptake. This edition expands the selection to seventy technologies, showcasing the versatility and variability of creativity in chemistry. IUPAC's objective in putting these highly-innovative ideas under the spotlight is to strongly encourage collaboration across all scientific disciplines in order to accelerate progress towards a more sustainable and equitable world.

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References

- (a) F. Gomollón-Bel. *Chem. Int.* 2019, 41, 2, 12, DOI: 10.1515/ci-2019-0203. (b) <https://iupac.org/what-we-do/top-ten/>
- F. Gomollón-Bel, J. García-Martínez. *Nat. Chem.* 2022, 14, 2, 113, DOI: 10.1038/s41557-021-00887-9.
- F. Gomollón-Bel, J. García-Martínez. *ACS Cent. Sci.* 2025, 11, 6, 819, DOI: 10.1021/acscentsci.5c00530.
- C. Caldeira et al. "Safe and sustainable by design chemicals and materials." European Commission JRC (2022). DOI: 10.2760/879069
- M. Regehy et al. *Nature*, 2020, 588, 7839, 620, DOI: 10.1038/s41586-020-3029-7.
- C. Q. Choi. "3D-printing hollow structures with xolography". *IEEE Spectrum*, 28 December 2020. Accessed 17 July 2025. Link: <https://spectrum.ieee.org/xolography-printing>
- P. Nunez Bernal et al. *Nat. Rev. Mater.* 2025, DOI: 10.1038/s41578-025-00785-3
- Z. Hussain. "Xolography—The Latest Innovation in 3D Printing". *Engineering.com*, 22 January 2021. Accessed 17 July 2025. Link: <https://www.engineering.com/xolography-the-latest-innovation-in-3d-printing/>
- L. Stüwe et al. *Adv. Mater.* 2023, 36, 4, 2306716, DOI: 10.1002/adma.202306716.
- N.F. König et al. *Adv. Mater.* 2025, 37, 5, 2413391, DOI: 10.1002/adma.202413391.
- Xolo (2023). Accessed 17 July 2025. Link: <https://xolo3d.com/about/>
- The Nobel Prize (2023). Accessed 17 July 2025. Link: <https://www.nobelprize.org/prizes/chemistry/2023/summary/>
- S.E. Elugoke et al. *ACS Symposium Series*, Vol. 1465. DOI: 10.1021/bk-2024-1465.ch001
- S. Ashok Kumar et al. *Mater. Adv.* 2023, 4, 18, 3951, DOI: 10.1039/D3MA00254C.
- M. Jorns, D. Pappas. *Nanomaterials* 2021, 11, 6, 1448, DOI: 10.3390/nano11061448.
- (a) N. Panwar et al. *Chem. Rev.* 2019, 119, 16, 9559, DOI: 10.1021/acs.chemrev.9b00099. (b) Z. Yhang et al. *Chem. Rev.* 2023, 123, 18, 11047, DOI: 10.1021/acs.chemrev.3c00186.
- A. Döring et al. *Light Sci. Appl.* 2022, 11, 1, 92, DOI: 10.1038/s41377-022-00764-1.
- I.M. Feigel et al. *J. Mat. Chem.* 2011, 21, 25, 8940, DOI: 10.1039/c1jm10521c.
- S. Kralj, S. Marchesan. *Pharmaceutics* 2021, 13, 8, 1262, DOI: 10.3390/pharmaceutics13081262.
- Q. Xiong et al. *Nat. Commun.* 2018, 9, 1, 1743, DOI: 10.1038/s41467-018-04172-1.
- Z. Zhang et al. *Angew. Chem. Int. Ed.* 2021, 60, 45, 24234, DOI: 10.1002/anie.202109985.
- E. Karatahnasis, K.B. Ghaghada. *Wiley Interdiscip. Rev.: Nanomed. Nanobiotechnol.* 2016, 8, 5, 678, DOI: 10.1002/wnan.1387.
- W. Jiang et al. *ACS Nano* 2022, 16, 10, 15705, DOI: 10.1021/acsnano.2c06104.

24. C.P. Pilkington et al. *Nat. Chem.* 2024, 16, 10, 1612, DOI: 10.1038/s41557-024-01584-z.
25. W. Wang et al. *Angew. Chem. Int. Ed.* 2025, 64, 11, e202421827, DOI: 10.1002/anie.202421827.
26. C.A. Hutchinson et al. *Science* 2016, 351, 6280, aad6253, DOI: 10.1126/science.aad6253.
27. A. Guan et al. *Biotechnol. Adv.* 2024, 73, 108366, DOI: 10.1016/j.biotechadv.2024.108366.
28. Q. Xu et al. *Mater. Today Bio* 2023, 23, 100877, DOI: 10.1016/j.mtbio.2023.100877.
29. (a) S. Razavi et al. *Sci. Adv.* 2024, 10, 24, adk9731, DOI: 10.1126/sciadv.adk9731. (b) S. Mukwaya et al. *Commun. Chem.* 2021, 4, 1, 161, DOI: 10.1038/s42004-021-00597-w.
30. S. Mitchell, J. Pérez-Ramírez. *Nat. Commun.* 2020, 11, 1, 4302, DOI: 10.1038/s41467-020-18182-5.
31. M.A. Bajada et al. *Cell Rep. Sustain.* 2025, 2, 1, 100286, DOI: 10.1016/j.crsus.2024.100286.
32. S.K. Kaiser et al. *Chem. Rev.* 2020, 120, 21, 11703, DOI: 10.1021/acs.chemrev.0c00576.
33. C.E. Creissen, M. Fontecave. *Nat. Commun.* 2022, 13, 1, 2280, DOI: 10.1038/s41467-022-30027-x.
34. (a) S. Back et al. *Chem. Sci.* 2016, 8, 2, 1090, DOI: 10.1039/C6SC03911A. (b) S. Mitchell et al. *Angew. Chem. Int. Ed.* 2018, 57, 47, 15316, DOI: 10.1002/anie.201806936.
35. A. Extnance. "Single-atom catalysis." *Chemistry World*, 21 October 2019. Accessed 19 July 2025. Link: <https://www.chemistryworld.com/features/single-atom-catalysis/3010930.article>
36. Z. Chen et al. *Nat. Nanotech.* 2018, 9, 1, DOI:
37. T.A. Gazis et al. *ACS Catal.* 2025, 15, 9, 6825, DOI: 10.1021/acscatal.4c07405.
38. S. Qiao, H. Wang. *Nano Res.* 2018, 11, 10, 5400, DOI: 10.1007/s12274-018-2121-x.
39. M. Chen et al. *Small* 2021, 17, 52, 2104773, DOI: 10.1002/smll.202104773.
40. H.A. Pearce, A.G. Mikos. *Curr. Opin. Biomed. Eng.* 2022, 24, 100412, DOI: 10.1016/j.cobme.2022.100412.
41. (a) "New polymer gel for treating blindness." *Nature India*, 9 April 2019. Accessed 19 July 2025. Link: <https://www.nature.com/articles/nindia.2019.44>. (b) Z. Liu et al. *Nat. Biomed. Eng.* 2019, 8, 3, 598, DOI: 10.1038/s41551-019-0382-7.
42. Q. Lin et al. *Acc. Mater. Res.* 2021, 2, 10, 881, DOI: 10.1021/accountsmr.1c00128.
43. R. Linke. "Additive manufacturing, explained." MIT Sloan School, 7 December 2017. Accessed 19 July 2025. Link: <https://mitsloan.mit.edu/ideas-made-to-matter/additive-manufacturing-explained>
44. E. Sanchez-Rexach et al. *Chem. Mater.* 2020, 32, 17, 7105, DOI: 10.1021/acs.chemmater.0c02008.
45. N. Nagabandy. "How 3D Printing Can Dramatically Reduce Carbon Emissions in the Manufacturing Industry". *Manufacturing Tomorrow*, 6 September 2023. Accessed 19 July 2025. Link: <https://www.manufacturingtomorrow.com/story/2023/05/how-3d-printing-can-dramatically-reduce-carbon-emissions-in-the-manufacturing-industry/20720/>
46. O. A. Alimi, R. Meijboom. *J. Mater. Sci.* 2021, 56, 16824, DOI: 10.1007/s10853-021-06362-7.
47. F. Gomollón-Bel. *Chem. Int.* 2020, 42, 4, 3, DOI: 10.1515/ci-2020-0402.
48. M. Alberts, et al. *arXiv* 2024, DOI: 10.48550/arXiv.2407.17492.
49. Y. Su et al. *arXiv* 2025, DOI: 10.48550/arXiv.2508.08441.
50. IEA (2022). "Direct air capture: a key technology for net zero." IEA, Paris, April 2022. Accessed 24 July 2025. Link: <https://www.iea.org/reports/direct-air-capture-2022>
51. (a) E.S. Sanz-Pérez et al. *Chem. Rev.* 2016, 116, 19, 11840, DOI: 10.1021/acs.chemrev.6b00173. (b) X. Zhu et al. *Chem. Soc. Rev.* 2022, 51, 15, 6574, DOI: 10.1039/D1CS00970B.
52. X. Zhang et al. *Carbon Capture Sci. Tech.* 2023, 9, 100145, DOI: 10.1016/j.ccst.2023.100145.
53. F. Bisotti et al. *Chem. Eng. Sci.* 2024, 283, 119416, DOI: 10.1016/j.ces.2023.119416.
54. M. Burke. "Warning that carbon capture not a silver bullet for climate change." *Chemistry World*, 8 September 2022. Accessed 24 July 2025. Link: <https://www.chemistryworld.com/news/warning-that-carbon-capture-not-a-silver-bullet-for-climate-change/4016198.article>
55. A.M. Zito et al. *Chem. Rev.* 2023, 123, 13, 8069, DOI: 10.1021/acs.chemrev.2c00681.
56. I. Sullivan et al. *Nat. Catal.* 2021, 4, 11, 952, DOI: 10.1038/s41929-021-00699-7.
57. Y.C. Li. *Commun. Chem.* 2024, 7, 1, 48, DOI: 10.1038/s42004-023-01096-w.
58. Y. Hori et al. *Chem. Lett.* 1985, 14, 11, 1695, DOI: 10.1246/cl.1985.1695.
59. J. Han et al. *Chem. Sci.* 2024, 15, 21, 7870, DOI: 10.1039/D4SC01931H.
60. (a) D.-J. Liu. *Joule* 2022, 6, 9, 1978, DOI: 10.1016/j.joule.2022.08.012. (b) Y. Zhou et al. *Nat. Catal.* 2022, 5, 6, 545, DOI: 10.1038/s41929-022-00803-5.
61. (a) D. Xu et al. *Carbon Energy* 2022, 5, 1, e230, DOI: 10.1002/cey2.230. (b) G. Leonzio et al. *Chem. Eng. Res. Des.* 2024, 208, 934, DOI: 10.1016/j.cherd.2024.07.014.
62. I. Ghat et al. *J. CO₂ Util.* 2025, 95, 103075, DOI: 10.1016/j.jcou.2025.103075.
63. F. Gomollón-Bel, J. García-Martínez. *Chem. Sci.* 2024, 15, 14, 5056, DOI: 10.1039/D3SC06815C.

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Preventing spread of chemical weapons in an era of rapid technological change

by Sarah Clapham and Peter Hotchkiss

Science and technology are evolving at a remarkable pace, providing innovative solutions to global challenges. Developments are improving healthcare, driving sustainability, and enhancing quality of life, while playing a critical role in achieving the United Nations Sustainable Development Goals. But this rapid progress also brings new complexities, particularly for science-based disarmament treaties. How can we ensure these agreements remain robust in this rapidly evolving scientific landscape? Using the Chemical Weapons Convention (CWC) as an example, Sarah Clapham and Peter Hotchkiss from the Organisation for the Prohibition of Chemical Weapons (OPCW) explore this question, describing the mechanisms in place to effectively monitor and assess progress in science and technology while highlighting select relevant advances.

Success in chemical disarmament

The ultimate aim of the CWC is to eliminate all chemical weapons worldwide while promoting the peaceful uses of chemistry, thereby enhancing international security and stability [1]. One of several disarmament treaties for weapons of mass destruction, the CWC is widely regarded as the most successful. Its success is often attributed, in part, to its near-universal membership. With a total of 193 states that have joined, so-called States Parties, and only four countries yet to do so, 98% of the global population is living under the protection of the Convention [2]. The success of the CWC is further underscored by the recognition of the OPCW, which was awarded the Nobel Peace Prize in 2013 for “its extensive efforts to eliminate chemical weapons” [3]. However, this success is most clearly demonstrated by the tangible results that have been achieved. A historic milestone was reached in July 2023, when the last chemical weapon from the stockpiles declared by all States Parties was verified as irreversibly destroyed [4]. Over 72,000 metric tonnes of chemical warfare agents—including nerve agents, mustard gas, and their precursors—have been eliminated, overcoming significant technical challenges in a process that took 26 years to complete. This marks a monumental achievement in chemical disarmament.

Aside from its adherence and achievements in chemical disarmament, the CWC’s significant success also stems from its comprehensive scope. The CWC’s scientific counterpart, the Biological Weapons Convention (BWC), entered into force in 1975, more than 20 years

before the CWC [5]. The text of the BWC is less than four pages long and has just 14 articles. By contrast, the CWC spans 167 pages, with 24 articles and three annexes. Addressing some of the BWC’s limitations, the CWC is a more robust and enforceable treaty for chemical weapons. For example, while the BWC lacks an implementing body, the CWC has the OPCW, a permanent body based in The Hague, the Netherlands. The OPCW oversees implementation, verification, and compliance. Additionally, the CWC incorporates a rigorous verification regime which ensures transparency, builds confidence, and provides a strong framework for monitoring compliance. Notably, the CWC is designed to be adaptable to advances in science and technology. To achieve this, the Convention requires regular review of these advances relevant to its implementation. Furthermore, the CWC mandates the establishment of a Scientific Advisory Board (SAB)—the only disarmament treaty to do so—which is tasked with conducting this review.

Unique scientific advice mechanism

Since its first meeting in 1998, the SAB has become a trusted source of objective, well-informed, and sound scientific advice [6]. The SAB achieves its robust and reliable outputs by ensuring diverse expertise among its members. Advances in science and technology that may impact the CWC are vast, ranging from developments in chemical detection and analysis to emerging technologies such as synthetic biology and artificial intelligence (AI). This breadth is reflected in the multidisciplinary knowledge and skills of the 25 SAB members. Fixed-term appointments leading to regular turnover of members allow the SAB’s knowledge base to evolve alongside scientific progress. Additionally, members are drawn from diverse professional roles, including academia, industry, and government, and represent a wide range of geographic regions across CWC States Parties. Importantly, SAB members serve in their individual capacities and do not represent their governments, ensuring that their advice remains objective, impartial, and politically neutral.

The SAB convenes in person at the OPCW headquarters at least once a year, engaging in dynamic, in-depth discussions on a wide array of topics relevant to the CWC. These discussions are informed not only by the expertise of the SAB members but also by the insights of external experts who are invited to share their knowledge and perspectives. The SAB monitors and reviews relevant advances in science and technology, adopting a risk-based and holistic approach to assess how they may impact the implementation of the



Convention. This approach reflects the interdisciplinary nature of modern science. These developments can present opportunities, risks, or—most often—both. The SAB examines a broad range of scientific and technological topics. It may recommend that a temporary working group (TWG), with a time-bound mandate, is established to explore specific, relevant topics in more detail. The findings from the SAB and TWG meetings are captured in detailed reports which are made publicly available on the OPCW's website [7]. One of the principal products of the SAB's work is its comprehensive report on developments in science and technology, submitted to every five-yearly "Review Conference" which reviews the operation of the CWC.

The SAB's fifth and latest report, covering the period between the 4th Review Conference in 2018 and the 5th in May 2023, was issued in February 2023 [8]. It consolidates insights from its meeting reports, temporary working groups, and workshops during this period, in addition to data from its review of the scientific literature and other relevant documentation. Reflecting the rapid pace of developments in science and technology, over the past 20 years the SAB's reports to the Review Conferences have expanded in length, complexity, and the range of topics covered, with the latest report presenting a record total of 45 recommendations.

Key advances in science and technology

In this recent report, the SAB identified several overarching trends. It noted that developments in science and technology are progressing at an unprecedented pace. Scientific fields and technologies are converging and the boundaries between the traditional physical, biological, and digital realms are becoming blurred. Transdisciplinary approaches facilitated by international

collaborations are emerging to address modern challenges. Instrumentation and equipment are becoming more affordable and powerful, often with an increased flexibility of application. Consequently, these tools and technologies are becoming easier to access by would-be malicious actors, and the technical barriers to their use are lowering. The SAB highlighted that advances in science and technology are presenting an ever-changing set of challenges and opportunities to the implementation of the CWC and the work of the OPCW.

The SAB's core focus, which has remained consistent since its inception, is on understanding chemicals, their production methods, and trends in the chemical sciences, including those in industry. This deep knowledge helps the OPCW and States Parties identify potential threats, such as novel chemicals or emerging production technologies that could facilitate the creation of chemical weapons. It also supports the development of detection equipment and medical countermeasures and can lead to improvements in chemical safety. By monitoring these advances, vulnerabilities can be addressed and emerging threats can be mitigated, while also leading to increased efficiency, sustainability, and safety.

In its review of technological advances during the preparation of its recent report, the SAB identified and examined a number of relevant cross-cutting technologies. For example, AI, additive manufacturing (often called 3D printing), nanotechnology, unmanned aerial vehicles (also known as drones), and biotechnology are transforming the scientific and technological landscape, with wide-ranging applications and impact across multiple domains relevant to the Convention. These technologies are often combined, creating synergies that enhance capabilities, providing additional means to address challenges relevant to the Convention.

Preventing spread of chemical weapons

In the context of the CWC, these cross-cutting technologies are classified as “dual use” in the sense that they have legitimate civilian and commercial purposes, but could also be used in the creation of weapons. For example, AI-driven automated processes can be used in chemical production or the targeted application of pesticides to crops using drones. At the same time, these technologies pose risks if misused for harmful purposes, such as using AI to design new chemical weapons with specific properties, 3D-printing chemical equipment to bypass export controls, or using drones to disperse toxic chemicals over populated areas or critical infrastructure. This dual-use potential underscores the critical need for ongoing vigilance and continuous monitoring of developments in these areas.

Of particular significance is AI, whose developments the SAB has been monitoring over the past decade. The SAB noted that AI is incredibly versatile, with an “unparalleled flexibility of application”. It is emerging as a powerful enabling technology that is increasingly being integrated into many disciplines and technologies, including robotics, drones, and biotechnology. For example, AI can be applied throughout the entire chemical synthesis process. AI-powered retrosynthesis platforms can provide possible synthesis routes to a target molecule. AI can also be used to optimise reaction conditions and outcomes, as well as predict key properties such as toxicity, bioactivity, and solubility.

In automated synthesis, AI-driven robots not only produce chemicals more reproducibly but also accelerate development, enhance productivity, and augment safety. However, automation is not the only way in which AI is driving improvements in safety. The Internet of Things and connected workers with smart personal protective equipment can monitor an operating environment in real time, ensuring worker safety. Computer vision and AI-driven predictive analytics can analyse camera footage and sensor data to monitor safety conditions and equipment viability.

