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BOLD

Color from Test Tube to Textile

Radical Polymerization Design ▶

Youth Reflections on IUPAC Assembly ▶

INTERNATIONAL UNION OF
PURE AND APPLIED CHEMISTRY

Chemistry International

CHEMISTRY International

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

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Cover: On view through August 2024 at the Hach Gallery of the Science History Institute in Philadelphia is an exhibit called BOLD. It is simply 'Vibrant, dazzling, and BOLD' to recognize that our world is full of color. In the feature page 6, Elisabeth Berry Drago, Director of Visitor Engagement, at the Science History Institute, is taking CI readers to a tour of the exhibit. Drawing on dye sample books, vivid clothing, and scientific instruments, BOLD: Color from Test Tube to Textile explores more than 150 years of efforts to expand our access to color. This exhibition—and the feature—is a colorful journey through the history of science, with stops at coal mines, factory floors, and fashion runways.
Color also comes at a cost, and the pursuit of new and brighter dyes has at times harmed humans and environments. BOLD also examines scientists' efforts to understand these impacts and the efforts of dye makers to produce color more sustainably for people and for places. Read on p. 6.


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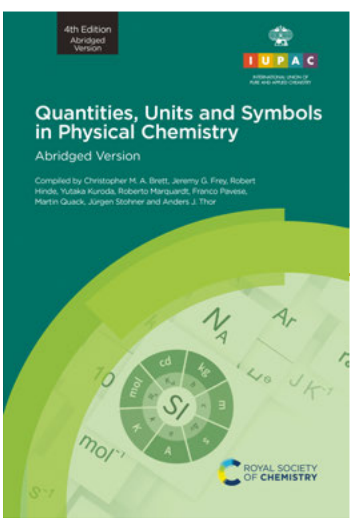
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ROYAL SOCIETY OF CHEMISTRY

Embracing Change: IUPAC's Opportunities Moving Forward

by Javier García Martínez

The year 2024 marks the beginning of important changes at IUPAC, the result of a journey that began in 2019 and crystallized in some of the most important decisions for IUPAC's future in recent decades, adopted at our latest General Assembly in The Hague last August. In this column, I would like to talk about the many things we have accomplished together in recent years but most of all the future, about the many opportunities I see for IUPAC in the years ahead.

I would like to begin by mentioning that in recent months I have had the privilege of attending several meetings of the newly established Science Board and Executive Board. It is difficult to overstate the dynamism, enthusiasm, and ambition with which the people who are part of this new IUPAC structure are working. On the one hand, we are in the process of reinventing the structure of our Divisions and Committees. Until now, we have been organized according to the traditional areas of chemistry (organic, inorganic, analytical...) This traditional view of chemistry promotes silos and hinders interdisciplinarity. That is why we are already working on organizing ourselves around "topics" or "challenges" such as chemistry and energy, chemistry and health, chemistry and the environment, to foster interdisciplinarity and collaboration among our members. I want to emphasize that everyone will be heard in this process of rethinking the organization of IUPAC. I would also like to express my gratitude to the extraordinary individuals who serve on both our Executive and Scientific Boards. Thanks to their vision and hard work, I am confident that we will make IUPAC more effective, agile, and impactful.

Regarding the opportunities that I see for IUPAC in the coming years, the most obvious and perhaps most relevant is Digital IUPAC, an initiative to which we have given the highest priority, and to which we are dedicating resources, time, and focus. This is a collaborative effort involving all IUPAC Divisions and Committees to provide standards and resources that facilitate the robust exchange and use of chemical information. Among the many activities involved, I would like to highlight the update of the IUPAC Compendium of Chemical Terminology, our famous Gold Book. This is one of the most ambitious projects we are working on, as it involves every single Division and Committee. Updating and expanding the terms in the Gold Book, which in its current version already contains more than 7,000 terms, and bringing all this information into a new, more user-friendly platform, will have a huge impact on the chemistry community and will greatly contribute to making all our efforts more valuable and the results of our work more accessible.

Similarly, artificial intelligence, machine learning, and especially large language models are transforming entire industries; and science is no exception. Thanks to these automatic learning techniques, machines are helping us look for patterns in the scientific literature and suggest the most effective experiments. As Andrew D. White recently titled his commentary in *Nat Rev Chem* 7, 457–458 (2023), the future of chemistry is language; and I would add that language is at the core of what we do at IUPAC. That is why why we are increasing our efforts to create standards for the digital chemistry word. This is critical because, with the explosion of artificial intelligence and machine learning in chemistry, many different formats, standards, and protocols are being developed without any coordination, causing much confusion and problems in the management, sharing, and use of chemical data. In collaboration with the broader chemistry and data science communities, we are working to translate chemical communication standards into the digital domain, to align standards development and implementation with the FAIR (Findable, Accessible, Interoperable, Reusable) data principles. Coordinated by CODATA, and with the Research Data Alliance as a key partner, the WorldFAIR project will work through a series of case studies to advance the implementation of the FAIR data principles, particularly those for interoperability, and to develop a set of recommendations and a framework for FAIR assessment in a number of disciplinary or cross-disciplinary research areas. This effort is a key priority and an unavoidable opportunity to prepare FAIR implementation profiles appropriately adapted to each (cross)disciplinary area. (See https://worldfair-project.eu/2023/09/27/iupac-worldfair-chemistry-managing-chemical-data-digitally/)

We chemists are very good at making connections, but we have a much harder time coordinating with each other. The different organizations working for chemistry, associations, professional bodies, societies,

(Fig 1) HRH Princess Chulabhorn of Thailand refers to the IUPAC Top Ten Emerging Technologies in Chemistry at the PACCON2024 Conference in Bangkok, as an example of innovations that can help us build a more sustainable future.

and federations hardly coordinate their actions, and share their resources and information. That is why the Presidents' Forum—which was a recommendation of the IUPAC Structure Review and which inaugural session was held in August 2023 during our General Assembly in The Hague—is such a great strategic opportunity for IUPAC. See page 41 for a report on this activity. This is a meeting of the presidents of all chemical societies and federations with the objective of sharing information, coordinating actions, and serving as a high-level global platform for chemistry. More than 40 representatives responded to our call. I am convinced that the Presidents' Forum is a strategic initiative for IUPAC and a great opportunity to act as a convenor for the international chemistry community to work together for the common goal of better serving the chemistry community worldwide. In the coming months, we will be launching a Presidents' Forum website on the IUPAC website with resources, information, and joint activities to serve as a meeting place for the entire international chemistry community.

I am convinced that the integration of the International Younger Chemists Network (IYCN) into the IUPAC structure is one of the most obvious, even inexorable, opportunities for our organization. Not only will we bring talented early-career scientists into our structure, but we will also have access to hundreds of dedicated volunteers in more than 70 countries around the world. IYCN and IUPAC have worked together for many years. Successful activities such as the Periodic Table of Younger Chemists, ChemVoices, or the Global Conversation on Sustainability are the result of our collaboration, but the effective integration of IYCN into IUPAC will take the impact of our activities to a whole new level. It will also allow us to improve our diversity, and inclusiveness. It will also significantly increase our representativeness, as IYCN is present in many countries, including Latin America, Africa and the Middle East, where our membership is significantly lower. This is one of the most significant and transformative changes in recent IUPAC's history.