The SAB observed that the field of AI is incredibly fast-moving: scientific publications are prolific and growing, and the applications are continuing to emerge. In its view, AI presents many opportunities for implementation of the CWC and the work of the OPCW. Examples included “strengthening the verification regime, streamlining certain chemical weapons-related research activities, and possibly leading to breakthroughs in research on medical countermeasures to chemical weapons exposure.” Nevertheless, the SAB highlighted the potential for AI to be misused to discover novel routes to, and accelerate the production of, new and existing chemical weapons. The Board

recommended that the OPCW should monitor closely developments in AI-assisted chemistry and consider not only the potential risks they pose, but also the opportunities they may offer. It also underscored the need for ethical guidelines and robust safeguards to promote the responsible use of AI.

One of the technologies increasingly benefitting from AI integration is drones, particularly those used in agriculture. Drones are becoming more widely available and affordable, making them accessible to a broader range of users. Advances in battery technologies are increasing flight times and payload capacities, meaning that agricultural drones can transport greater quantities of chemicals over greater distances. AI-powered drones are employed in precision farming, enabling autonomous navigation, real-time crop monitoring, and optimised pesticide application. These advances are boosting efficiency and sustainability, reducing the quantities of chemicals released and improving yields.

Within the context of the CWC, drones are a versatile tool offering numerous benefits. They could be used for the real-time monitoring of a chemical incident site or chemical production plant, or designed to take samples in hazardous or inaccessible environments. Drones could also be integrated with sensor technologies to detect chemical warfare agents. However, as a dual-use technology, drones also have the potential to be misused. The SAB recognised that they could be used to deliver toxic chemicals causing deliberate harm and, if integrated with facial recognition technology, drones could carry out highly targeted chemical attacks. It advised that continued monitoring and assessment of advances in this area will be important for minimising the potential risks of misuse.

In its report, the SAB also highlighted some of the developments in additive manufacturing since 2018. These include increased layer thickness and laser power, leading to quicker build times. In some industries, additive manufacturing has shifted from enabling rapid prototyping to being incorporated in production processes. It is now routinely used in many industrial sectors, including automotive, robotics, pharmaceutical and medical, and even the food industry.

Similar to AI and drones, the SAB noted that additive manufacturing presents some significant opportunities in the context of the Convention. It could be leveraged to accelerate research due to its low cost, decreased fabrication times, and flexibility. Its application in drug delivery can be used to either print medication with specific or personalised release profiles, or it can be used to print a variety of drug delivery devices. This could have a potential application in developing

medical countermeasures to chemical weapons exposure. At the same time, the SAB noted the potential risks posed by this technology. Reactionware can be fabricated using chemically resistant materials, potentially overcoming the difficulties in acquiring controlled equipment. Additive manufacturing can also be used to produce components of improvised explosive devices, including the energetic materials.

The application of continuous flow chemistry is gaining traction in the chemical and pharmaceutical industries due to its advantages over traditional batch processes. By enabling faster, safer, and more environmentally sustainable reactions, flow chemistry produces higher quality products with a smaller operational footprint. It is increasingly integrated with other emerging technologies, including AI.

The Board suggested that the modularity and mobility of continuous flow equipment could make it a suitable tool for the on-site destruction of chemical warfare agents. However, these same features could be exploited for nefarious purposes, including the production of hazardous materials like organophosphorus compounds.

Impact of the SAB's advice

By effectively monitoring and assessing developments in science and technology, the SAB ensures a comprehensive understanding of their implications for the Convention. Its robust and impartial advice is crucial not only for the Director-General and Technical Secretariat of the OPCW but also for States Parties, particularly those with limited access to scientific resources. This advice also forms the technical basis for informed policy development, as well as ensuring that the Technical Secretariat and States Parties are best prepared to address future challenges and able to harness the benefits and opportunities offered as science and technology progress.

Only a small proportion of the advances discussed in the SAB's report are presented here. A more detailed summary of its findings, with an update on advice since the report, will be published in the coming months.

This article will also highlight how the OPCW is taking forward the SAB's advice and recommendations and implementing them in its work. The Director-General has emphasised that the implications of AI for the CWC remain a priority for the OPCW [9]. Ongoing monitoring, assessing, and adapting to advances in science and technology are essential to support non-proliferation and disarmament goals, rather than undermine them. 

References

1. <https://www.opcw.org/chemical-weapons-convention>
2. <https://www.opcw.org/about-us/member-states>
3. <https://www.opcw.org/about-us/nobel-peace-prize>
4. <https://www.opcw.org/media-centre/news/2023/07/opcw-confirms-all-declared-chemical-weapons-stockpiles-verified>
5. <https://disarmament.unoda.org/biological-weapons/>
6. <https://www.opcw.org/about/subsidiary-bodies/scientific-advisory-board>
7. <https://www.opcw.org/resources/documents/subsidiary-bodies/scientific-advisory-board>
8. Report of the Scientific Advisory Board on Developments in Science and Technology to the Fifth Special Session of the Conference of the States Parties to Review the Operation of the Chemical Weapons Convention (OPCW, 2023); <https://www.opcw.org/sites/default/files/documents/2023/02/rc5dg01%28e%29.pdf>
9. Conference of the States Parties, Thirty-Ninth Session, 25-29 Nov 2024, Opening Statement by the Director-General <https://www.opcw.org/sites/default/files/documents/2024/11/c29dg17%28e%29.pdf>

The views expressed in this article are those of the authors and do not necessarily reflect the views of the OPCW.

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Why think philosophically about chemistry?

by Vanessa A. Seifert

Whether one realises it or not, chemistry is everywhere. In our everyday lives, chemistry is vital to ensure that what we eat is nutritious and safe, that the medicine we take will cure us of our ailments, and that the detergents we use to clean things will do the job. From a collective perspective, chemistry is vital to our societal growth: from tackling climate change to understanding brain activity, there isn't much which is not somehow affected by chemistry.

Given this, it should not come as a surprise that phenomena that standardly belong to the subject matter of chemistry have drawn the interest of philosophers. In ancient times, Aristotle did a systematic analysis of phenomena and concepts that nowadays are regarded within the purview of chemistry [1]. Alchemists, at least from the time of ancient Egypt up until Renaissance Europe, built entire metaphysical worldviews based on the study of chemical phenomena [2].

However, the philosophy of chemistry as an organised research study is relatively new. Its first official society was the International Society for the Philosophy of Chemistry (ISPC) which organises annual conferences since 1997 and publishes the journal *Foundations of Chemistry* since 1999. Books and collections of papers are published by publishing houses such as Oxford University Press, Springer and Cambridge University Press, and articles are regularly published in general philosophy of science journals such as *Philosophy of Science (PSA)* and the *British Journal for the Philosophy of Science (BJPS)*. The presence of the philosophy of chemistry has also expanded online. *Hyle*, which is published in printed and online form since 1997, was the first international journal on philosophy of chemistry. A more recent online contribution is *Jargonium* and there are also entries on philosophy of chemistry in the *Stanford Encyclopedia of Philosophy* [3] and in the *Internet Encyclopaedia of Philosophy* [3].

But what sort of questions does the philosophy of chemistry examine? There are a variety of issues which occupy philosophers with respect to chemistry. One is chemical classification. Chemists organise elements and substances, but also their properties into different classes. For example, they group elements into alkalis and halogens, substances into acids and bases, and even have different types of bonds such as covalent, ionic, and metallic bonds. In light of this, philosophers are interested in spelling out the scope and limits of these classifications. How precise are they? Do they

capture everything they are meant to? Moreover, do they correspond to structures that are out there in nature or are they—at least to some extent—inventions? How are they used for the explanation and understanding of chemical and other phenomena? These questions are valuable not just in their own right but because they can impact how we teach chemistry.

To appreciate the importance of philosophical thought to chemical education, consider another issue, that of models. How scientific models are developed and used is a tricky thing to teach. The use of idealisations and approximations, but also the development of models that are *prima facie* inconsistent to each other raises important challenges when attempting to explain their scientific role to students. Philosophy can help disambiguate this by spelling out models' scope and limitations and by offering useful classifications of different types of models in science, depending on their characteristic use.

The history of chemistry has also been of particular interest to philosophers. A favourite example is of course the study of the periodic table. In the 19th century there were several classifications of elements proposed and it was, for some time, an open question which proposal should be adopted. Philosophers are interested in this episode from the history of chemistry because it illustrates, among other things, the different values chemists thought as important when evaluating different classificatory schemes [4]. Another very important episode from the history of chemistry is the so-called Chemical Revolution in the 18th century which refers to the period during which chemists rejected the received view that phlogiston accounts for phenomena such as combustion, eventually substituting it with Lavoisier's oxygen theory. This is a central case study for the philosophy of science which examines how scientists reject previously accepted scientific theories to adopt new ones.

But philosophy is not only valuable to how chemists practice, teach, or understand the history of their discipline. It also informs how the wider public perceives chemistry and its societal value. Take for instance the issue of how to build public trust towards chemistry. Unfortunately, that science in general is humanity's most reliable source of knowledge is no longer evident to all. People do not trust what scientists say about climate change nor do they always follow the recommendations of international organisations regarding healthcare or disease control. There is a general mistrust which is partially based on misconceptions or ignorance regarding how science is actually done. Philosophers can help overcome this because part of



its studies involves spelling out how scientific practice is realised and how knowledge is tested and developed, illuminating the importance of experimentation and observation. Scientific hypotheses are not accepted without sufficient empirical evidence backing them up. Whenever an experiment contradicts scientific hypotheses, scientists re-examine if not revise them completely. These are some of the features that render chemistry trustworthy and philosophy has extensively worked on illuminating them correctly.

All in all, even though philosophy as a whole is (to some extent correctly!) thought of as a practice that is very abstract and detached from the way scientists think about the world, this is not true with respect to the philosophy of science. A close study of the sciences, including chemistry, is vital in order to pose questions that pertain to how scientific knowledge is developed and to how we understand nature through science. I encourage you all to explore it! 🧪

References

1. See in particular the following works of Aristotle: *On Generation and Corruption*, *Meteorology*, *Physics*, and *On the Heavens* (Barnes 1984).
2. See for example Principe, L. M. (2020). *The secrets of alchemy*. University of Chicago Press.
3. Hendry Robin F., Needham Paul, Weisberg Michael, *Philosophy of Chemistry*, (2011), <<https://plato.stanford.edu/entries/chemistry/>>, 3/11/2017. Seifert, V., *Reduction and Emergence in Chemistry*, (2019) <<https://iep.utm.edu/reduction-and-emergence-in-chemistry/>>
4. E.g. Pulkkinen, K. (2020). Values in the Development of Early Periodic Tables. *Ambix*, 67(2), 174–198. <https://doi.org/10.1080/00026980.2020.1747325>

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Check out Vanessa's recorded presentation from the D-UST Conference 2025; see report on p. 20, about the chemical progress in the age of AI.

Spotlight on IUPAC Young Observers

by **Daniel (Dan) Reddy**, *series convenor*
Queen's University, Kingston, Ontario, Canada; YO 2023

Last year, I was fortunate to be able to shine an spotlight on two recent IUPAC Young Observers (YOs), **Silvina Di Pietro** and **Tien Thuy Quach**, with whom I have had the pleasure of interacting through IUPAC and other organizations (*Chem Int.* Oct 2024, p.6). Through the spotlight article, Silvi and Tien were able to share the impact of serving as an IUPAC YO, as well as IUPAC initiatives about which they are interested and passionate. In this spotlight, we asked two YOs from Italy, **Fabiana Piscitelli** and **Elisa Carignani**, to share their thoughts on how chemistry can be viewed as a globally-engaged science. Directly following is a feature introducing the U.S. YO who participated in IUPAC 2025.

In each piece, the YOs are invited to respond to the following four prompts:

- 1) Tell us about yourself (*e.g.*, Your hometown/country, where you go to school/work, your current role, *etc.*) and if this is your first time as a Young Observer.
- 2) Describe some of your favorite/transformational/valuable experiences in your role as a YO at the IUPAC World Chemistry Congress/General Assembly (GA).
- 3) How will you use these experience(s) as you progress, and how might you advise/encourage individuals who are hoping to serve as YOs and/or become involved within the broader chemical community, especially IUPAC? and
- 4) If you had a couple hours each week to contribute to IUPAC, to which project (already initiated or not yet started), would you contribute these hours?

IUPAC is far more than just nomenclature and rules

by *Fabiana Piscitelli*

My name is Fabiana Piscitelli, and I am from the Institute of Biomolecular Chemistry (ICB) of the Italian National Research Council (CNR) in Pozzuoli (Naples). I graduated in Chemistry from the University of Naples "Federico II," and I received a Ph.D. in Neurobiology at the University of Insubria in Busto Arsizio (Varese) in January 2013. During my Ph.D., I spent some months as a visiting student at the Scripps Research Institute in La Jolla (San Diego, California USA). I am currently a Senior Researcher, which is equivalent to an Associate Professor in academia, at ICB-CNR, where I focus

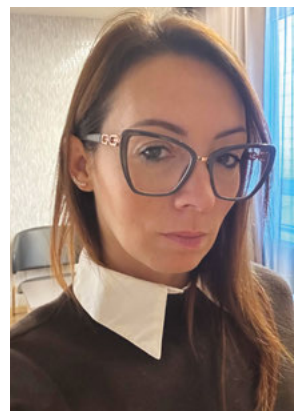
my research activities in analytical chemistry and biochemistry for human health. I was selected as one of the Italian YOs in 2021, and due to the travel restrictions from COVID-19, the IUPAC General Assembly (GA)/Congress went virtual that year. However, I had the chance to participate in the meetings of Divisions III (Organic and Biomolecular), V (Analytical) and VII (Human Health), as well as several committees. Then, in 2023, I attended my first GA in-person in the Netherlands.

I am really active in scientific dissemination and outreach activities for schools and/or the general public. Therefore, I took the opportunity to be a YO as a unique chance to connect and network! My favorite experience as a YO was the meeting of Division V (Analytical Chemistry) at the 2023 GA, where I could meet people *in-person* whom I had met only virtually two years prior as a YO; the 2023 GA was also my first chance to engage with my IUPAC project in-person.

One of the benefits of attending an event like IUPAC is the feeling that everyone is welcomed, a sensation of total inclusion with no barrier(s), geographically and/or gender, *etc.* In IUPAC, you can freely share your ideas, and everyone is happy to help you to foster your project/collaboration. IUPAC is far more than just nomenclature and rules!

This experience led me to propose a project as Task Chair, and this opportunity provides me with a lot of new collaborations and networking avenues. Moreover, I have supported the activities of the Subcommittee on Publications and Editorial Board, engaging with relevant tasks. Furthermore, I became an associate member of Division V, and we are organizing a workshop for the project that I chair (<https://iupac.org/project/2021-036-1-500>). Therefore, I strongly encourage young people to serve as YOs and join Division and Committee meetings and activities to gain a better understanding of IUPAC's mission, as well as advance chemical knowledge.

To foster IUPAC knowledge in the world during the years in which I have been involved, I have tried to connect IUPAC with Italian entities and organizations by endorsing national events and activities. In fact this December, I will organize the Joint IUPAC- Mass Spectrometry Division of the Italian Chemical Society



(DSM) Workshop on LC-MS method validation and performance (<https://www.spettrometriadi massa.it/Congressi/MethodsValidation2025/index.html>), thanks to support from DSM, CNR, and IUPAC. Dissemination of IUPAC's mission and vision has become one of my main activities, and I hope that the younger generation of chemists will join us and be part of this beautiful community!

IUPAC value in gaining a broad perspective

by Elisa Carignani

My name is Elisa Carignani. I graduated in Chemistry from the University of Pisa and received a Ph.D. in Chemical Sciences from the same university. I have worked as a postdoctoral researcher at the University of Southampton (United Kingdom), the University of Pisa, and the Italian National Research Council (CNR), where I am currently a researcher at the Institute of Chemistry of OrganoMetallic Compounds (ICCOM). Since my undergraduate studies, my main research interest has been the development of Nuclear Magnetic Resonance (NMR) methods and their applications, particularly in the study of solid materials for diverse purposes, ranging from pharmaceuticals to energy and environmental applications. I was selected by the Italian NAO as a IUPAC Young Observer in 2021, and I attended the IUPAC General Assembly (GA) and Congress virtually that year. Despite the limitations of the online format, it was an extremely valuable experience, during which I had the opportunity to attend meetings of Divisions I (Physical and Biophysical), IV (Polymer), and VI (Chemistry and the Environment), as well as the CHEMRAWN Committee (Chemistry for Applied World Needs). Following this opportunity, my activities as a YO focused on Division VI and the CHEMRAWN. Two years later, I had the chance to attend the 2023 General Assembly and World Chemistry Congress in The Hague (Netherlands).

Both the 2021 virtual and the 2023 in-person GAs were incredible experiences for me. During the 2021 GA, I was introduced to IUPAC and immediately felt that



I was part of a global organization. It was particularly valuable for my research to gain a broad perspective on diverse and interdisciplinary topics, which allowed me to see the bigger picture. Another invaluable aspect was the opportunity to meet top-level scientists who were open and interested in exchanging ideas and collaborating to advance IUPAC's mission. The networking was definitely more intense and productive in The Hague, where in-person interaction made a significant difference. Importantly, I deepened my involvement with Division VI and CHEMRAWN, which led to the development of a IUPAC project that I am currently co-chairing. Collaborating with other Young Observers from various countries was also a great experience; it strengthened my commitment to IUPAC and boosted my confidence in proposing new ideas.

In my opinion, the most valuable benefit of attending and networking at a global event like the IUPAC GA and Congress was gaining a broad perspective. There are few opportunities like IUPAC to hear from leading chemists who are eager to share their vision and views on major topics of global importance. Beyond high-quality science, I believe that understanding the global context truly makes a difference. Moreover, at the 2023 GA, there were many informal opportunities to engage with scientists at various career stages and from diverse scientific and cultural backgrounds. These conversations were both inspiring and insightful, offering different perspectives on some of the challenges that we all face in research/work.

All of the experiences that I have gained through IUPAC meetings and GAs have been valuable for my professional development. In particular, I will apply the skills that I have developed in organizing events and hosting meetings. Observing skilled, high-level professionals has also been instrumental in helping me to understand different styles of leadership and organization. As I mentioned, I am currently co-chairing the IUPAC project 2023-017-2-600 (<https://iupac.org/project/2023-017-2-600/>), "Develop Solid State NMR Potential for Environmental Protection and Sustainability." This project has been an invaluable experience, teaching me the importance of teamwork and new strategies for engaging with colleagues around the world; I strongly encourage young chemists to get involved in IUPAC projects and activities. The best way to start is by being proactive: Participate in meetings, ask questions, share your opinions, etc., and do not be afraid to speak up.

There are several truly fascinating IUPAC projects, and one of my favorites is the project about open science and open data (<https://iupac.org/>)

Spotlight on IUPAC Young Observers

project/2022-012-1-024). Although I am not an expert in this field, I find the project incredibly valuable as a stakeholder. As noted earlier, my main commitment at the moment is the project “Develop Solid State NMR Potential for Environmental Protection and Sustainability.” Together with my co-chair, Dr. Silvia Borsacchi, and the entire task group, we are organizing a symposium within the scope of this project for the

upcoming 2025 IUPAC World Chemistry Congress in Kuala Lumpur, Malaysia. 🌏

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Spotlight on IUPAC U.S. Young Observers

*by Brian Li *, Liana Vaccari *, Luis R. De Jesús Báez, Reza Foudazi, Annabelle Lolinco, Alexis R. Myers, Wilson McNeil, and Hee Jeung Oh*

The IUPAC Young Observer Program strives to introduce the work of IUPAC to a new generation of distinguished researchers and provide them with opportunities to address international science policy issues. As an IUPAC Young Observer (UK 2025) and member of *Chemistry International* Editorial Board, Brian Li took the opportunity to interview several IUPAC YOs across the world. In this article, you will read an introduction by Liana Vaccari about USNC/IUPAC, followed by U.S. YOs interviews about their research interests, knowledge of IUPAC, and career advice for young chemists, and concluding remarks were written by Mark Cesa, IUPAC President (2014–2015) and U.S. YO (1997).