Our global initiatives, such as the Top Ten Emerging Technologies in Chemistry, are another great opportunity for IUPAC. This activity is an extraordinary example of how we can raise awareness of some of the most important scientific discoveries of our time while promoting chemistry. Through this global initiative, IUPAC is projecting a modern, forward-looking image, helping to improve the public perception of chemistry and connecting the laboratory with industry and society. In addition, this initiative is part of a call we make every year for anyone in the world to propose a technology to our international panel. In 2024, we'll be celebrating the sixth edition of the Top Ten Emerging Technologies in Chemistry, which continues to grow in popularity and reach year after year. Media from many parts of the world, prestigious journals and scientific congresses have picked up on the technologies we highlight at IUPAC and have become a sign of recognition and support for chemical technologies that can shape our future and contribute to a better, more sustainable future for all. (See Figure 1 and https://iupac.org/what-we-do/top-ten/)

Another of our most successful global activities is the Global Women's Breakfast. By promoting inclusivity, the GWB creates a platform for dialogue and collaboration to address diversity and leadership challenges in chemistry worldwide. This is a highly visible initiative that IUPAC organizes each year and that place our organization at the heart of the efforts to improve diversity and inclusiveness in science worldwide. I cannot thank Laura McConnell and Mary Garson, co-chairs of the Global Women Breakfast, enough for making this annual event such a great success. In 2022, we reached over 30,000 people from 78 different countries at 407 individual events, and in 2023, we held over 380 events in 75 different countries, with Morocco, Rwanda, Slovenia, Sudan, Tanzania, the United Arab Emirates, and Vietnam participating for the first time. This global activity not only helps raise awareness of the need to increase diversity and inclusion in science around the world, but also gives IUPAC additional visibility and helps us reach out to communities where we have very little presence. The 2024 Global Women's Breakfast on February 27, "Catalyzing Diversity in Science," demonstrated once again how IUPAC can help promote a more diverse and inclusive science worldwide.

Our commitment to diversity, inclusion, best practices, and respect for others has crystallized in the Committee on Ethics, Diversity, Equity, and Inclusion (CEDEI). I could not be more proud of this important committee and the work it has accomplished in just a few short years. In this regard, I would like to highlight the IUPAC project entitled *Guiding Principles for the Responsible Practice of Chemistry* (see project 2022-034-3-060), which they are leading. This initiative aims to produce a set of guidelines that will provide a framework for transparent, responsible, and ethical behavior in all aspects of the chemistry enterprise. These Guidelines will be developed in line with the mission statement of the IUPAC Strategic Plan, and it represents an outstanding opportunity, as IUPAC should also make recommendations regarding best practices, ethical use of chemistry, and the promotion of diversity, equity, and inclusion in chemistry. CEDEI is therefore a strategic opportunity to consolidate IUPAC's international leadership and the fundamental role of our organization in emerging areas of increasing importance.

(Fig 2) Workshop on System Thinking in Chemistry Education held here in Cairo during the African Conference on Research in Chemistry Education (ACRICE).

A few weeks ago, I had the honor of representing IUPAC at the closing ceremony of the International Year of Basic Sciences for Sustainable Development (IYBSSD) at CERN, Geneva, Switzerland. See page 44 for a short report on this meeting. It was a celebration of all that we can achieve together and of the importance of knowledge, evidence, and international collaboration in achieving the Sustainable Development Goals. Now, in 2024, we have a new opportunity with the start of the Decade of Science for Sustainable Development (DSSD), declared by the UN General Assembly on 25 August 2023. It will certainly be a challenge to fill an entire decade with activities and content, but at IUPAC we have many global initiatives, such as the Periodic Table Challenge, ChemVoices, the GWB, and the Top Ten Emerging Technologies in Chemistry, that can grow much more thanks to this International Decade. Undoubtedly, if we seize the opportunity, the Decade of Science for Sustainable Development (DSSB) will allow us to build and explain how chemistry can help us address some of the major challenges we face and accelerate the achievement of the Sustainable Development Goals.