Liana Vaccari: Since 1977, the U.S. National Committee for the International Union of Pure and Applied Chemistry (USNC/IUPAC) has supported the participation of over 250 U.S. Young Observers (YO) at IUPAC General Assemblies (GA) with the aim of introducing the best young researchers to the union, encourage young chemists and chemical engineers to become involved in the union's activities, and prepare the next generation of IUPAC leaders. Several U.S. YOs have gone on to serve in IUPAC division and union leadership, including Mark Cesa as IUPAC President (2014–2015) and Michelle Rogers on the inaugural IUPAC Science Board (2024–2025).

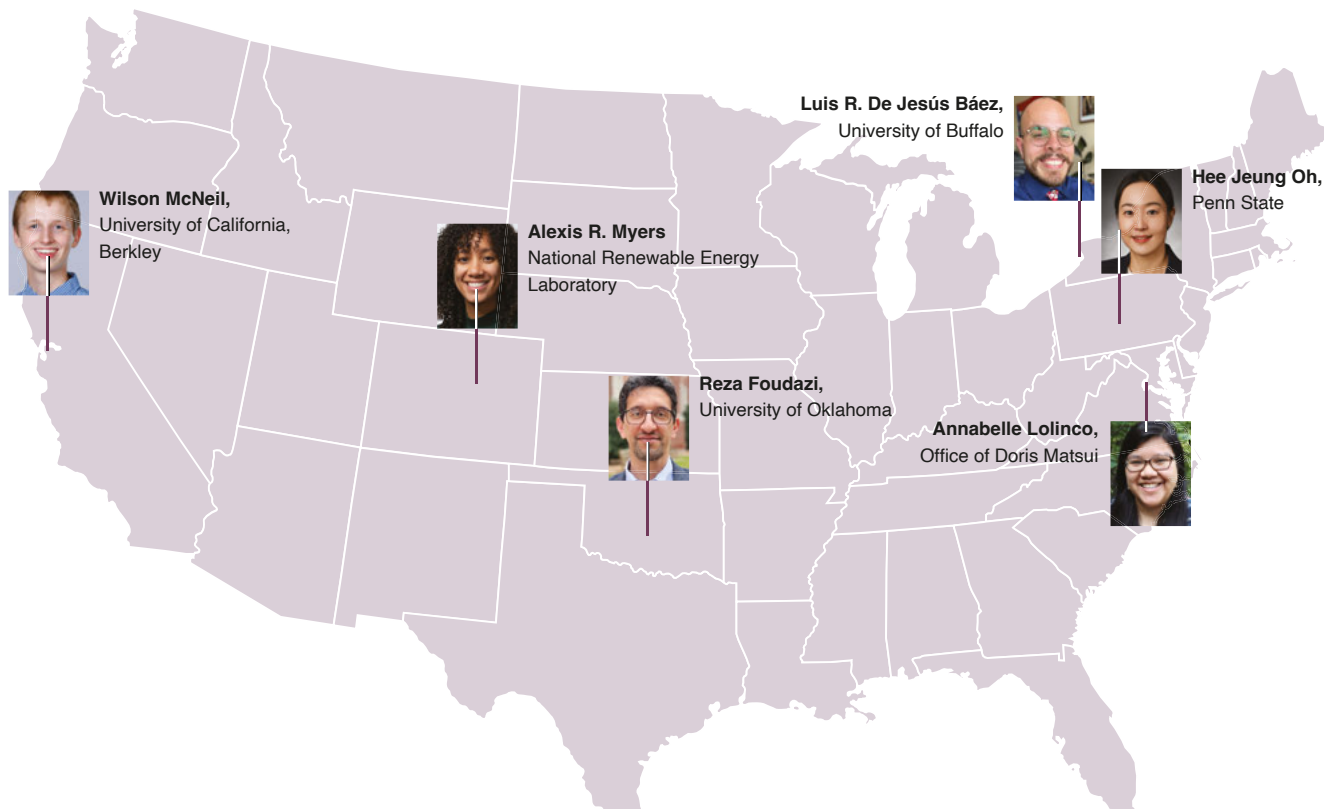
On a biennial basis in the year prior to the GA, the USNC/IUPAC puts out a call for applicants to the U.S. YO program within the chemistry and chemical engineering communities. A subset of the USNC then evaluates the applications and chooses twelve awardees, two of whom serve as delegates to the International Younger Chemists Network. These YOs receive travel awards to subsidize participation at the GA by contributions from corporations and grants.

Once the cohort is formed, there are at least two virtual meetings, one to introduce them to each other and IUPAC and what it means to get involved in IUPAC projects, and the other just ahead of the GA to prepare them for the experience. Each U.S. YO is also assigned a mentor who is, or has been, active in IUPAC divisions/committees of interest to the YO to facilitate their entry to the business meetings and guide them to join or develop IUPAC projects.

YOs are enthusiastic about connecting with the global community both using and developing the shared scientific language of chemistry. The U.S. YO program has been an invaluable pathway for jumpstarting the participation of U.S. based scientists and engineers in IUPAC.



Spotlight on IUPAC U.S. Young Observers



Brian Li (BL): Tell us about yourself, your hometown/country, where you go to school/work, your current role, etc. and if this is your first time as a Young Observer. Are you involved in young chemists' network at the moment?

Luis R. De Jesús Báez:

I was born and raised in the beautiful Caribbean Island of Puerto Rico, in the town of Caguas. From a young age I grew curious with what makes my surroundings work. My first ever experiment was evaluating if the light inside the refrigerator kept on after you closed the door; what a beautiful thrill it was to learn that there's a button that turns it off. I moved with that curiosity to my undergraduate institution which was the University of Puerto Rico at Cayey. I then decided to attend graduate school in the Department of Chemistry of the University at Buffalo but my Ph.D. advisor, Prof. Sarbajit Banerjee, decided to move to Texas A&M University, where I decided to continue my work with him and finish my Ph.D. in physical/inorganic chemistry. From there, I was able to join Prof.



Tom Mallouk at Pennsylvania State University, where after a short year, I moved with him to the University of Pennsylvania. Then, in 2021, I was able to interview for a position as an assistant professor in the University at Buffalo and in 2022, I started my independent career. This is my first time as a YO, and I am so thrilled to be a member of this unique group.

Reza Foudazi:

I was born and raised in Tehran, Iran. In 2007, I moved to South Africa for my doctorate in chemical engineering. From 2011 to 2013, I was a research associate in the Department of Macromolecular Science and Engineering at Case Western Reserve University, working on the polymerization of emulsions and production of fibrous macroporous polymers. I joined New Mexico State University (NMSU) in 2013 and was promoted to associate level with tenure in 2019. Since 2021, I have been an associate professor in the School of Sustainable Chemical, Biological, and Materials Engineering at the University of Oklahoma. In addition,



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I spent a summer as a visiting faculty at the University of Crete in Greece. These experiences have provided me with a unique perspective on the diverse challenges faced by different regions and the importance of international collaboration in addressing them. I have regularly attended national and regional meetings of American Chemical Society (ACS) and also have been involved in some services. However, this will be my first time as a Young Observer and joining the IUPAC World Chemistry Congress/General Assembly.

Annabelle Lolincó:

I grew up in Fresno, California, USA. I currently work in the U.S. Congress as a Science and Technology Policy Fellow (through ACS/AAAS), supporting the Office of Congresswoman Doris Matsui in telecommunications and tech matters in Washington, D.C. This is my first time as a Young Observer. I am a science and technology policy fellow working in the federal government in the U.S. I am also currently involved in the ACS Younger Chemists Committee leadership. One project I'm working on is the Catalyze the Vote initiative. We aim to increase ACS voter participation among younger chemists for the annual Society election. Catalyze the Vote is primarily centered on getting folks to interact with and learn more about the ACS President-Elect candidates before submitting their ballots. I also volunteered to help reconnect the Younger Chemists Committee of the American Chemical Society (YCC) with the global network of younger chemists across the world.



Wilson McNeil: I am originally from Morgantown, West Virginia, and now live in San Francisco, California for graduate school. I am a PhD candidate at UC Berkeley. My doctoral research is related to air pollution modelling and the associated human health effects of emissions



from sources such as electricity generation and transportation. This is my first time serving as a Young Observer and involvement with International Young Chemists Network, and I am so excited to represent the U.S. at the General Assembly in Kuala Lumpur!

Alexis R. Myers:

I am from Beaufort, SC, a small town on the coast of South Carolina. I earned my B.S. in Chemistry from Furman University before moving to Boulder, Colorado for my PhD in Chemistry from the University of Colorado Boulder, where I conducted research at the



National Renewable Energy Laboratory (NREL). After completing my PhD, I moved to DC for a science policy fellowship with the National Academy of Sciences, which led to my current role as a full-time researcher at NREL. This is my first time as a Young Observer, and I'm excited to see how chemistry is advancing globally and to learn from international perspectives on addressing shared challenges. I am an early-career professional working at a national laboratory, which occupies a unique space between academia and industry. I am not currently involved in any young chemist networks, which is part of why I'm interested in this Young Observer opportunity

Hee Jeung Oh:

I am an assistant Professor of Chemical Engineering at Penn State University. I earned my B.S. in Chemical Engineering from the Korea Advanced Institute of Science and Technology (KAIST) in South Korea. I completed my Ph.D. in Chemical Engineering at the University of



Texas at Austin and did my postdoctoral training at the University of California, Berkeley. I am an early-career assistant professor. I am a member of the American Chemical Society (ACS) and am actively involved in the ACS Division of Polymer Science, Materials, and Engineering (PMSE). This is my first time as a Young

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Observer, and I am truly honoured and grateful for the opportunity.

BL: *How did you develop your interest in Chemistry and what do you know about IUPAC?*

Luis: From a young age, my curiosity of science was apparent. My first, true interaction with chemistry was during my junior year (11th grade) in High School in Riverita's (how we affectionately called her) class. I can't precisely say what topic or when was the moment that I connected with chemistry, but it was in this High School class that I developed a new sense of reality and perception of life and the universe which transformed and redirected my efforts into chemistry. This interest continued up to college, where I first got to know the name of IUPAC in Prof. Reyes organic chemistry class; we had just started to discuss nomenclature of organic compounds. I sat with curiosity about the creative process chemist must go through to come up with a rationale to name all sorts of compounds; I hold in high regards the work IUPAC goes through.

Reza: What first made me fall in love with chemistry was the periodic table and the elements. Over time, my interest evolved toward organic chemistry and eventually to polymers. The first time I heard about IUPAC was in the context of standardizing chemical nomenclature. Of course, my naïve high school understanding has since matured, and I now recognize IUPAC as a United Nations-like forum that brings together chemists from around the world.

Annabelle: I had a wonderful high school chemistry teacher, Mrs. Alvarez at Edison High, who fostered my love for chemistry. I was fascinated with how chemists have both a micro and macro-view of systems and how that can help us think about the ways chemistry is in everything we interact with. I knew IUPAC as a governance body for international standards in the chemical sciences, and I am glad I get to know more about how it convenes the participating countries in conversations about the global chemical sciences community.

Wilson: I became interested in this program because of the opportunity to collaborate on important issues with an international team. The issues that I study in my research (air pollution, climate change, global health) are international in nature and require a diverse group of stakeholders to solve them. International collaboration became important to me when I was on a yearlong Fulbright fellowship at the University of Canterbury in

Christchurch, New Zealand, where I enjoyed networking and working on projects with an international team. I am greatly looking forward to networking with an international audience through IUPAC.

Alexis: My love for chemistry has evolved throughout my career, but it was first sparked during a summer research experience at the University of South Carolina before my senior year of high school. I learned to weld and conducted flux crystal growth research for new materials in LED technologies. That hands-on discovery of creating something new through chemistry hooked me. I know what most young chemists learn in undergrad that IUPAC serves as the global authority for chemical nomenclature, standards, and scientific communication, ensuring chemists worldwide can collaborate effectively through shared language and methods.

Hee Jeung: I work at the intersection of chemistry, chemical engineering, and materials science, focusing on designing advanced polymer membranes for efficient chemical separation. My interest in polymer membranes began as a student when I became fascinated by how nature achieves precise molecular transport through cell membranes. That curiosity has shaped my career, driving me to uncover new chemical ways to mimic biological efficiency using synthetic polymer materials. Thus, chemistry and chemical science are central to my research where I will develop my lifetime career. IUPAC is the central ground of chemistry and chemical innovations.

BL: *What is your current and future career goal, and what aspect of your research/work are you most excited about?*

Luis: This is an interesting question because I recently reflected on my goals and my relationship with this career. I will say that both present and future goals encompass two vertexes: provide students with opportunities for them to be successful in chemistry and connect (or reconnect) the community with the chemical sciences. About my work, I am excited to see some of our initial curiosities starting to take a nice scientific shape. You'll have to wait for the articles to come out soon to see what I'm talking about.

Reza: In the coming years, I aim to further advance my career by integrating my research on self-assembly, colloidal science, and polymer science with sustainability-driven applications. My academic journey

Spotlight on IUPAC U.S. Young Observers

has focused on engineering functional soft materials through the principles of colloid and interface science, with a particular emphasis on lyotropic liquid crystals (LLCs), high internal phase emulsions (HIPEs), and liquid foam templating. These systems serve as versatile platforms to design responsive membranes, ionogels, and porous polymers that address environmental and energy challenges. For instance, I have explored the fabrication of porous hydrogels and microcellular foams with tailored pore structures suitable for applications in agriculture and biomedical engineering (10.1021/acs.langmuir.2c02253), designed stimuli-responsive nanofiltration and ultrafiltration membranes for separation applications (10.1021/acsestengg.4c00033), and developed remediation methods for PFAS or “forever chemicals” through foam fractionation (10.1039/D4SM00931B) and functional graphene oxide (10.1039/D4VA00171K). Moving forward, my research will delve into design of hierarchical porous polymers, ion transport phenomena in membranes and ionogels, and PFAS degradation through interfacial reactions. These efforts are complemented by my commitment to mentoring students, collaborative science, and contributing to professional communities such as American Chemical Society and Royal Society of Chemistry.

Annabelle: I want to work in policy spaces and use my skills as a scientist to help shape and inform evidence-based policies. I really enjoyed my work in the U.S. legislative branch because of the sheer amount I get to learn, especially to see how science is integrated in policy areas beyond funding for science research. There’s an incredible wealth of knowledge from the policy ecosystem, so I am glad that I’ve gotten to add the scientific voice for my time in the fellowship.

Wilson: My research focuses on the environmental and health impacts of the energy transition, with an emphasis on atmospheric chemistry, human health, and environmental justice. At UC Berkeley, I developed a life-cycle assessment framework to quantify the health and climate impacts of electrifying heavy-duty vehicles in the U.S., integrating electricity grid modelling and air quality/atmospheric chemistry modelling (10.1021/acs.est.3c05139). In a follow-up study, I evaluated how recent federal energy policies will impact pollution burdens in vulnerable communities, contributing to broader environmental justice discussions (10.1038/s41893-025-01515-x). My most recent work has focused on quantifying the human health externalities associated with carbon capture and storage technologies. This allows me to combine my atmospheric chemistry and

energy modelling interests into a single framework. Looking ahead, I am interested in expanding this research to include critical infrastructure transitions globally, applying similar air quality and climate modelling tools to assess local and global trade-offs in energy and environmental policy. I also plan to explore how large-scale electrification and carbon dioxide removal strategies may intersect with equity and public health. My long-term goal is to build an interdisciplinary lab at an R1 institution that supports students in developing quantitative tools to tackle pressing chemical and environmental problems across the globe.

Alexis: I currently work at the intersection of scientific research and real-world application, connecting our laboratory discoveries with the needs of industry, government, and communities. Rather than focusing on a single technology, I’m passionate about de-risking and deploying innovations where they’re needed most, particularly in energy resilience, grid infrastructure, and workforce development. What excites me most is ensuring our scientific advances translate into tangible benefits for people and communities. I aim to continue growing in this role of bridging science and societal impact.

Hee Jeung: I aspire to continue my academic career, aiming to be a solid scientist, engineer, educator, and thought leader in the field of Chemistry and Chemical Sciences. Throughout my academic journey, I have focused on designing advanced polymer membranes for efficient chemical separation in energy, environment and health. Separation is fundamental to countless processes, from producing clean drinking water to refining pharmaceuticals and optimizing energy storage. My team is specialized in designing multifunctional polymer membranes that control molecular transport at an unprecedented level, enabling selective separation of water, ions, and small molecules in a variety of applications. Our unique approach addresses multi-level microscopic phenomenon at interfaces with macroscopic, practical properties. In water and liquid-based separations, we explore how tailored membrane structures can extract clean water and precious resources from unconventional sources while minimizing energy costs (10.1021/acsapm.4c01877). In healthcare, we apply our expertise to biopharmaceutical processing and biomedical devices, designing polymer membranes that precisely filter and transport molecules for targeted treatment. Moving forward, I plan to pursue fundamental breakthroughs that translate into real-world separation applications, always seeking to bridge the microscopic

Spotlight on IUPAC U.S. Young Observers



U.S. Young Observers and delegates at IUPAC 2025 in Kuala Lumpur: (from L to R) Dan Rabinovich, Jennifer Nielson, Melody Morris, Alexis Myers, Danniebelle Hasse, Annabelle Lolinco, Reza Foudazi, Dorothy Phillips (2025 ACS President), Wilson McNeil, Michelle Rogers, Luis De Jesús Báez, Sean Bowen, Maxx Arguilla, Liana Vaccari, and Hee Jeung Oh.

understanding of materials with macroscopic performance (10.1021/acs.macromol.4c02290).

BL: What IUPAC Divisions / Committees / Projects are of interest to you and why?

Luis: I am interested in Division II (Inorganic Chemistry). I am part of the materials' chemistry community, which is relatively a younger discipline within the chemical sciences. There's so much space to grow this discipline within this division, and that makes me feel excitement for the field and my interest in learning the inner workings of this division. I am also interested in Committee on Chemical Research Applied to World Needs (CHEMRAWN) and Committee on Chemistry Education (CCE). These highlight my goals, as mentioned before, on providing students with opportunities and reconnecting with the community.

Reza: I am interested in Division IV (Polymer) as it is related to my research background and activity. In this division, I see opportunities for contribution in following projects: *Definition of Terms Relating to the Ultimate Mechanical Properties of Polymers* (2015-050-3-400); *Definition of Terms Pertaining to Polymers in the Solid State: Molecular Arrangement from the Nano- to the Micrometer Scale* (2016-018-1-400); *An International Exercise-Based Syllabus in Polymer Chemistry*

(2017-019-2-400). For committees, I like to learn more about the *Chemistry International* Editorial Board, Committee on Chemical Research Applied to World Needs (CHEMRAWN), and Interdivisional Committee on Green Chemistry for Sustainable Development (ICGCSD) because they align closely with my professional expertise and interests in promoting sustainable chemistry and global scientific collaboration. For example, The CHEMRAWN Committee focuses on applying chemistry to address pressing global challenges, which resonates with my work on sustainable materials for environmental remediation, such as PFAS remediation. The ICGCSD is critical in promoting green chemistry principles to achieve global sustainability goals. My research on green/sustainable synthesis of responsive multifunctional materials and porous polymers aligns with the committee's objectives.