The involvement of such major international initiatives as the IYBSSD and now the Decade of Science are great opportunities to strengthen our relationships and collaborations with other international scientific organizations such as UNESCO, Academies of Sciences, other Scientific Unions, and the International Science Council. To achieve our goals and to ensure that IUPAC can better serve the scientific community, we must strengthen our relationships with the major international scientific organizations that share our goals. (See https://iupac.org/iybssd2022/)

One of my great heroes, Nelson Mandela, used to say, "*Education is the most powerful weapon (I would say tool) you can use to change the world*." That is why we at IUPAC are working hard to reimagine the future of chemistry education. In particular, systems thinking offers an extraordinary opportunity for a more relevant and contextualized chemistry education, giving students the tools to connect the molecular description of the problems we face with their solution. IUPAC's various projects to design, implement, and disseminate System Thinking in chemistry education have given us great visibility and placed IUPAC at the center of reimagining the chemistry education of the future. These kinds of efforts, which make IUPAC the engine of change in chemistry and a key player in the future of our profession, are a unique opportunity and a key priority that we should take advantage of also in other areas such as chemical entrepreneurship, the transfer of discoveries to the marketplace, and university-industry relations.

I have always been aware of the extraordinary work done by our staff and volunteers, but my time as IUPAC President gave me the opportunity to see this work first-hand. I cannot begin to describe the titanic work that Tammy, Enid, Fabienne and Greta do. Just four people who take care of the logistics and coordination of all IUPAC activities. They are the real Fantastic Four. I am deeply grateful for their commitment and dedication, which goes far beyond the call of duty. Please, if you have time, send them a note and talk to them the next time you see them to let them know how much you appreciate their contributions as well. But the heart of IUPAC's work is done by our volunteers. Hundreds of people from around the world who give generously of their time and talents so that we can serve the chemical community. Personally, and on behalf of the entire organization, I would like to express my gratitude to each and every person who contributes to our work, from the recently appointed members of the Executive and Scientific Boards to the volunteers who help us organize the Global Women Breakfast in hundreds of cities each year.

The last few years have not been easy; disease, climate change, and war are threats to our survival. Our best defense against these existential risks is science and international cooperation. That is why organizations like IUPAC are needed now more than ever to build a better world together, with evidence-based action, diversity and respect for others, and with ethics at the heart of everything we do. After a process of reflection and change that began with our Centennial, we are now ready to realize the ambitious but achievable commitment that defines our mission: "*The application and communication of chemical knowledge for the benefit of humankind and the world*." What a wonderful goal to work toward.

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

BOLD: Color from Test Tube to Textile

by Elisabeth Berry Drago

Red can be the color of passion and danger, or luck and prosperity. Blue can be the shade of sadness—singing the blues—or a sign of tranquility and serenity. As the Russian painter Wassily Kandinsky once affirmed, in his 1911 treatise *Concerning the Spiritual in Art*, "Color is a power which directly influences the soul." Color is also culture: we've colored our environments, clothes, and bodies for thousands of years, since early humans applied simple organic stains derived from the plants around them. The art and science of dyeing is an ancient one; today it's an economic and commercial powerhouse. The arrival of the first synthetic dyes in the 1850s—discovered by happenstance from experiments with coal tar waste—brought us a rainbow of new possibilities for fashion and textiles, from color "fads" and trends to new means for self-expression. But synthetic color's dark side lingers in polluted waterways. A new exhibit at the museum of the Science History Institute explores these complex legacies. *Bold: Color From Test Tube To Textile* takes visitors on a colorful 150-year journey through the history of synthetic dyes, examining the people and places who've shaped our modern understanding of color—from the laboratory to the factory floor, from the runway to retail, and beyond.

The Science History Institute is a museum, library, and center for scholars in the heart of Philadelphia's historic district, Old City. We collect and exhibit a vast array of materials from the history of science, from instruments and labware to product samples to rare books, advertisements, fine art, and ephemera. Our museum, research, and programs share the stories *behind* the science—hidden histories, surprising ways that scientific questions have shaped our daily lives. As the curator of *Bold*, I wanted to encourage visitors to make connections between the colorful clothes they wear and the world of chemical innovation and experimentation that helped produce them. When we move through the world as consumers, we—myself included—often take our endless array of color choices for granted. *Bold* explores how fashion, taste, and self-expression can be shaped by new technologies, and reveals what's lost or found in that process.