Annabelle: I'm interested in getting involved with the Committee on Chemistry Education (CCE), which is my technical home in the chemical sciences. I worked on curated predictive chatbots and their impact to how students asked questions and used digital tools to learn chemistry in context. I would love to stay involved in the broader conversation as we consider how generative artificial intelligence has a role with science learning. Additionally, I am excited to be engaged with the International Younger Chemists Network (IYCN).

Spotlight on IUPAC U.S. Young Observers

I am part of the Governance, Interface and Outreach (GIO) subcommittee of the ACS Younger Chemists Committee and we have been trying to reconnect with our international sister organizations to build a connected global community of younger chemists.

Wilson: I am particularly interested in Division VI (Chemistry and the Environment), Division VII (Chemistry and Human Health), and Interdivisional Committee on Green Chemistry for Sustainable Development (ICGCSD). My research is quite interdisciplinary, cutting across chemistry, engineering, and public health. These divisions and committees allow me to connect my chemistry foundation to other fields such as the environment and human health. I am also interested in International Younger Chemists Network (IYCN). It is the opportunity to engage with early-career chemists from around the world. I look forward to conversations about sustainability and green chemistry with a diverse group that can offer new perspectives. I plan to get involved with Global Conversation on Sustainability (2021-034-2-041), a joint project between IUPAC and IYCN to use chemistry in working towards the United Nations Sustainable Development Goals.

Alexis: I'm most interested in Division II (Inorganic Chemistry) and Division VIII (Chemical Nomenclature and Structure Representation). As an inorganic chemist, I value being part of the international dialogue shaping our field's development. Nomenclature serves as chemistry's universal language. It's critical as we make new discoveries. I often tell students that learning organic chemistry is like learning a new language. It may feel hard and daunting at first, but it's essential for maintaining clear and consistent communication standards for global collaboration.

I'm also drawn to Committee on Chemical Research Applied to World Needs (CHEMRAWN). This aligns well with my mission of translating research into real-world solutions, and I'm eager to stay informed about emerging research priorities as global challenges evolve.

Hee Jeung: My research designs polymer membranes that can enable the world's important, but challenging separations for energy, environment, and health. In this regard, my research corresponds to the mission and aims of the Division IV (Polymer), and Committee on Chemical Research Applied to World Needs (CHEMRAWN), in particular "to promote macromolecular and polymer science and technology," "useful for the improvement of humankind and environment." Because the development of polymer membranes is

critical to various chemistry disciplines and real-life applications, I'd like to contribute to the IUPAC Division and Committee's activities and discussions. I hope to enthusiastically facilitate international scientific exchange, cooperate with other international organizations, and promote polymer science and technology at the international level. Participating in these activities will also enable me to develop collaborations and form friendships with researchers from all polymer chemistry disciplines and from industry, universities, and federal labs, and thus, create more innovative and interdisciplinary research ideas.

BL: Where can we see you in the next few months, are you going to any conferences, any poster or talk, or any volunteer work you are involved in?

Luis: I am going to be at the American Conference on Inorganic Nanoscience (ACIN) which is a new conference to unite efforts specifically on inorganic nanoscience. I believe this will be a wonderful and successful conference.

Reza: I will be in IUPAC 2025 in Malaysia!

Annabelle: I just gave a few talks at ACS Fall 2025 in Washington D.C., but you will probably find me in California as I look for my next career opportunity, plug back into my community, and re-connect to my service as an ACS volunteer and leader. One of the opportunities to find me is at the Catalyze the Vote town hall happening in September in partnership with ACS Webinars and the ACS Committee on Nominations and Elections where the Younger Chemists Committee chats with the ACS President-Elect candidates about their positions. I am hoping to plug in with the International Younger Chemists' Network as well.

Wilson: After graduating, I am looking forward to beginning a postdoctoral research fellowship at Stanford University. I am grateful to have been awarded a Stanford Energy Postdoctoral Fellowship to continue my research at the nexus of air quality, energy, and public health.

BL: (optional) Can you share one piece of career-related advice with other young chemists?

Luis: As a young undergraduate, I had the misfortune of having a professor tell me that I wasn't "smart enough to be a chemist." This really rattled my identity as a chemist, but thanks to support from my support

Spotlight on IUPAC U.S. Young Observers

circle, I was able to stick with it and achieve my early goal of being a chemist and a professor. My advice: community and self-reassurance are the two ingredients to any success story.

Reza: The greatest learning often begins with a question. While lectures and presentations can inform, it is through inquiry that curiosity is sparked, understanding deepens, and true discovery begins.

Annabelle: Stay curious and be open for experiences that provide you insight into pathways you have not considered or build professional skills that are critical to your career. Your career is not a linear progression, and taking some adventures in trainings, fellowships, and other opportunities outside of research can help your research and technical skills.

Wilson: Get involved! This is a great time to learn about new topics through an internship, student organization, or research. You never know what opportunities these might lead to.

Alexis: Stay excited about chemistry, but don't limit yourself to one narrow path. While becoming an expert in your area is valuable, remember that chemistry trains you to understand fundamental processes that underlie countless fields. This broad analytical thinking is incredibly transferable— embrace the versatility of your chemical training and look for unexpected ways to apply it.

Concluding Remarks by Mark Cesa

The Young Observer Program offers an effective way for early career chemists to learn about how an international scientific Union like IUPAC functions, to be a part of a truly global gathering of scientists, to interact with fellow chemists working on projects and programs in IUPAC Divisions and Standing Committees, and to take advantage of opportunities to generate and contribute to IUPAC's goals. The Young Observer experience has

motivated many young scientists to become members of IUPAC project task groups, Division Committees, and Standing Committees as a rewarding part of their career development. Many others have even assumed positions of leadership in IUPAC.

I started in IUPAC in 1997 as a Young Observer at the meeting of the Committee on Chemistry and Industry (COCI). I was so impressed with the enthusiasm of the members of COCI at that meeting that I approached the Chair to offer my help wherever I might be needed. I was given responsibility for coordinating the IUPAC Safety Training Program, which provides opportunities for chemists from the developing world to learn best practices in chemical safety by shadowing professionals at chemical companies. From there I became COCI Chair, then Vice-President, then President. I cannot imagine a more rewarding professional experience than the one I had as IUPAC President. Traveling around the world to represent IUPAC, meeting enthusiastic researchers, teachers, and students, and collaborating with IUPAC volunteers was a great privilege.

As Young Observers, being a part of the 2025 IUPAC General Assembly and World Chemistry Congress will have a positive impact on your career. 

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Annabelle Lolinco, ACS/AAAS, orcid.org/0000-0002-1686-778X

Alexis R. Myers, National Renewable Energy Lab, orcid.org/0000-0002-6432-5758

Wilson McNeil, University of California, Berkeley, orcid.org/0009-0007-4074-3537

Hee Jeung Oh, Penn State University, orcid.org/0000-0003-1846-9547

IUPAC Launches Global Call to Action for Responsible Chemistry

In a world grappling with climate change, pollution, disinformation, and rapid technological shifts, the question is no longer can chemistry help—but how should it?

On 14 July 2025, at the opening of the IUPAC World Chemistry Congress, the International Union of Pure and Applied Chemistry (IUPAC) officially launched the *Guiding Principles of Responsible Chemistry*, a bold, forward-looking framework designed to transform how chemistry is practiced, taught, and perceived worldwide.

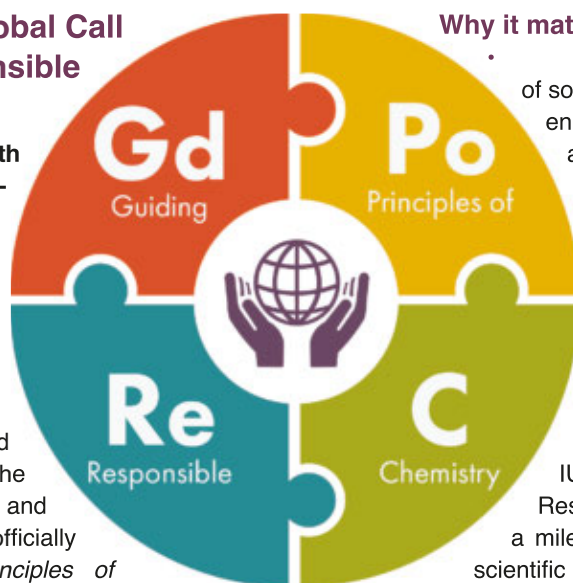
These Guiding Principles are more than a code of ethics: they are a call to action for scientists, educators, industry leaders, policymakers, and the next generation of chemists to align their work with humanity's most urgent needs. Linked to IUPAC's mission and core values and developed by a diverse global team over two years, the Principles define what it means to do chemistry responsibly in the 21st century, with transparency, equity, accountability, and sustainability at the core.

"Chemistry is not just about what we *can* make," says; Javier García-Martínez, IUPAC Past-President and member of this IUPAC Project, "It's about what we must do to ensure a livable, just, and sustainable future."

The Principles aim to spark a cultural shift across the entire chemistry enterprise—from university labs to multinational corporations. They are especially targeted toward students and young scientists, equipping them to lead with purpose and integrity in a rapidly changing world.

A unique collaboration with the King's Centre for Visualization in Science brought students directly into the process, ensuring the voices of future chemists helped shape the message. The student team contributed not only design elements—such as the website, icons, and taglines—but also crucial reflections that made the final product more engaging and relevant.

Accessible globally via <https://iupac.org/responsible-chemistry>, the Guiding Principles are a living resource designed to evolve and be used in classrooms, research labs, policy discussions, and public discourse alike.



Why it matters now

- Chemistry sits at the heart of solutions to climate resilience, energy transition, sustainable agriculture, and global health.
- The pace of innovation is outstripping public understanding and regulation.
- Society demands greater transparency and ethical conduct from science.

The launch of the IUPAC Guiding Principles for Responsible Chemistry marks a milestone moment for the global scientific community—and an invitation to all to help shape a more ethical, inclusive, and sustainable future through the power of chemistry.

<https://iupac.org/guiding-principles-of-responsible-chemistry/>

IUPAC Announces the 2025 Top Ten Emerging Technologies in Chemistry

IUPAC has now released the 2025 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 the chemical sciences to foster the well-being of Society and the sustainability of our planet.

The 2025 finalists are (in alphabetical order):

- Additive Manufacturing
- Carbon Dots
- Direct Air Capture
- Electrochemical Carbon dioxide Capture
- Multimodal Foundation Models for Structure Elucidation
- Nanochain Biosensor
- Single-Atom Catalysis
- Synthetic Cells
- Thermogelling Polymers
- Xolography

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 that were submitted by researchers from

around the globe, ultimately selecting the final top ten that cover a broad range of fields from synthesis and polymer chemistry to health and machine learning. These technologies are defined as transformative innovations that lie in between a eureka-moment discovery and a fully-commercialized technology and that have outstanding potential to open new opportunities in chemistry, sustainability, and beyond. IUPAC's objective in putting these highly-innovative ideas under the spotlight, is to strongly encourage collaboration across all scientific disciplines in order to accelerate progress towards a more sustainable and equitable world.

In its seventh consecutive year of operation, the IUPAC Top Ten Emerging Technologies in Chemistry initiative continues to look into sustainability and circularity, connecting new and innovative ideas towards a greener future, while maintaining a strong interest in the development of methods for the improvement of human health. Overall, the selection of the 2025 Top Ten, carefully crafted by a panel of experts from a pool of global nominations, continues to carry the spirit established by the first Top Ten list released in 2019 and that is to highlight the potential of chemistry—and chemists—to provide solutions to the most urgent societal issues.

The 2025 Top Ten Emerging Technologies in Chemistry are further detailed in a feature article published in the October issue of *Chemistry International* (CI). Fernando Gomollón-Bel, the author of that feature, recognized that this edition showcases once more the versatility and variability of creativity in chemistry. As noted above, he concludes his review by saying that "IUPAC's objective in putting these highly-innovative ideas under the spotlight, is to strongly encourage collaboration across all scientific disciplines in order to accelerate progress towards a more sustainable and equitable world".

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 (<https://doi.org/10.1515/ci-2019-0203>) The results of subsequent editions and the related articles in *CI* can be accessed at: <https://iupac.org/what-we-do/top-ten/>.

*The following comprised the panel of judges for the 2025 Top Ten Emerging Technologies in Chemistry: Michael Droscher, (Chair, German Association for the Advancement of Science and Medicine), Bonnie Lawlor (secretary), Ehud Keinan, Javier García Martínez, Arasu Ganesan, Molly Shoichet, Juliane Sempionatto, Mamia El-Rhazi, Jorge Alegre Cebollada, Bernard West, Natalia Tarasova, Zhigang Shuai, Rai Kookana, and Kira Welter.

<https://iupac.org/what-we-do/top-ten/>

Actions Taken by IUPAC Council, Kuala Lumpur, Malaysia, July 2025

In July 2025, the 53rd IUPAC Council Meeting took place in Kuala Lumpur, Malaysia, alongside the General Assembly and the 50th World Chemistry Congress. The Council approved several motions and reports covering governance, scientific recommendations, and organizational matters. Highlights include:

- Governance & Membership: English confirmed as the official record language (2026–2029); new National Adhering Organizations admitted from Estonia, Guatemala, Peru, and Singapore.
- Scientific Standards: Adoption of updated recommendations on atomic weights (gadolinium, lutetium, zirconium).
- Elections & Committees: Appointment starting in January 2026 of new Vice President, Treasurer,

Officers and Boards members 2026-2027

Mary Garson (Australia), President

Christine Luscombe (Japan), Vice President

Ehud Keinan (Israel), Past President

Derek Craston (UK), Treasurer

Zoltan Mester (Canada), Secretary General

Executive Board

Mary Garson (Australia), President, Chair

Lidia Armelao (Italy)

Richard Hartshorn (New Zealand)

Miki Hasegawa (Japan)

Bonnie Lawlor (USA)

Zhigang Shuai (China/Beijing)

Supawan Tantayanon (Thailand)

Science Board

Christine Luscombe (Japan), Vice President, Chair

Abeer Al Bawab (Jordan)

Pierre Braunstein (France)

Edwin C. Constable (Switzerland, Div VIII Chemical Nomenclature and Structure Representation)

Evamarie Hey-Hawkins (Germany)

Ari Koskinen (Finland, Div III Organic and Biomolecular)

Igor Lacík (Slovakia, Div IV Polymer)

Uday Maitra (India, CCE Chemistry Education)

Alejandra Palermo (UK)

Floris Rutjes (Netherlands)

Fani Sakellariadou (Greece, Div VI Chemistry and the Environment)

and Executive/Science Board members; reauthorization of commissions and committees (education, younger chemists, ethics, diversity).

- Finance & Administration: Approval of audited accounts and provisional budgets; negotiations for a European-based Secretariat.
- Events: Beijing selected as the host city for the 2031 Congress.

For the complete record of motions and detailed outcomes, please visit the official IUPAC page: <https://iupac.org/actions-taken-by-iupac-council-kuala-lumpur-malaysia-july-2025/>

Recognising Excellence: CCE 2026 Awards—Call for Nominations

The IUPAC Committee on Chemistry Education (CCE) is soliciting nominations for three types of awards, which will be made during the 28th International Conference on Chemistry Education (ICCE 2026). ICCE 2026 will be held jointly with the 17th ECRICE conference in Erzurum, Türkiye, on 13–17 July 2026. These prizes recognise outstanding work being done in any part of the world to promote excellence in the teaching and learning of chemistry. The awards are:

- Distinguished Contribution to Chemistry Education (DCCE) Award, which recognises outstanding service to chemistry education and practice and/or professional service to chemistry education over a lifetime.
- Outstanding Early Career Researcher in Chemistry Education Award, which recognises early career researchers who are producing high-quality and impactful chemical education research as evidenced by their research output.
- Special Recognition Award for Excellent Service to the Committee on Chemistry Education, which acknowledges individuals who have given excellent service to the CCE, *i.e.* to further CCE priorities and IUPAC strategic objectives related to chemistry education.

For detailed announcement, description and procedures are available online. Nominations are open till 15 October 2025

<https://iupac.org/recognising-excellence-cce-2026-awards-announcement/>

2026 IUPAC-Richter Prize—Call for Nominations

IUPAC and Gedeon Richter, Plc. announce that the 2026 IUPAC-Richter Prize in Medicinal Chemistry will be presented during the *39th ACS National Medicinal Chemistry Symposium* (31 May – 3 June 2026) in Atlanta, GA, United States and the recipient will also give a lecture on the subject of their research at the *XXIXth EFMC International Symposium on Medicinal Chemistry* (6–10 September 2026) in Basel, Switzerland.

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, which includes a gift of USD 10000, 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.

Nominations are open till 15 December 2025.

For details, nomination procedure and contacts, visit <https://iupac.org/2026-iupac-richter-prize-call-for-nominations/>

2026 IUPAC–Soong Prize for Sustainable Chemistry—Call for Nominations

The IUPAC–Soong Prize for Sustainable Chemistry is to be awarded annually to a scientist whose breakthrough discovery or conceptual advance has made a transformative impact on sustainable chemistry. This prestigious international prize celebrates innovation and bold thinking, recognizing discoveries rather than lifetime achievement.

Deadline for nominations: 15 November 2025

Prize Details

The laureate will receive:

- A certificate and medal
- A monetary award of USD 30 000
- Travel support to attend the prize ceremony

The 2026 award will be presented during the 10th EuChemS Chemistry Congress (ECC10), 12–16 July 2026, in Antwerp, Belgium. Within two years of receiving the prize, the laureate will also be invited to deliver a lecture at National Taiwan University.

Eligibility

- Open to scientists worldwide, regardless of background, affiliation, or identity
- Nominations may only be submitted by others (self-nominations are not accepted)

Background

The IUPAC–Soong Prize was established through a generous endowment by Raymond Soong, founder of LITEON. It aims to recognize and promote discoveries that help tackle global sustainability challenges, uniting academia, industry, and society.

The inaugural award was presented in July 2025 to Omar M. Yaghi at the IUPAC World Chemistry Congress.

How to Nominate

Full details, including regulations and the nomination form, are available online. For further information, please contact: Ehud Keinan, IUPAC President, ekeinan@iupac.org

<https://iupac.org/what-we-do/awards/iupac-soong-prize/>

2026 IUPAC-Solvay International Award for Young Chemists—Call for Applicants

In July 2025, ten Young Chemists were recognized with the IUPAC-Solvay International Award during the opening of IUPAC 2025 Congress in Kuala Lumpur. The awards were presented on a grand stage by IUPAC President Professor Ehud Keinan and Solvay representative Ajay Khandkar. Who will be the next Awardees recognized in Montreal in 2027? Could it be you?

About the Award

The IUPAC–Solvay International Award for Young Chemists recognizes and encourages exceptional young researchers at the start of their careers. The award celebrates the most outstanding Ph.D. theses in the chemical sciences, as described in a short essay



by the candidate.

Each year, up to five prizes are awarded. Each prize includes:

- USD 1 000 cash award
- Up to USD 1 000 in travel support to attend the next IUPAC Congress
- An invitation to present a poster at the Congress, participate in a plenary award session, and submit a review article to *Pure and Applied Chemistry*

The awards are generously sponsored by Solvay. IUPAC takes care to ensure a fair geographic distribution of prizes, reflecting its global mission.

For this round, the awards will be presented at the 2027 IUPAC Congress, taking place in Montreal, Canada (8–16 July 2027).

Who Can Apply?

You are eligible if:

- You completed your Ph.D. in 2025, including the defense.
- Your Ph.D. was granted by an institution in an IUPAC member country/territory.
- Your research is in the **chemical sciences**: chemistry and disciplines or technologies that make significant use of chemistry.

How to Apply

- Applications must be submitted **online only**.
- Deadline: **15 February 2026**

Submit your application here; <https://iupac.org/2026-iupac-solvay-international-award-for-young-chemists-call-for-applicants/>

Systems Thinking in Chemistry Education—Call for Papers

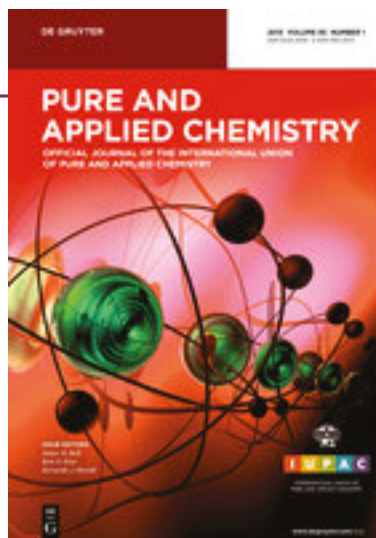
Chemistry Teacher International invites submissions for a special issue under the theme “From Concept to Classroom: Success Stories of Systems Thinking in Chemistry Education.”

Why this special issue?

- This call builds on two completed IUPAC projects (2017-010-1-050 and 2020-014-3-050) and the launch of a new project (2025-004-2-041), signaling growing institutional momentum to embed systems thinking into chemistry teaching and learning.
- Systems thinking in chemistry aims to extend beyond “green,” “sustainable,” and “circular” chemistry, helping learners tackle interdisciplinary, real-world challenges involving human and ecological well-being and planetary justice.
- The special issue intends to showcase **10–15 exemplar case studies** from various educational levels (primary, secondary, tertiary, teacher training, professional development) that integrate systems thinking into chemistry pedagogy.

For details on the kinds of contributions that are sought, Submission timeline and process, see online

<https://iupac.org/systems-thinking-in-chemistry-education-call-for-cti-papers/>



Special issue IQY in PAC

2025 was proclaimed by the United Nations proclaimed the International Year of Quantum Science and Technology (IQY). This year-long and worldwide initiative aims at increasing public awareness of the importance of quantum science and applications. As the world authority on chemical nomenclature and terminology, standardized methods for measurement, atomic weights and many other critically evaluated data, IUPAC is naturally a supporter. Compiled under the leadership of Russell Boyd and Manuel Yáñez acting as co-editors, a special issue of IUPAC journal *Pure and Applied Chemistry* (PAC) is dedicated to the celebration of IQY.

Invitations were extended to more than 50 leading researchers in quantum chemistry in late 2024 and today, the result today is a unique collection of about 40 articles of a very broad coverage. Some papers describe state-of-the-art research, while others provide authoritative reviews. A few provide fascinating insight into the contributions of leading researchers and the evolution of the early days of quantum and theoretical chemistry into what we may call more broadly computational chemistry.

The first issue of PAC compiling articles in this IQY collection has been released in the September issue. Additional articles will follow, and some are already online ahead of print. (Special Issue Keyword (degruyterbrill.com/search): Quantum science and technology)

Read Russell Boyd and Manuel Yanez's **Introduction to the Special Issue of The International Year of Quantum**, *PAC* vol. 97, no. 9, 2025, pp. 999-1000. <https://doi.org/10.1515/pac-2025-0592>

<https://iupac.org/special-issue-iyq-in-pac/>

In Memoriam

Edwin D. Becker 3 May 1930 – 4 August 2025

It was with tremendous sadness that we received the message that Edwin D. (Ted) Becker passed away August 4th, shortly after his 95th birthday. With his passing, IUPAC has lost a most passionate supporter, who played a crucial role on several occasions in the history of the Union.

Becker was Secretary General of IUPAC from 1996 through 2003, a service he carried out with integrity, good judgment, and a willingness to help when need be. All these virtues were instrumental on many occasions, in particular when he was in charge of moving the Secretariat from Oxford to RTP, North Carolina, and when he overlooked the transformation of the Union operation from a commission-driven to a project-driven system. He was also a driving force when IUPAC started the development of the International Chemical Identifier (InChI) for chemical substances. And at outset of the collaboration with the Organisation for the Prohibition of Chemical Weapons (OPCW), his diplomatic skills surfaced on several occasions and contributed to move the process forward.



After Ted stepped down as Secretary General, he did not leave the Union behind but remained an active and reliable volunteer that was always interested and willing to listen and give advice. His departure therefore leaves a tremendous void, but also great memories that will remain an inspiration.

<https://iupac.org/edwin-d-becker/>



Guiding Principles of Responsible Chemistry

Guided by IUPAC's mission as a global organization that provides objective scientific expertise and develops the essential tools for the application and communication of chemical knowledge for the benefit of humankind and the world, chemists should practice:



► Responsible Innovation



► Safety, Security & Sustainability



► Ethical Behaviour



► Inclusivity, Equity & Belonging



► Communication & Collaboration



► Equitable Access



► Integrity & Accuracy



► Convergence Across Disciplines

Terminology for Dynamic Polymer Networks and Hydrogels

The field of dynamic covalent polymer networks, including hydrogels, is a rapidly developing area that involves researchers across several areas of chemistry (organic, catalysis, polymer) and beyond (physics, materials science, chemical and biomedical engineering). However, because this area has developed recently, a comprehensive set of terms describing these materials is utterly lacking in IUPAC terminology documents. As a result of rapid development of these materials across the world, confusion in the literature exists, including terms used synonymously in some papers that are defined as different classes in others.

This project seeks to collect these terms and provide guidelines for their application in a Recommendations document to be published in *Pure and Applied Chemistry*. This will benefit the wide group of researchers working on dynamic polymer materials by providing a common language.

For more information and comment, contact task group chair Roxanne KIELTYKA <r.e.kieltyka@chem.leidenuniv.nl> | <https://iupac.org/project/2025-005-2-400>

Systems Thinking, Sustainability and Chemical Industry

In partnership with International Organisation of Chemical Sciences for Development (IOCD), this project builds on engagement with chemical industry established during IUPAC project 2020-014-3-050, Systems Thinking in Chemistry for Sustainability: Toward 2030 and Beyond (STCS 2030+), providing a channel for collaboration between chemical companies that facilitates dialogue, collaboration and commitment on tackling sustainability challenges and concentrated efforts to identify and implement solutions. In particular, the task group will:

- develop a Policy Paper (“White Paper”) on the enabling environment needed to strengthen chemical industry engagement in systems thinking and sustainability.
- develop representative Case Studies of using systems thinking to advance sustainability in chemical industry: unpacking the factors, options and trade-offs in each selected industrial system; providing a model of system-wide approaches to sustainability.
- strengthen tertiary education, in-service training

and professional development on systems thinking in chemical industry: equipping chemistry graduates and those working in industry with specific systems thinking skills.

For more information and comment, contact task group chair Peter Mahaffy, Stephen Matlin, or Jane Wissinger | <https://iupac.org/project/2025-004-2-041/>

Small-Scale Chemistry Initiative in India

In a concerted effort to revolutionize chemistry education and promote sustainable laboratory practices, IUPAC in collaboration with the Chemical Society of Thailand and various partners, launched a transformative project in India. This initiative, titled “*IUPAC Capacity Building of Teachers in Chemistry: Hands-on Small-Scale Experiments in High School in Asia*,” unfolded through four impactful phases from August 2024 to February 2025.

This report narrates the journey of this transformative initiative aimed at enhancing chemistry education through small-scale, sustainable experiments. The project empowered teachers with practical skills, green chemistry awareness, and innovative teaching methods. It unfolded in four strategic phases: hands-on workshops, a national video competition, international networking, and advanced trainer development. Through regional collaboration and capacity building, the program supported the United Nations Sustainable Development Goals. Ultimately, it laid the groundwork for lasting change in science education across Asia.

Phase One: Laying the Foundation in Bangalore

The journey began in August 2024 in Bangalore, India, where 100 secondary school teachers gathered for a hands-on workshop on small-scale chemistry. Led by an expert team from Thailand and supported by institutions such as JNCASR and the Federation of Asian Chemical Societies, the workshop introduced innovative techniques using minimal chemical quantities to enhance safety, reduce costs, and lower environmental impact.

Over two days, teachers engaged in nine meticulously designed experiments, learning to use everyday materials to illustrate key chemistry concepts. These sessions not only equipped them with practical skills but also sparked a deeper interest in green chemistry and sustainability. At the conclusion of the workshop,



ten outstanding participants were selected for further training and international collaboration.

Phase Two: Encouraging Innovation Through Competition

Building on the momentum, the next phase focused on creativity and application. Teachers were invited to participate in a video competition, where they designed and demonstrated original small-scale experiments aligned with their teaching curricula. This phase aimed to reinforce their learning and encourage classroom implementation.

The response was enthusiastic, with 20 submissions received. A panel from the Chemical Society of Thailand evaluated the videos and selected ten winners. These teachers earned the opportunity to attend PACCON 2025 in Thailand—an international platform for further training and recognition.

Phase Three: Building Bridges Across Borders

In February 2025, the selected Indian teachers traveled to the Khao Yai Convention Center in Thailand to attend PACCON 2025. Here, they joined peers from Vietnam, the Philippines, and Thailand for a vibrant



networking session. Guided by Angela Koehler, participants conducted catalytic reaction experiments and collaborated in multicultural teams.

This event was more than just an academic exchange—it was a celebration of regional unity. It fostered enduring connections among educators committed to advancing hands-on, sustainable chemistry education. The shared experiences laid the groundwork for continued collaboration and mutual support.

Phase Four: Cultivating Future Leaders

The final phase took place on February 14, 2025, with a “Training the Trainers” session at the Local Khao Yai Hotel. Participants delved into the theoretical and practical aspects of integrating green chemistry with STEM education, led by renowned educators including Supawan Tantayanon and Chatree Faikhamta.

Through lectures, discussions, and group presentations, the teachers were empowered to become trainers themselves. With their enhanced knowledge and skills, they pledged to return to India and spearhead the dissemination of small-scale chemistry techniques, aiming to reach classrooms across the nation.

This four-phase initiative not only strengthened chemistry teaching in India but also laid the foundation for a sustainable educational movement throughout Asia. By promoting small-scale, resource-efficient experimentation, the project aligned with global sustainability goals and inspired a new generation of educators to champion change—one experiment at a time.

For more information and comment, contact task group chair Supawan Tantayanon <supawan.t@chula.ac.th>. A detailed report is available on the project webpage <https://iupac.org/project/2023-029-1-050/>

Definitions and preferred symbols for mass diffusion coefficients in multi-component fluid mixtures including electrolytes (IUPAC Technical Report)

Tobias Klein, Chathura J. Kankanamge, Thomas M. Koller, Michael H. Rausch, Andreas P. Fröba, Marc J. Assael, William A. Wakeham, Gabriela Guevara-Carrion and Jadran Vrabec

Pure and Applied Chemistry, 2025

Vol. 97, no. 7, pp. 689-713.

<https://doi.org/10.1515/pac-2024-0251>

This work summarizes the fundamentals of the description of molecular diffusion in liquid and gaseous non-electrolyte and electrolyte systems at constant temperature and pressure and in the absence of external fields. On the basis of Fick's law and the theory of Maxwell and Stefan, the description of diffusive fluxes in commonly used reference frames and a recommendation for the terminology of the associated diffusion coefficients are given. For non-electrolyte systems, the corresponding equations for the diffusive fluxes are outlined for a general n -component mixture and are explicitly stated for binary and ternary mixtures. Additionally, the transformation of the component order is discussed for a general n -component mixture. For electrolyte mixtures, explicit equations for the diffusive fluxes are stated for binary mixtures consisting of a molecular solvent and a dissolved electrolyte component and binary mixtures consisting of two electrolyte components sharing a common ion. Furthermore, explicit equations for the diffusive fluxes are given for ternary systems consisting of one electrolyte component dissolved in two non-electrolyte solvents. For all the aforementioned systems, transformations of the diffusion coefficients between commonly used reference frames are included.

<https://iupac.org/project/2014-010-1-100/>

IUPAC/CITAC guide: interlaboratory comparison of categorical characteristics of a substance, material, or object (IUPAC Technical Report)

Ilya Kuselman, Tamar Gadrich, Francesca R. Pennecchi, D. Brynn Hibbert, Anastasia A. Semenova and Angelique Botha

Pure and Applied Chemistry, 2025

Vol. 97, no. 7, pp. 715-750

<https://doi.org/10.1515/pac-2025-0408>

This Guide is intended for harmonization of interlaboratory comparisons of categorical—nominal (qualitative, *i.e.*, non-quantitative) and ordinal (semi-quantitative)—characteristics of a substance, material, or object. It provides guidance for application of relevant methods of mathematical statistics for design of such interlaboratory comparisons and analysis of the obtained data, when the methods developed for continuous quantitative values (*e.g.*, ANOVA—analysis of variance) cannot be used without violation of their basic assumptions. The proposed approach employs recently-developed two-way nominal analysis of variation CATANOVA and two-way ordinal analysis of variation ORDANOVA. The Guide also addresses correlation between the categorical characteristics, as well as correlation between these characteristics and the chemical composition of the material or object. A multisensory quality index of a product, combining information on its categorical characteristics, is detailed. It allows for comparison of the quality of the same material produced by different producers. The examples provided in the Guide are from the fields of macroscopic examination of weld imperfections, comparison of odor intensity of drinking water, and comparison of sensory (ordinal) characteristics of a sausage. A corresponding calculation tool with an Excel spreadsheet including macros, and programs written in the R environment, are available in the specified references.

<https://iupac.org/project/2021-017-2-500/>

<https://iupac.org/project/2023-016-1-500/>

Blockchain technology: driving change in the scientific research workflow

Bonnie Lawlor, Stuart Chalk, Jeremy Frey, Kazuhiro Hayashi, David Kochalko, Richard Shute and Mirek Sopek

Pure and Applied Chemistry, 2025

Vol. 97, no. 4, pp. 279-330

<https://doi.org/10.1515/pac-2023-1204>

The goal of this white paper is to present an objective overview of the current use of blockchain technology along the scientific research workflow and in related areas such as chemical/drug supply chains and education. It represents the culmination of three years of data gathering, including input from multiple interviews with pioneer users of the technology, as well as from more recent adopters around the globe, and recent industry technology analysts' reports. Within these

pages are descriptions of successful applications of the technology at each step of the scientific research workflow—from the timestamping of ideas to funding, to actual experimentation, to the analysis of research results, and ultimately to the sharing of information and the publication of results. However, not all blockchain use cases have such a successful conclusion. In this white paper you will learn where the technology has not worked—and why—thanks to those interviewed who discussed in detail the lessons that they themselves learned during their own blockchain journey. In addition, the paper highlights the potential future uses of

the technology; the pitfalls to avoid when considering its use; when and how legislation and regulatory policies come into play; and how the technology is evolving and growing stronger (some say that the fourth generation of the blockchain evolution is on the horizon!). The paper also discusses parallel developments in quantum computing, its potential impact on blockchain technology, and what developments are in progress to ensure a stable and provably secure, quantum safe alternative to the existing blockchain approaches.

<https://iupac.org/project/2023-009-1-024/>

Let's celebrate IYQ

The 2025 International Year of Quantum Science and Technology (IYQ) recognizes 100 years since the initial development of quantum mechanics <quantum2025.org>. Joining in the celebrations, IUPAC has prepared a special Issue of *Pure and Applied Chemistry*, containing about 40 invited articles that recognize the impact of quantum science and technology in many branches of chemistry. The Guest Editors are Manuel Yáñez (manuel.yanez@uam.es), Autonomous University of Madrid, Spain and Russell J. Boyd (russell.boyd@dal.ca), Dalhousie University, Canada.



IUPAC Provisional Recommendations

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

Basic Classification and Definitions of Polymerization Reactions

Corresponding Author: John B. Matson jbmatson@vt.edu

This document provides recommendations addressing the long-standing dilemma of the wide variety of terms that are used to describe the two common classes of polymerization mechanisms in the scientific literature, which includes chemistry and polymer-science textbooks. It is an update of a 1994 IUPAC document on this topic and provides clarification and hierarchical structure regarding the basic classification and terminology describing polymerization reactions. The term step polymerization describes polymerizations in which growth occurs by reactions between monomer, oligomer, or polymer molecules of any length. We clearly denote here the two subclasses

of step polymerization: additive step polymerization (synonym: polyaddition) and condensative step polymerization (synonym: polycondensation). The term chain polymerization describes polymerizations that proceed via a chain reaction with monomer molecules adding to active sites on polymer chains. Subclasses of chain polymerization include additive chain polymerization and condensative chain polymerization. The terms provide a logical and straightforward structure for describing the two common classes of polymerization mechanisms. Previously defined terms relevant to these two classes of polymerization reactions are also replicated in this Recommendation document.

Comments by 30 November 2025

<https://iupac.org/recommendation/basic-classification-and-definitions-of-polymerization-reactions/>



IUPAC 2025 in Kuala Lumpur Opened with Focus on Sustainability and Excellence

On 14 July 2025 at the Kuala Lumpur Convention Centre, hundreds gathered from around the globe for the official launch of the 50th IUPAC World Chemistry Congress (50WCC), held alongside the 53rd IUPAC General Assembly. Under the theme “**Chemistry for a Sustainable Future**,” this joint opening marked the first time these major IUPAC events took place in an ASEAN country—sparked international attention and regional pride.

The Opening Ceremony began at 3:00 PM. Delegates were greeted with a blend of local hospitality and global ambition. Attendees heard warm welcoming remarks from Datuk ChM Dr. Soon Ting Kueh, President of Institut Kimia Malaysia, who underscored the event’s historic significance and the country’s expectation that chemistry will drive sustainability initiatives across food, energy, and environment.

Ehud Keinan, President of IUPAC, opened the ceremony saying that this congress is the high point in the 106-year history of the organization, founded in 1919. Keinan believes the image of chemistry around the world has improved greatly from the end of the last century. He believes the world recognizes the necessity of chemistry in modern life and recognizes, for example, that the semiconductor industry is a chemical industry.

The Congress was officially declared open by Datuk Dr. Soon Ting Kueh, who ceremoniously struck the gong three times, symbolising the commencement

of the congress and setting the stage for a week of scientific exchange and collaboration.

Awards followed. The first group was the twelve 2025 Distinguished Women in Chemistry/Chemical Engineering.

The second group includes the 2025 and 2024 recipients of the IUPAC-Solvay International Award for Young Chemists. The awards were presented by Javier García Martínez, IUPAC Past President and Ajay Khandkar from Solvay.

Next was the IUPAC–Zhejiang NHU International Award for Advancements in Green Chemistry. Announced at the ceremony, the Experienced Chemist award went to Javier Pérez Ramírez (ETH Zurich). Simultaneously, the Young Chemist awards were presented to Jianbin Li (Chinese University of Hong Kong), Sahel Fajal (Indian Institute of Science Education and



On stage for the opening gong strike (from left): Helen Pain, Dorothy J. Phillips, Soon Ting Kueh, Ehud Keinan, and Zhigang Shuai

Research), and to Philip Stanley (Technical University of Munich). Recipients were honored on stage by IUPAC President Ehud Keinan and Li Haoran of NHU.

These awards, co-established by NHU and IUPAC, reflect a growing emphasis on green chemistry at the intersection of academia, industry, and global development. The program continues to build momentum: during the congress, Javier PérezRamírez delivered an award lecture, and Li Haoran spoke on low-impact phenol-to-quinone transformations—promising industrial applications and cleaner production processes.

The last award presentation was the 2025 Chemistry Europe Award to Stefan Grimme from the University of Bonn, Germany, in recognition of his pioneering work in theoretical and computational chemistry. Jan Willem Toering, Chemistry Europe Council Member and CEO of the Koninklijke Nederlandse Chemische Vereniging (KNCV), presented the award, acknowledging Grimme's scientific achievements, while the Award Lecture took place the following day in a session chaired by Jing Tang from Wiley Shanghai.

After the awards and before the audience transitioned to the Welcome Reception, attendees heard two plenary lectures. The first was delivered by Peter Mahaffy, King's University, Canada on the topic "Realizing Chemistry's Pivotal Role in Our Sustainable Future" and ended with launching the IUPAC Guiding Principles of Responsible Chemistry website (<https://iupac.org/responsible-chemistry/>). Second was David Winkle, La Trobe University, Australia on "The Exciting Potential of AI for Drug and Therapeutic Discovery."

The Welcome Reception was an opportunity for attendees to connect before a packed week of symposia and side events.

IUPAC 2025 opened with high-level talks and awards rooted in sustainable innovation underscored a realignment of chemistry with global needs. This first phase of the congress made clear that the agenda was about applying science to urgent problems.

The Conference by the numbers

More than 3000 delegates from 82 countries participated in the long week event combining the IUPAC GA and Congress.

IUPAC2025 is a truly global event. The International Advisory Board consisted of Ehud Keinan (President, IUPAC) as Chair and Datuk ChM Dr Soon Ting Kueh (President, Institut Kimia Malaysia) as Co-Chair. The International Advisory Board members consisted of Andy Tzi Sum Hor (Agency for Science, Technology & Research, Singapore), Ernesto Joselevich (Weizmann Institute of Science, Israel), Francesca Kerton (Memorial



University of Newfoundland, Canada), Javier García Martínez, (Past President IUPAC, University of Alicante, Spain), Jung-II Jin (Korea University), Marietjie Potgieter (University of Pretoria, South Africa), Mary Garson (Vice President and President Designate, IUPAC, University of Queensland, Australia), Mei-Hung Chiu (National Taiwan Normal University), Peter Atkins (University of Oxford) and Zhigang Shuai (Tsinghua University, China).

IUPAC 2025 National Organising Committee Chair was Datuk ChM Dr Soon Ting Kueh, Scientific Committee Chair was ChM Dr Edward Juan Joon Ching, and 53rd IUPAC General Assembly Committee Chair was ChM Dr Yang Farina Abdul Aziz.

IUPAC General Assembly, 12–17 July, 2025

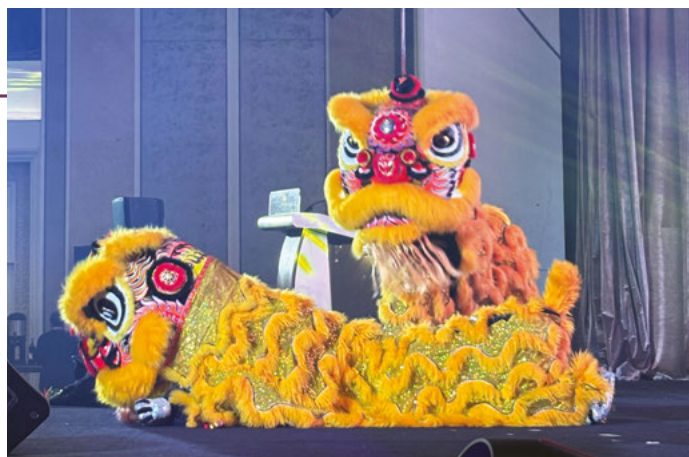
IUPAC carries out its work through 8 Divisions and a number of Committees. The Annual meetings of all the Divisions and Committees were held during the General Assembly. The 8 Divisions are: (i) Physical and Biophysical Chemistry Division (ii) Inorganic Chemistry Division (iii) Organic and Biomolecular Chemistry Division (iv) Polymer Chemistry Division (v) Analytical Chemistry Division (vi) Chemistry and the Environment Division (vii) Chemistry and Human Health Division (viii) Chemical Nomenclature and Structure Representation Division.

IUPAC Committees include (a) Committee on Chemistry and Industry (b) Committee on Chemistry Education (c) Committee on Chemical Research Applied to World Needs (d) Inter-Divisional Committee on green Chemistry for Sustainable Development (e) Committee on Ethics, Diversity, Equity and Inclusion Meetings of different Sub-committees like Crop Protection Advisory Group Sub-Committee, Subcommittee on Polymer Terminology and Interdivisional Subcommittee Critical Evaluation of Data, and were also held.

Young Observers from different countries were also invited to IUPAC2025.

Conference Call





View the full gallery of
pictures from IUPAC 2025
in Kuala Lumpur at
iupac2025.org/image-gallery





An interesting event was the Joint Networking Session of IUPAC and International Young Chemist Network, followed by a poster presentation. In this session, young chemists from many parts of the world interacted with President/Chair/Representatives of different Divisions and Committees of IUPAC in a speed networking session to understand the diverse activities of IUPAC. This was followed by poster presentations by IUPAC Divisions and Committees.

A “Town Hall Meeting” was held in which all IUPAC members present were invited. Mary Garson, IUPAC Vice President and President Elect led the discussion. In this meeting, opinions of members were sought on restructuring proposal of IUPAC.

World Chemistry Leadership Meeting (WCLM)

The theme of WCLM was “**Trust in Science and the Right to Science**”.

WCLM brought together a distinguished group of scientific leaders and thinkers to explore a topic of growing global importance: trust in science.

See separate report

Council Meeting

The Council is the primary IUPAC governing body to which the Science Board, Executive Board,

Standing Committees, Divisions, Commissions, and all other IUPAC bodies are responsible. The Council is composed of Delegations from the National Adhering Organizations (NAOs) and each NAO appoints its Delegates for every Council meeting.

IUPAC Council meetings were held on 15 and 16 July and led by IUPAC Secretary General Zoltan Mester. Many important discussions and decisions were taken, including discussion of the relocation IUPAC Head Office, approval of the four new members countries, namely Estonia, Guatemala, Peru and Singapore.

IUPAC Recommendations on Nomenclature, Symbols and Standard Atomic Weights were adopted. The Council also voted to elect key members for 2026-27 biennium.

IUPAC President Ehud Keinan presented his report on the State of the Union and highlighted achievements during the biennium.

IUPAC Vice President and President Elect Mary Garson made Critical Assessment of the programs and projects of IUPAC. She highlighted the paramount importance of strengthening global project systems, fostering diversity across gender, age, and regions, and leveraging education and ethics to align with Sustainable Development Goals. Garson underscored IUPAC’s strategic role in large interdisciplinary initiatives aimed at meaningful contributions to sustainable development, and emphasized anticipating challenges and opportunities to reinforce IUPAC impact on global scientific collaboration and policy.

IUPAC Division Presidents and Standing Committee Chairs presented their reports through posters. IUPAC Treasurer Wolfram Koch presented Financial Report and Budget Proposal. Report of the Secretary General was presented by Zoltan Mester.

The Council elected new Officers and members of the Executive and Science Board Member, including



Delegates appointed by National Adhering Organizations (NAOs) vote at the council meeting.

Christine Luscombe, Vice President and Derek Craston, Treasurer starting on January 2026.

Bids were received from China, Thailand, and Singapore to host IUPAC 2031. The Council voted in favour of China.

See Actions taken by IUPAC Council, at <https://iupac.org/actions-taken-by-iupac-council-kuala-lumpur-malaysia-july-2025/>

IUPAC World Chemistry Congress 2025, 14–19 July

The 50th World Chemistry Congress was held from 14–19 July. After the joint inaugural session, a large number of Symposia and Workshops organized under 3 clusters:

Cluster I: Pure & Applied Chemistry

1. Physical and Biophysical
2. Inorganic and Bioinorganic
3. Organic & Biomolecular
4. Polymers and Materials
5. Analytical & Forensic
6. Environmental
7. Cheminformatics
8. Education & Public Understanding
9. Human Health and Well Being
10. Green Chemistry

Cluster II: Chemistry & SDGs

11. SDG2: Zero Hunger [Agriculture & Food Chemistry]
12. SDG3: Good Health & Well Being [Natural Products & Medicinal Chemistry]
13. SDG5: Gender Equality [Ethics, Diversity and Inclusion in Science Education]

14. SDG6: Clean Water & Sanitation [Water & Wastewater Management]
15. SDG7: Affordable & Clean Energy [Renewable & Low-cost Energy]
16. SDG13: Climate Action [Sustainable & Green Chemistry]

Cluster III: Thematic Sessions

17. Artificial Intelligence in Chemistry
18. Green Chemistry in Education
19. Symposium on Chemical Safety and Security
20. Malaysian Rubber Board (MRB) Celebrating 100 Years of Excellence in Rubber and Latex Sciences
21. Professional and Responsible Practices in Chemistry Including Responsible Care
22. PhosAgro/UNESCO/IUPAC Symposium—Green Chemistry: Experiences and Opportunities for Co-operation for Sustainable Future
23. IYCN/MYCN Young Chemist Programme

Plenary Lectures:

The following Plenary lectures were presented

- Realizing Chemistry's Pivotal Role in Our Sustainable Future, Peter Mahaffy, King's University, Canada
- The Exciting Potential of AI for Drug and Therapeutic Discovery, David Winkle, La Trobe University, Australia
- Green Chemistry toward Low sugar Universal Vaccines and Glycoengineered Antibodies Chi-Huey Wong, Scripps Research Institute, United States
- Pushing Boundaries: Innovations in Organometallic Complexes and Catalysts for Advanced Chemical Transformations Zhaomin



The Committee on Chemistry Education gathers for a picture at IUPAC2025

- Hou, RIKEN Center for Sustainable Resource Science, Japan
- Rethinking Fluorine Chemistry with Global Challenges in Mind, Veronique Gouverneur, University of Oxford, United Kingdom
 - Advancing the Frontiers of Semiconducting Polymers Through Precision Synthesis, Christine K Luscombe, Okinawa Institute of Science and Technology, Japan
 - Design and Synthesis of Nanomaterials for Biomedical and Energy Applications, Jackie Yi-Ru Ying, King Faisal Specialist Hospital & Research Centre, Saudi Arabia
 - Continuous Movement of Carbon Atoms in Organic Molecules: Merry-Go-Round Reactions Tamotsu Takahashi Hokkaido, University, Japan
 - From Coherence in Photosynthesis to Chemical Quantum Information Science, Gregory D. Scholes, Princeton University, USA
 - Single Atom Catalysis, Tao Zhang, Dalian Institute of Chemical Physics, Chinese Academy of Sciences, China
 - Biosensors Without Frontiers: Nucleic Acid Testing in Low Resource Areas, EAH Hall, University of Cambridge, UK
 - Cinematic Chemistry: The Journey of Electron Microscopy From Organic Synthesis To Molecular Statistics, Eiichi Nakamura, The University of Tokyo, Japan

Award Lectures

- 2025 CHEMISTRY EUROPE AWARD LECTURE: g-xTB: DFT accuracy at tight-binding speed,

- Stefan Grimme, University of Bonn, Germany
- IUPAC-SOONG PRIZE FOR SUSTAINABLE CHEMISTRY LECTURE: Reticular Chemistry, Climate, AI, Omar Yaghi, University of California, United States
- PhosAgro/UNESCO/IUPAC/IKM Lecture: The Stockholm Declaration on Chemistry for the Future, Paul T Anastas, Yale University, United States
- KM GOLD MEDAL AWARD LECTURE: Mesosstructured Materials Driving Innovations in Clean Energy and Environmental Sustainability, Juan Joon Ching, University Malaya, Malaysia

Symposiums:

Some of the symposiums were:

- A. Artificial Intelligence in Chemistry
- B. A.I. Guided Automation in Synthetic Processes
- C. Organic and Mechanochemistry
- D. Biopolymers and Sustainability
- E. Nuclear Magnetic Resonance Spectroscopy for Environment and Sustainability
- F. Carbon-Neutral Chemical Production via Advanced Nanocatalysis
- G. Green Chemistry in Education—Innovative teaching methodologies, curriculum development strategies and latest research on green chemistry education
- H. Evaluation of Advanced Technologies for Carbon Sequestration, Utilization and Capture.
- I. Diradical Chemistry
- J. Nano Technology and Sustainable Agriculture
- K. Systems Thinking in Chemistry for Sustainability



Below: Omar Yaghi received the IUPAC-Soong Prize, on 16 Jul 2025; pictured with Ehud Keinan, IUPAC President (left) and Chi-Huey Wong.



- L. Microplastics and Nanoplastics
- M. PFAS in the Environment: Management and Remediation
- N. IUPAC Contributions and Green Chemistry Innovations Towards Sustainable Development
- O. Towards a Sustainable Future: Engaging Society for a Systemic Change
- P. Chemical Safety and Security
- Q. Professional and Responsible Practices in Chemistry including Responsible Care
- R. Gender Equality- Ethics, Diversity and Inclusion in Science Education
- S. IUPAC-IYCN Safety Training Workshop
- T. Elastomers and Latexes
- U. Environmental Impact of Tyres
- V. Global scenario and Challenges of Radioactive Waste in the Environment
- W. Chemicals of Emerging Concern in Polar Environment

IYCN/ MYCN Young Chemist Programme on Safety:

“IUPAC-Young Scientists Safety Training Workshop” was organized by the International Young Chemists Network and Malaysian Young Chemists Network.

In this workshop, after the introductory talk by Gracia María Romero, Bipul Saha and Tien Thuy

Quach, Bipul Saha made a presentation on “Safety in Chemistry.” Ayush Agarwal—IYCN spoke on “Safety from the Perspective of a Young Chemist.” Gracia María Romero—COCI National Representative gave an overview of “IUPAC COCI Safety Training Program.” Finally, there was a group discussion. The whole program was moderated by Lovish Raheja, Executive Board Member of IYCN and Sook Mei Khor of Malaysia.

After 7 days of hectic activities, the program came to an end. In the closing ceremony, the baton was passed from Malaysia to Canada. The next Congress will be held in Montreal in 2027.

A photo report prepared by Victoria Foo and Dee Dee Quah, Project Lead and co-lead IUPAC 2025 is available online at <https://isu.pub/xXwnVqD>



WCLM 2025 panelists (from left): David Winkler, Peter Mahaffy, Elizabeth Hall, Dorothy Phillips, Helen Pain, Paul Anastas, and Omar Yaghi.

Restoring Trust in Science: A Global Imperative

report by Neil Gussman

In an era dominated by digital media, artificial intelligence, and information overload, the credibility of science is under unprecedented threat. Eihud Keinan, President of the International Union of Pure and Applied Chemistry (IUPAC), warned that the vulnerability of science has escalated into a global crisis—so severe that it now ranks alongside climate change, public health, and food security as one of the greatest challenges facing humanity.

At the heart of this crisis lies a toxic mix of scientific misconduct, widespread misinformation, and systemic manipulation. From fabricated studies and unethical research practices to the proliferation of over 18,000 predatory journals, the integrity of scientific communication is eroding. Digital platforms amplify this decay, spreading conspiracy theories, pseudoscience, and AI-generated disinformation that distort reality and polarize societies.

The situation is worsened by cyberbullying of researchers, AI-powered bots manipulating public discourse, and the rise of echo chambers that reinforce ideological biases while undermining objective evidence. These dynamics disproportionately affect marginalized communities, further fueling mistrust in science and democratic institutions.

In his talk Keinan called for a collective scientific response—not just to diagnose the threats but to

actively restore public confidence. He urges the scientific community to reaffirm the fundamental human right to participate in and benefit from science, as enshrined in Article 27 of the Universal Declaration of Human Rights (1948).

As seven leading voices in global chemistry gather for the World Chemistry Leadership Meeting (part of IUPAC2025) on July 15, to share insights and propose actions, the message is clear: trust in science is not a given—it must be earned, protected, and promoted. And it begins with transparency, education, ethical rigor, and inclusive access to scientific progress for all.

Can the “Right to Science” Restore Public Trust?

by Dorothy J. Phillips, American Chemical Society, 2025 President

Our world is increasingly shaped by misinformation. Declining trust in science poses a serious challenge. Dorothy J. Phillips, 2025 President of the American Chemical Society, believes that restoring this trust may begin with something long overlooked: the “Right to Science.”

Recognized in Article 27 of the Universal Declaration of Human Rights (1948) and elaborated in Article 15 of the International Covenant on Economic, Social and Cultural Rights (1966), the Right to Science affirms that everyone has the right to access scientific knowledge, education, and the benefits of progress. Yet despite being enshrined in international law for over

seven decades, this right remains largely unknown to the public.

Drawing on her decade of experience with the AAAS Science and Human Rights Coalition, Phillips argues that raising awareness of this right—especially among students—can play a powerful role in rebuilding public confidence. The UN's 2020 General Comment No. 25 provides a framework for implementation, emphasizing not only the protection of scientific freedom but also proactive efforts by governments to ensure access to accurate information and counter disinformation.

This mission is urgent. A 2023 Pew Research Center survey revealed a sharp decline—up to 14 percentage points—in Americans' trust in scientists since the COVID-19 pandemic. Phillips suggests that reversing this trend begins in the classroom. Early science education, inclusive of all demographics, is critical to cultivating a generation that values evidence-based thinking.

The American Chemical Society's recent webinar, *How to Break Through to Reach Science Deniers*, underscores the growing recognition that trust must be earned through outreach, education, and transparency. Phillips' lecture explored whether affirming and communicating the Right to Science can help shift the tide—promoting a more informed, engaged, and scientifically literate public.

Chemistry for a Fairer, Safer, and More Sustainable World

by Helen Pain, Chief Executive, Royal Society of Chemistry

Public trust in science—especially chemistry—is more vital than ever said Helen Pain, Chief Executive of the Royal Society of Chemistry in her talk. She says chemistry lies at the heart of the materials we use, the medicines we depend on, and the solutions we seek for today's challenges. But it's not just the science that matters—it's how society perceives and interacts with it.

Pain emphasized that chemistry must serve the public good. Ethical considerations now shape both research priorities and regulatory frameworks, especially in areas such as sustainability and chemical safety. Chemistry cannot be divorced from the societal values it impacts.

The Royal Society of Chemistry (RSC) is actively ensuring that chemistry contributes meaningfully to the United Nations Sustainable Development Goals (SDGs). This includes advancing ethical standards, influencing chemical policy, and fostering global equity in science. A key part of this mission is expanding

opportunities in the Global South through initiatives like the Pan Africa Chemistry Network and support for early-career researchers.

Inclusivity is another cornerstone of the RSC's vision. From gender and ethnicity to disability and socioeconomic background, the RSC is working to dismantle barriers within the field. By supporting inclusive education and research, they aim to broaden participation and harness the full potential of diverse talent.

Pain's message is clear: chemistry is not just a technical discipline—it's a force for justice, safety, and sustainability. But to fulfill that potential, it must be guided by care, collaboration, and conscience. Through ethical practice and inclusive engagement, chemistry can build a world that is not only more advanced—but also more equitable.

The Future of Science in the Digital Age: Chemistry at a Crossroads

by Omar M. Yaghi, UC Berkeley

In 21st century, science—especially chemistry—stands at a transformative crossroads said Omar M. Yaghi of UC Berkeley in his plenary talk. The rise of digital technologies and artificial intelligence (AI) is unlocking unprecedented opportunities for discovery. Yet, this progress is shadowed by growing vulnerabilities: cyber threats, misinformation, knowledge suppression, and geopolitical tensions.

Prof. Yaghi emphasizes that the scientific enterprise must evolve swiftly to remain relevant. Chemistry, in particular, has the potential to become a fully data-driven and adaptive discipline. AI technologies are already revolutionizing the field—from generative models that design new materials to autonomous laboratories that accelerate experimental work. These innovations offer powerful tools to tackle global challenges in sustainability, energy, and health.

But the path forward demands more than technological capability; it requires ethical clarity and visionary governance. Yaghi warns against prematurely regulating AI in ways that might stifle innovation. Instead, he advocates for a balanced approach—one that safeguards ethical standards while protecting the freedom of scientific inquiry. We must resist fear-driven responses and focus on maximizing the benefits AI can offer to humanity.

Equally important is the democratization of science. Yaghi said that the benefits of scientific progress must be shared equitably across societies. This means ensuring open access to knowledge, fostering global



From left: David Winkler, Elizabeth Hall, Peter Mahaffy, Helen Pain, Dorothy J. Phillips, Soon Ting Kueh, Ehud Keinan, Omar M. Yaghi, and Paul T. Anastas

collaboration, and strengthening institutions that uphold the right to science as a universal human entitlement.

In his vision, the future of science lies not only in technological advancement but also in intelligent stewardship. To meet the challenges ahead, we must modernize science with humility, protect it with vigilance, and commit to its role as a global public good—open, inclusive, and driven by innovation with conscience.

Science at a Crossroads: Restoring Integrity and Public Trust

by Elizabeth (Lisa) A. H. Hall, University of Cambridge, UK

Science has long held a privileged place in society, built on the ideals of truth, integrity, and intellectual freedom. But according to Elizabeth Hall, this trust is eroding. Drawing on the foundational ideas of sociologist Robert Merton—who emphasized the unique ethos of science. Hall argues that the distinction between science and other forms of knowledge is increasingly blurred and under attack.

At the heart of this crisis is a breakdown in communication and integrity. Misinformation, conspiracy theories, and information overload have made it difficult for the public—and even scientists themselves—to distinguish fact from fiction. This confusion undermines not only the credibility of individual researchers but also the public's broader trust in science.

Compounding this issue is the growing number of misconduct cases, including plagiarism, fraud, and data fabrication. While most scientists uphold rigorous ethical standards, even a few violations can cast a long

shadow. Hall warns that scientific freedom must come with accountability. Researchers have a duty to ensure reproducibility, transparency, and honest interpretation of results.

Beyond the lab, scientists must consider how their work affects society. Should all research aim to improve human life or provoke intellectual transformation? Does the right to discovery include the freedom to explore without interference from politics, law, or ideology?

Hall calls on the scientific community to reflect on its responsibilities. Rebuilding trust will require more than sound methods—it demands a recommitment to openness, critical self-examination, and public engagement. In an age of rapid technological change and growing skepticism, the future of science depends not just on what we discover, but how we uphold the values that make science worthy of society's trust.



Helen Pain and Paul Anastas

Science: A Truth Worth Defending

by Paul T. Anastas, Yale University, USA

Science and scientific institutions face growing skepticism said Paul T. Anastas in his plenary talk. He called for a critical and honest reflection: Why does science now need defending?

Citing Einstein's assertion that "the right to search for the truth implies also a duty," Anastas argues that ethical conduct and integrity must remain central to science. But the need to preserve and protect science goes beyond defending its credibility—it requires understanding why it is under attack in the first place.

Historically, science emerged from resistance. The Scientific Revolution challenged entrenched beliefs and often faced accusations of heresy. Over centuries, science transformed into a dominant force of knowledge—what some have called a new orthodoxy. But with power comes scrutiny, and Anastas urges us to examine whether modern science's methods, culture, or institutions may themselves contribute to public distrust.

Do individuals or institutions feel threatened by scientific findings? Are political, ideological, or economic forces driving the backlash? Is science too often perceived as elitist, opaque, or disconnected from public concerns?

Anastas does not simply lament the erosion of public trust. Instead, he challenges the scientific community to confront uncomfortable truths about itself. Introspection, he suggests, is essential—not only to restore confidence but to build a science that truly serves society.

By asking hard questions and acknowledging past shortcomings, science can be strengthened—not weakened. The path forward lies not in defensiveness, but in openness, accountability, and a renewed commitment to the values that made science a trusted pursuit in the first place. In doing so, we affirm that science is not just worthy of protection—it is worthy of the public's belief, engagement, and support.

Building Trust in Science: A Two-Way Commitment

by Peter Mahaffy, The King's University, Edmonton, Canada

Restoring trust in science requires more than correcting misinformation—it demands that scientists understand their audiences and that science itself is demonstrably worthy of trust said Peter Mahaffy in his plenary talk. He argues that effective science communication



David Winkler, Peter Mahaffy, and Elizabeth Hall

must move beyond the outdated "deficit model," which assumes public mistrust stems from a lack of knowledge. Instead, scientists must engage with the public's values, perspectives, and lived experiences.

Drawing from his work with IUPAC and other international bodies, Mahaffy emphasizes that science communication should be rooted in mutual understanding. A key reference is the IUPAC Project *Chemists and "The Public"* (2008), [1] which highlights how scientists can better connect with diverse audiences by applying systems thinking and acknowledging context—critical in combating the spread of misinformation.

Equally important is ensuring science remains trustworthy. Mahaffy highlights global initiatives like the International Science Council's *Principle of the Universality of Science*, which balances the freedom to conduct research with the responsibility to uphold ethical standards. This principle was refined to reinforce that scientific freedom must go hand-in-hand with accountability.

Ethical practice in chemistry is central to Mahaffy's message. The *Hague Ethical Guidelines*, developed by chemists worldwide, underscore the importance of safeguarding science from misuse, particularly in light of the Chemical Weapons Convention. Similarly, the IUPAC CEDEI task force has developed *Guiding Principles for the Responsible Practice of Chemistry*, that was formally launched at the 2025 World Chemistry Congress in Malaysia. These principles aim to foster a culture of integrity, transparency, and public engagement.

Mahaffy's vision for building trust in science is clear: scientists must listen as much as they speak, commit to ethical conduct, and embrace responsibility as part of their professional identity. Only then can science

maintain the public's confidence and fulfill its role in advancing the common good.

1. (Mahaffy 2008, *Pure Appl. Chem.*, Vol. 80, No. 1, pp. 161–174, 2008, <https://doi.org/10.1351/pac200880010161>, or <https://iupac.org/project/2004-047-1-050/>)

Science Under Siege: Confronting the Hydra's Many Heads

by David Winkler, La Trobe University, Monash University, University of Nottingham

Science is facing a multifaceted and intensifying assault, likened by Professor David Winkler to a Hydra—each challenge spawning new threats even as others are addressed. While attacks on science are nothing new, today's wave is unprecedented in scale and complexity, fueled by political polarization, digital disruption, and growing public skepticism.

The internet has democratized access to scientific research but also enabled the rise of predatory journals and conferences, diluting the impact of legitimate science. The explosion of AI-generated content—often built on flawed, biased, or insufficient data—has further strained the credibility of scientific outputs. Peer reviewers, overwhelmed by a flood of low-quality submissions, are stretched thin, making it easier for unvetted studies to slip through.

A reproducibility crisis also looms large. A 2016 *Nature* survey found that over 70 % of researchers across disciplines failed to replicate others' results—and more than half failed to reproduce their own. Confirmation bias, underpowered studies, and a rush to publish are compounding the issue. Pre-registration of experiments and new models of continuous online review may help reverse this trend.

Ethical oversight remains uneven. While some organizations like the American Chemical Society and Royal Society of Chemistry enforce formal codes of ethics, many universities still fail to mandate coursework on scientific integrity and bias. Winkler highlights the urgent need for a global chemical ethics framework, especially given the powerful—and potentially dangerous—applications of chemistry and biology.

Finally, anti-science rhetoric, particularly in the U.S., has been amplified by social media influencers and uncredentialed commentators. The erosion of expert voices, visible during the COVID-19 pandemic, underscores the need for renewed advocacy. The path forward may include more grassroots efforts—like the March for Science—and a renewed global commitment

to uphold the integrity, transparency, and public value of scientific inquiry.

<https://iupac.org/event/wclm-2025-trust-in-science-and-the-right-to-science/>

Sustainable Practices for Promoting Diversity in Chemistry

by Siu Yee New and Mei-Hung Chiu

The issue of gender has been highlighted as one of the United Nations' Sustainable Development Goals. To further raise public and policymakers' awareness, the IUPAC World Chemistry Congress 2025, held in Kuala Lumpur, Malaysia, organized an SDG5 (Gender Equality) symposium. The event brought together participants and experts to exchange ideas and share actions aimed at reducing gender disparity, while promoting inclusion, diversity, and equality.

The SDG5 symposium convened a vibrant and diverse group of scientists, educators, and leaders to explore how chemistry can serve as a catalyst for gender equality and inclusive innovation. Titled "*Sustainable Practices for Promoting Diversity in Chemistry*," the session attracted strong participation and featured dynamic, engaging Q&A discussions that encouraged open dialogue and knowledge exchange.

Rethinking Leadership and Redefining Success

Speakers emphasized that advancing gender equality in chemistry demands systemic change—reimagining who leads, who participates, and how success is defined. Josephine Tsang (Chemical Institute of Canada) called for a transformation in scientific culture through inclusive leadership and allyship, urging institutions to amplify underrepresented voices and build equitable frameworks that support resilience in the sciences. Javier García-Martínez (University of Alicante) introduced IUPAC's initiative to establish *Guiding Principles for Responsible Chemistry* [1], grounded in ethics, diversity, and inclusion. He stressed that chemistry must align with societal goals and embed equity across research, education, and public engagement.

Mentorship and Visibility: Building Inclusive Communities

The symposium highlighted the importance of mentorship and visibility in supporting women and



From left, Nurul Huda (Universiti Kebangsaan, Malaysia; SDG5 Symposium organizing committee), Zuriati Zakaria (Institut Kimia, Malaysia), Mei-Hung Chiu (National Taiwan National University), and Siu Yee New (University of Nottingham, Malaysia)

underrepresented groups in STEM. Chao-Ping Hsu (Academia Sinica, Taiwan) shared three impactful initiatives: the Women in Science & Technology (WiST) Convention, the NSTC Career and Gender Equality Workshop, and a Mentor-Mentee program launched by the Taiwan Chemical Society—all aimed at strengthening professional networks, fostering thematic discussions, and supporting junior chemists.

Keynote speaker Frances Separovic (University of Melbourne) discussed Australia's Women in STEM Decadal Plan and the *STEM Women Global* directory, which enhances visibility and career progression. She also introduced a mentoring program launched in 2024 that connects early-career researchers from low-income countries with experienced mentors worldwide.

Inclusive Education and Equitable Access

Education emerged as a central theme, with calls to develop inclusive curricula and accessible learning environments. Mustafa Sözbilir (Atatürk University, Türkiye) presented inclusive strategies for blind and low-vision (BLV) students, including adapted lab activities and 3D-printed materials. His work demonstrated how simple, cost-effective modifications can enhance learning and motivation for visually impaired students.

Ghada Bassioni (SEU Egypt) emphasized the role of inclusive education strategies in promoting gender equality. She advocated for chemistry curricula that feature diverse role models and for workshops focused on leadership and communication skills tailored to women in chemistry. She also emphasized the importance of internships and hands-on research opportunities for female students.

Chemistry for Climate and Community

The intersection of sustainability and gender equity was compellingly illustrated by Rozzeta Dolah (Universiti Teknologi Malaysia), who introduced the metaphorical shift from a “Periodic Table” to an “Equal Table.” Her work on MIZU Paint and ZetaTech™ nano-carbon coatings demonstrated how green chemistry innovations can address environmental challenges while empowering women scientists and entrepreneurs.

Global Perspectives, Shared Challenges

Jane Catherine Ngila (University of Johannesburg) provided insights into the African context, outlining how digital divides and systemic barriers deepen gender gaps in STEM. She highlighted policy frameworks and success stories from the continent that showcase how inclusive science, technology, and innovation (STI) ecosystems can contribute to multiple SDGs.

Tracey Peter and collaborators (University of Manitoba, with partners in Sweden and Germany) presented cross-national research on how workplace incivility and perceptions of inequity contribute to emotional exhaustion and attrition among women in STEM.



From left Supawan Tantayanon (Thailand, newly elected member of the IUPAC Executive Board), Sieng Huy (Cambodge), Zuriati Zakaria (Malaysia), Ale Palermo (UK, member of the IUPAC Science Board)



Attendees of the “Sustainable Practices for Promoting Diversity in Chemistry” event at IUPAC2025

Their findings underscore the urgent need for supportive workplace cultures and institutional reforms.

A Call to Action

The symposium concluded with a collective commitment to embed ethics, equity, and inclusion into the core of chemical research, education, and leadership. The engaging Q&A session reflected the enthusiasm and urgency among participants to collaborate across borders and disciplines. Chemistry, as the speakers affirmed, must not only solve technical problems but also contribute to a more just and sustainable world.

These efforts build on IUPAC’s long-standing commitment to equity, reflected in initiatives such as the Global Women’s Breakfast [2], the Gender Gap in Chemistry project [3], and the Distinguished Women in Chemistry Award [4]. By linking the symposium outcomes to these global initiatives, the chemistry community strengthens its collective efforts to embed diversity, equity, and inclusion into the heart of scientific progress.

References

1. IUPAC Guiding Principles of Responsible Chemistry <https://iupac.org/responsible-chemistry/> (viewed 18 Aug 2025)
2. IUPAC Global Women’s Breakfast <https://iupac.org/gwb/>
3. IUPAC project The Gender Gap in Chemistry – Building on the ISC Gender Gap Project <https://iupac.org/project/2020-016-3-020/>
4. IUPAC Distinguished Women in Chemistry or Chemical Engineering

<https://iupac.org/what-we-do/awards/iupac-distinguished-women/>

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Green Chemistry for a Sustainable Future

by Aleksander Antonov

As part of the IUPAC 2025 World Chemistry Congress in Kuala Lumpur, PhosAgro, UNESCO and IUPAC hosted an international symposium titled “Green Chemistry: Experience and Opportunities for Cooperation for a Sustainable Future.” The event brought together leading scientists along with representatives of industry, government agencies and international organizations. The results of the Green Chemistry for Life grant programme were presented during the symposium. Over eight rounds, the jury has reviewed more than 1,000 scientific works, and grants have been awarded to 55 young scientists from 33 countries in Asia, Africa, the Middle East, Europe, North America and Latin America.

UNESCO Assistant Director-General for Natural Sciences, Lidia Brito, said: “Our PhosAgro–UNESCO–IUPAC partnership, through the Green Chemistry for Life programme, supports young scientists from all



Above, Paola de Azevedo Mello receives her grant award from Aleksander Antonov. At top right, Hamdy Hefny, recipient of the research grant on phosphogypsum. At right, Azuma Mohamed poses with his award.



around the world by awarding grants of up to USD 30,000 to researchers working in the field of green chemistry.”

Paul Anastas, the founder of the green chemistry concept, said: “There’s great collaboration that has taken place [thanks to the Green Chemistry for Life programme]. It has just energized and accelerated that goal of how we use the best science, including the best science from the youngest and most creative minds, to turn it from concept into reality, from invention into impact.” Anastas added that the partnership between PhosAgro, UNESCO and IUPAC is an outstanding example of collaboration between the private sector and international institutions.

Siroj Loikov, PhosAgro’s First Deputy CEO, said: “As one of the world’s leading fertilizer producers, we recognize our responsibility to future generations. Business has a key role to play in ensuring sustainable development on our planet. That’s why we are grateful to our long-standing partners, UNESCO and IUPAC, for supporting the idea to launch a grant programme in green chemistry. Today, it has become a symbol of progress and of our shared success.”

Christopher Brett, Vice Chair of the international scientific jury for the Green Chemistry for Life grant programme and past President of IUPAC, noted that “the Green Chemistry for Life programme has proven its immense importance by becoming a driver for scientific research, publications in scientific journals and

the careers of young scientists around the world. “This field is so important that we must continue to develop it and to raise broader public awareness of green chemistry as a tool for life, sustainable development and the future,” emphasized Brett.

A meeting for grant recipients was held during the symposium, giving them an opportunity to share how the programme had changed their lives and enabled them to carry out their research projects.

Hamdy Hefny, a 2019 grant recipient from Egypt’s Central Metallurgical Research and Development Institute, presented preliminary findings from his project, which explores the use of phosphogypsum as a tool for recovering critical and rare earth elements. “Today, we have achieved promising results, particularly in recovering rare earth elements using ion exchange resins derived from phosphogypsum, a by-product of



phosphoric acid production,” Hefny explained. “We have completed our laboratory research, and the Egyptian company Phosphate Misr has shown a particular interest in our work. The company is currently building a phosphoric acid plant with an annual capacity of 500,000 tonnes. As soon as production begins, we will be able to move to the next stage—industrial implementation. The PhosAgro–UNESCO–IUPAC grant enabled me to move beyond theoretical research and to apply my findings in practice, implementing my developments in real-world conditions and helping improve the world. [This] grant is very important for the younger generation because ... young researchers in their early career [need funding].”

A grant was awarded in 2021 for another project focused on the beneficial use of phosphogypsum. The project’s creator, Mohamad Azuwa Mohamed, from the National University of Malaysia, said that the grant opened up new opportunities for him: “My research project [focuses on] converting phosphogypsum waste into functional photocatalysts. We have already successfully demonstrated the concept at laboratory scale and are now working on scaling it up. We have been holding meetings with industrial partners and presenting our work. In the near future, we plan to introduce our invention to industry. It is important to note that our approach is not limited to photocatalysis. We are also exploring the possibility of using phosphogypsum-based materials as adsorbents for wastewater treatment and environmental remediation, broadening their potential uses considerably. In addition, we are currently focusing on the extraction of non-radioactive rare earth elements from phosphogypsum. This area holds strong promise for addressing the problems of resource recovery and creating a circular economy in

the processing of industrial waste. I believe that green chemistry is a very versatile field that [can help make life better] for our nation, for our country and also for the worldwide scientific community.”

Bogdan Karlinsky from Tula State University, a 2024 grant recipient, noted that the grant had enabled him to broaden his research focus and shift towards more applied biotechnological research: “My project focuses on the efficient biotechnological processing of toxic substances that may form during the pretreatment of plant biomass and negatively impact the metabolic processes of the microorganisms that use that feedstock for biofuel production. The addition of the microorganisms proposed by us to known bacteria used for the production of bioethanol or biohydrogen can greatly reduce the concentration of toxicants in the feedstock, thereby improving the efficiency of biofuel production. As soon as the work is completed, it will represent a unique value proposition for industrial partners in the clean-fuel sector. I am grateful to PhosAgro for funding such international programmes, for giving me an opportunity to work at the forefront of global science, collaborate with international scientific organizations and expand my scientific interests.”

Another 2024 winner, Hassan Anwar, a scientist from Pakistan’s National University of Sciences and Technology, spoke about the progress he has made on his project to develop slow-release fertilizers: “These fertilizers help conserve water by optimizing nutrient delivery and uptake by plants, which is beneficial for regions facing water scarcity or drought. In addition, the reduction in greenhouse gas emissions associated with the use of slow-release fertilizers helps mitigate the effects of climate change and lower the carbon footprint of agriculture. Thus, the development and adoption of

slow-release fertilizers offers considerable potential for improving agricultural productivity, environmental quality and food security in the future. Our team of scientists recognizes and appreciates the initiative by PhosAgro, UNESCO and IUPAC to support scientific research.”

Natalia Tarasova, a member of the Green Chemistry for Life international scientific jury, Director of the Institute of Chemistry and Problems of Sustainable Development at the D. Mendeleev University of Chemical Technology of Russia and past President of IUPAC, said: “Today’s session showed that the launch of the Green Chemistry for Life programme was the right decision. The presentations by grant recipients addressed a wide range of issues related to human interaction with the environment and various fields of science and industry. All of these issues urgently need the expertise of chemists. And it is precisely green chemistry that has shown that countries in Latin America, Africa and Europe alike can use its approaches to develop solutions that can address challenges related to waste, clean water, public health and food production. As a member of the jury, I am completely satisfied with the work of our grant recipients. I believe that this programme has a bright future because it can evolve both through educational initiatives and through technological projects. I wish all our grant recipients continued scientific success and progress towards achieving the Sustainable Development Goals.”

Aleksander Antonov is Head of International Development Department, from PhosAgro

Advancing Scientific Terminology & Standards for the Digital Era—DUST Conference 2025

by *Colin L. Bird, Agnes Jasinska and Jeremy G. Frey*

The Units, Symbols, and Terminology in the Physical Sciences in and for the Digital Era (D-UST) Conference 2025 took place on 13–14 March 2025 at the Royal Society of Chemistry in London. Co-organized by IUPAC, CODATA, the Physical Sciences Data Infrastructure (PSDI) project, and hosted by the Royal Society of Chemistry, the conference brought together an international cohort of scientists, data experts, philosophers, and policy makers to address a common goal: ensuring scientific terminology, units, and symbols are fit for purpose in a predominantly digital and interdisciplinary research landscape.

The conference focused on harmonizing scientific expression across digital platforms,

enhancing machine-readability, and supporting data interoperability—key enablers for FAIR data practices and global collaboration. The programme featured expert-led sessions, interactive project tables, the IUPAC Green and Gold books, and in-depth discussion on emerging challenges and technologies.

Key highlights included:

- Vanessa Seifert (Universities of Bristol & Athens) explored the implications of artificial intelligence on scientific progress, questioning how opacity in AI systems challenges traditional scientific virtues such as explanation, prediction, and truth.
- Blair Hall (Measurement Standards Laboratory of New Zealand) introduced the M-layer, a novel framework enabling unambiguous expression and transformation of measurement data by linking quantitative values to defined aspects and scales.
- Cerys Willoughby (University of Southampton) presented user-experience research on improving metadata practices in electronic lab notebooks, emphasizing cognitive prompting techniques to enhance data quality and reusability.
- György Gyomai (OECD) examined the organisation of data using counting-units, proposing nuanced approaches for treating discrete quantities—such as population data—within measurement systems.
- Philip Dunn (LGC Group) provided a critical overview of ongoing IUPAC projects on isotopic analysis, highlighting inconsistencies in symbols, legacy definitions, and the importance of clear guidance for data comparability.
- Joseph Wright (University of East Anglia) illustrated the practical challenges of Unicode symbol representation in scientific computing, advocating for coordinated community input to encoding new concepts.
- Simon Coles (University of Southampton) offered a crystallographer’s perspective on FAIR data, detailing how information frameworks like CIF have supported reproducibility and transparency.
- Samantha Pearman-Kanza (University of Southampton) provided a pragmatic perspective on the Semantic Web, encouraging the use of modular, standards-based ontologies for scientific data exchange.

Parallel sessions included strategic planning for the Digital Green Book, updates on the Gold Book revision, exploration of CODATA’s Cross Domain Interoperability Framework (CDIF), and discussions on



digital tools for PSDI to support unit representation and metadata interoperability.

The conference reaffirmed IUPAC's leadership in standardising terminology and underlined the need for ongoing collaboration across scientific domains, policy-making, and data infrastructure initiatives. Attendees agreed on the urgency of creating durable, scalable digital frameworks that balance human understanding with machine readability.

In closing, Professor Jeremy Frey (University of Southampton) emphasized the value of interdisciplinary dialogue and philosophical insight in guiding future developments. Discussions at D-UST 2025 are expected to catalyse new partnerships and contribute meaningfully to the ongoing work by PSDI, CODATA/DRUM and IUPAC in supporting open, accurate, and interoperable science.

The talks can be found at <https://www.youtube.com/watch?v=2AmpX9OaGUQ>

The timestamps for the different talks are :

2:46 - Chemical progress in the age of AI - Vanessa A. Seifert*

45:47 - Stuff we don't know we know: unpacking tacit assumptions about the semantics of units and dimensions - Blair Hall

1:34:40 - Human aspects of Units, Symbols, Terminology - Cerys Willoughby

2:18:00 - Counting Units, are they different from first class units? - Gyorgy Gyomai

2:53:10 - 3rd time lucky - past and current IUPAC projects on terminology for isotopic analyses - Phil Dunn

3:18:09 - Unicode for Scientific Symbols - Joseph Wright

3:34:51 - IUPAC, UNDRR/ISC Hazard Information Profiles and Disaster Risk Reduction - Virginia Murray

3:53:46 - RSC-IUPAC Committee - Andrew Shore

4:06:00 - FAIR Data Standards - A Crystallographers Perspective - Simon Coles

4:42:53 - A Pragmatic view of the Semantic Web for the Physical Sciences - Samantha Pearman-Kanza

5:21:40 - Information on the digital Green Book and how to represent units and systems - Stuart Chalk

5:55:53 - Where next for DRUM, CDIF and WorldFAIR+? - Simon Hodson

6:26:15 - Discussion round: Units and Names

The presentations can be found at <https://www.psd.ac.uk/dust/>

A version of this report is published in the newsletter of CICAG, the Chemical Information and Computer Applications interest group of the Royal Society of Chemistry, RSC CICAG Distillate—Summer 2025, page 8, rsc.org/cicag.

*See Vanessa Seifert short feature in this issue of *Chem Int*, page 20

<https://iupac.org/event/units-symbols-and-terminology-in-the-physical-sciences-in-and-for-the-digital-era/>



Stockholm Declaration on Chemistry for the Future

J. García Martínez

The Nobel Symposium, “Chemistry for Sustainability: Fundamental Advances,” held in Stockholm from 19–22 May 2025, convened leading chemists worldwide to redefine the purpose and practice of chemistry. Hosted by the Stockholm University Center for Circular and Sustainable Systems (SUCCeSS), the symposium culminated in the launch of the Stockholm Declaration on Chemistry for the Future, emphasizing chemistry’s profound power as both a molecular science and a catalyst for human and planetary well-being.

The symposium provided an invaluable platform to showcase recent advancements in green chemistry and foster dialogue on the future of sustainable science. Over four days of intensive discussions, participants explored cutting-edge developments in catalysis, sustainable materials, green synthesis, and circular economy approaches. Beyond scientific breakthroughs, the symposium served as a forum for deep reflection on the discipline’s purpose, ethics, and societal impact. The central aim was to rethink and redefine chemistry’s role in addressing 21st-century challenges, including climate change, resource depletion, and social inequity.

A significant outcome of these discussions was the Stockholm Declaration on Chemistry for the Future. This declaration embodies a collective commitment from the global chemistry community to transform how chemistry is practiced and how it contributes to a sustainable, equitable future. Co-designed by symposium

participants, although the first discussions started more than a year ago, it drew upon the diverse perspectives and expertise assembled in Stockholm. The declaration was formally launched at the Nobel Prize Museum on 23 May. Four of us were invited to speak on this occasion. In my remarks, I emphasized the enormous potential of chemistry and encouraged everyone to utilize this power in a responsible and creative manner. Chemistry gives us the unique ability to design sustainable solutions that address global challenges, enrich human lives, and foster a more interconnected and resilient world. I encouraged all attendees, as well as the wider scientific community, to embrace their curiosity and unleash their creativity, collaborating to boldly venture into the unknown. Together, we can shape a hopeful, innovative and discovery-filled future that will benefit generations to come. The Stockholm Declaration articulates a bold, urgent, and inspiring vision for chemistry, urging a move beyond incremental progress toward fundamental transformation. It calls for chemistry that minimizes harm, is circular by design, transparent in its data, equitable in its outcomes, and committed to long-term societal value. The declaration is available at www.stockholm-declaration.org, where it can be read and signed.

Engaging with Society and Advancing IUPAC Initiatives

Beyond technical and institutional recommendations, the Declaration calls on chemists to become better storytellers of science, to engage with society, listen more deeply, and welcome every voice. As I shared at the Nobel Prize Museum:



“At the International Union of Pure and Applied Chemistry (IUPAC), we do not just standardize knowledge, we mobilize it. We do this by connecting people across borders, empowering the underrepresented, and ensuring that science is not only excellent but also accessible and inclusive. Because we cannot build the future with half the talent. We must embrace diversity—not just because it is the right thing to do, but because it makes science stronger. Evidence consistently shows that diverse teams produce more creative, effective, and impactful ideas, and that solutions that are culturally grounded, locally adapted, and globally connected are more resilient and better equipped to address real-world challenges. When every voice, background, and culture is welcome at the table, we unlock ideas that no algorithm could ever generate.”

The ongoing work of IUPAC’s Divisions and Committees, particularly the Committee on Chemical Research Applied to World Needs (CHEMRAWN) and the Interdivisional Committee on Green Chemistry for Sustainable Development (ICGCSD), is essential to advancing the goals outlined in this declaration. A recent and noteworthy initiative I highlighted is the IUPAC–Soong Prize for Sustainable Chemistry, awarded annually to recognize breakthrough discoveries or conceptual advances with sustainability at their core. The

inaugural recipient of this distinction was Omar Yaghi, honored for his pioneering contributions to reticular chemistry and for creating new materials and new pathways to address climate and water challenges facing our planet. Also, the theme of the 2025 IUPAC General Assembly and World Chemistry Congress, “Chemistry for a Sustainable Future,” aligns perfectly with the vision of the Nobel Symposium. Indeed, IUPAC’s wide array of activities demonstrates our unwavering commitment to championing sustainable chemistry and advancing the solutions needed to build a better world.

I took this opportunity to comment on a crucial IUPAC initiative: the upcoming launch of the Guiding Principles for the Responsible Practice of Chemistry, to be presented at the IUPAC General Assembly and World Chemistry Congress in Kuala Lumpur this July. This project addresses a pressing need for a unified, high-level framework for the global chemistry community, as existing codes like The Hague Ethical Guidelines, the ACS-led Global Chemists Code of Ethics, and the 12 Principles of Green Chemistry, while excellent, do not provide this comprehensive scope. This IUPAC project aims to create a concise, visually engaging, and widely adopted set of Principles rooted in ethics, transparency, sustainability, and equity. These principles articulate the values embedded in IUPAC’s Strategic Plan. The diverse task group has developed a poster, downloadable brochure, and a dedicated web platform to make these Principles accessible and adaptable worldwide, serving as foundational tools for educators, researchers, institutions, and policymakers. These Guiding Principles are designed to be inclusive, globally relevant, and subject to regular review, aiming to establish a clear, unified standard for responsible chemistry practice and inspire a shared sense of purpose. See <https://iupac.org/responsible-chemistry/>

Advancing Sustainable Chemistry Together

Over four intense and inspiring days in Stockholm, we explored the frontiers of our field across nine thematic sessions, covering areas from sustainable synthesis and materials design to CO₂ utilization, green toxicology, catalytic innovation, and the chemistry of the bio-refinery. Brilliant contributions from colleagues like Ben Feringa, Chao-Jun Li, Audrey Moores, Helen Sneddon, Buxing Han, Julie Zimmerman, and Desiree Plata showcased how chemistry can reshape entire industries.

What resonated most, however, was the shared realization that technology alone is insufficient. Chemistry must evolve not only to be more efficient but also more effective; not only to produce but to protect;

Conference Call

not only to optimize but to connect. This transformation necessitates a fundamental shift in education. We cannot prepare students for tomorrow's challenges with yesterday's tools. Our curricula must integrate systems thinking, life-cycle analysis, and a deeper understanding of how every chemical reaction has real-world implications. IUPAC actively promotes systems thinking in sustainable chemistry, notably through projects like Systems Thinking in Chemistry Education (STICE), to help integrate it into chemistry education and foster understanding of chemistry's connection to environmental and societal issues. IUPAC also supports collaboration across education, industry, and sustainability efforts to ensure chemistry plays a key role in creating sustainable solutions.

The urgency is stark: today, only 8.6 % of produced materials are reused. We continue to extract billions of tonnes of resources only to discard them, a testament to inertia, not innovation. This must change. Recognizing this critical challenge, the Royal Swedish Academy of Sciences hosted Reimagining Chemistry: Building a Circular World on 22 May 2025, a high-level event held at the famous Beijer Hall in Stockholm and streamed globally. Organized in collaboration with the Stockholm University Center for Circular and Sustainable

Systems, the event brought together leading scientists, policymakers, and innovators to explore chemistry's pivotal role in accelerating the shift to a circular economy. Through keynote talks and panel discussions, the program spotlighted groundbreaking solutions, emerging technologies, and cross-disciplinary approaches to closing material loops, minimizing waste, and rethinking how we use resources. This initiative reaffirmed chemistry's essential contribution to addressing global sustainability challenges and building a more resilient, circular future.

The Declaration's Call to Action is unequivocal: we must act boldly, together, and now. We must align policy with purpose, invest in open and transparent science, and design for inclusion and resilience from the outset. This is especially critical in a world where public trust in science is under pressure and misinformation spreads rapidly. As chemists, we must not retreat; we must engage, becoming not just better researchers but better communicators and collaborators.

With the launch of the Stockholm Declaration and the impending unveiling of the IUPAC Guiding Principles in Kuala Lumpur, we stand at the threshold of a new era for chemistry, one where our science is not only excellent but also ethical, inclusive, and transformative.

The poster for the GWB 2026 conference features a collage of four scientists in lab coats. A woman in the background looks upwards, while a man in the foreground holds a flask. A woman in a hijab and glasses holds a flask, and a man in the foreground holds a flask. The background is a gradient of orange and blue with red circles. The text 'February 10, 2026' is in purple, 'GWB' is in large green and yellow letters, and '2026' is in large white letters. Below this, a yellow box contains the text 'Many Voices, One Science'. The IUPAC logo is in the bottom right, and the URL 'iupac.org/gwb' is in the bottom left.

February 10, 2026

GWB

2026

**Many Voices,
One Science**

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IUPAC

2025 (from October 1st)

30 Nov – 5 Dec 2025 - Chemistry: A Window for Change - University of The Witwatersrand, Johannesburg

45th National Convention of the South African Chemical Institute (SACI-45)

Conference Chair: Dr. Manoko Maubane-Nkadimeng, University of The Witwatersrand,
manoko.maubane@wits.ac.za • <https://saci.co.za/SACI2025/>

10–11 Dec 2025 - LC-MS method validation and performance – Rome, Italy

*Joint IUPAC-DSM Workshop on LC-MS method validation and performance - 2nd edition of DSM workshop
“LC-MS and LC-MS/MS method validation in the scientific research”*

Contact: Fabiana Piscitelli, Consiglio Nazionale delle Ricerche, Istituto di Chimica Biomolecolare, fpiscitelli@icb.cnr.it • https://www.spettrometriadi massa.it/Congressi/Methods_Validation_2025
<https://iupac.org/project/2021-036-1-500>

11 February 2025 - IUPAC Global Women's Breakfast - Virtual

Held in conjunction with the International Day of Women and Girls in Science, the goal of “The Breakfast” is to establish an active network of people to overcome the barriers to gender equality in science.

7–11 Jun 2026 - 20th International Conference on Electroanalysis (ESEAC 2026) - Lisboa, Portugal

Chair: Dr. Felipe Conzuelo felipe.conzuelo@itqb.unl.pt • Instituto de Tecnologia Química e Biológica (ITQB) Av. da Republica 2780-157 Oeiras, Portugal • Contact: eseac2026@chemistry.pt
<https://eseac2026.events.chemistry.pt/>

21–24 Jun 2026 - 14th IUPAC International Conference on Bioorganic Chemistry (ISBOC-14) - Milano, Italy

Co-organizers: Francesco Nicotra, Anna Bernardi, Luigi Lay • E-mail: secretariat@iupac-isboc14.org
<https://www.iupac-isboc14.org/>

28 Jun – 2 Jul 2026 – Biotechnology - Kobe-city, Japan

The 20th International Biotechnology Symposium and Exhibition

Program committee co-chairs: Akihiko Kondo (Kobe University), E-mail: akondo@kobe-u.ac.jp
and Haruyuki Atomi (Kyoto University), E-mail: atomi.haruyuki.8r@kyoto-u.ac.jp
IBS2026 Secretariat E-mail: ibs2026@aeplan.co.jp, www tba

12–17 Jul 2026 - 30th IUPAC Symposium on Photochemistry - Zagreb, Croatia

Chair: Prof. Dr. Thorsten Bach (Technische Universität München), E-mail: thorsten.bach@ch.tum.de
Chair of the Local Organizing Committee: Dr. Nikola Basarić (Ruđer Bošković Institute, Zagreb), E-mail: nbasaric@irb.hr • photoiupac2026@hkd.hr

12–16 Jul 2026 - 10th EuChemS Chemistry Congress (ECC10) - Antwerp, Belgium

Contact: Ir. Thomas Vranken, ECC10 Co-Chair & KVCV Secretary-General, thomas.vranken@kv cv.be

13–17 July 2026 - Chemistry Education in the Age of AI - Erzurum, Türkiye

28th International Conference on Chemistry Education (ICCE) with a joint organization of 17th European Conference on Research in Chemical Education (ECRICE)

Contact: Mustafa Sozbilir, Atatürk University, E-mail: sozbilir@atauni.edu.tr • <https://iccecrice2026.org/>

28–31 July 2026 – MACRO - Kuching, Sarawak, Malaysia – NEW DATES

51st IUPAC World Polymer Congress

Chair, MACRO 2026: Rusli Daik, E-mail: rusli.daik@ukm.edu.my, www tba

15–17 Sep 2026 - 26th Isoprenoid Conference - Novotného Lávk, Prague

Program Chair: Pavel Drašar, drasarp@vscht.cz, UCT Prague, Czech Republic
<https://isopsoc.org/Isoprenoids2026.html>

28 Sep 2026 – 1 Oct 2026 - Next Horizons in Polymers - Busan, Korea

IUPAC-PSK50 International Conference on Next Horizons in Polymers: Beyond the past 50, toward the next 100

Contact: Jonghwi Lee, e-mail: jong@cau.ac.kr Chemical Engineering and Materials Science, Chung Ang University • 84 Heukseok-ro, Dongjak-gu, Seoul, Korea • <https://psk50.org/>

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The International Union of Pure and Applied Chemistry

is the global organization that provides objective scientific expertise and develops the essential tools for the application and communication of chemical knowledge for the benefit of humankind and the world. IUPAC accomplishes its mission by fostering sustainable development, providing a common language for chemistry, and advocating the free exchange of scientific information. In fulfilling this mission, IUPAC effectively contributes to the worldwide understanding and application of the chemical sciences, to the betterment of humankind.

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