But where to begin? To set the stage for synthetics, *Bold*'s journey starts with a brief history of natural dyeing. This first section of the exhibition is devoted to the natural palette—blue from indigo leaves, yellow from saffron flowers, red from rose madder root or cochineal. Visitors are introduced to basic dye terminology—fixative, mordant, lightfastness—and shown representations of dyers at work.

Two dyer's treatises from the Institute's collections showcase the technical complexity of the dye process, step-by-step: the first is the *Instructive and Practical*

Left: Tratado Instructivo, y Práctico Sobre el Arte de la Tintura (Instructive and Practical Treatise on the Art of Dyeing), 1778, Don Luis Fernández. Courtesy of Science History Institute.

Right: Detail from The Story of Ramie From Seed to Finished Garment, c. 1820 – 1870, Studio of Sunqua. Courtesy of Science History Institute.

BOLD: Color from Test Tube to Textile. Image Courtesy of Science History Institute.

Treatise on the Art of Dyeing, a 1778 text by Spanish master dyer Don Luis Fernández, profiling the technologies of the Royal Dyeworks in Madrid. The second is *The Story of Ramie From Seed to Finished Garment*, a bound album of watercolors detailing each step in ramie weaving and dyeing, produced between 1830 and 1860 by the late Qing dynasty painter Sunqua, once active in what's now Guangzhou, China. In each of these volumes, annotated illustrations outline the major steps in the dye process: preparing the fibers through softening and spinning, scouring and soaking the yarns, applying the dye baths, rinsing and finishing. Both of these works, produced a continent apart, were designed for the same purpose: to show off the skill and expertise of master dyers and boost international buyers' interests in, and appreciation for, their region's dyed goods. Each volume and its illustrations promise their viewers high-quality textiles produced by supremely experienced craftsmen. I am especially excited by the inclusion of *The Story of Ramie* in *Bold*, as this is the first time the Institute has exhibited its images in our galleries since the album was acquired in 2001; this collection is an important reflection both of Qing-era China's rapidly-growing manufacturing capability and the already globalizing textile and dye market, where competition between local and imported products generated curiosity as well as tension.

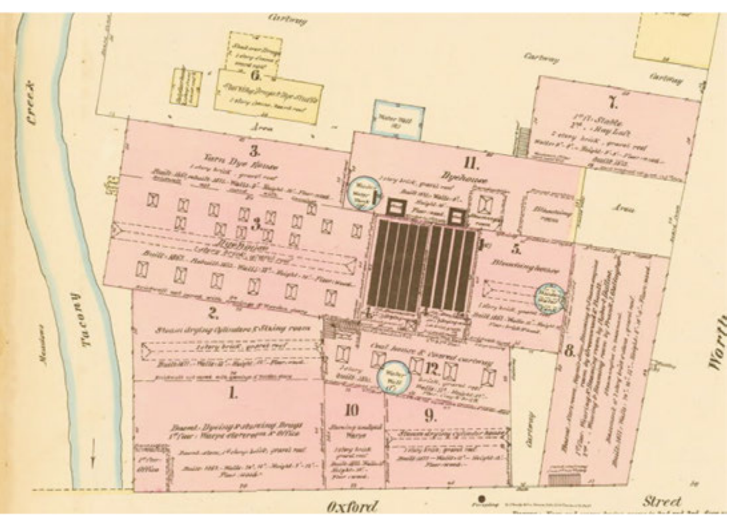
Any introduction to natural dyeing would be incomplete without the inclusion of indigo, an ancient dye derived from plants in the *indigofera* family, that was often at the center of culture and commerce. In Northern Nigeria, the Kofar Mata indigo dye pits (built in the 1400s) helped build the wealth of the Kano region. In Edo-period Japan, a law banning working-class citizens from wearing silk led to a boom in fine indigo-dyed cotton. During the American Revolution, indigo helped secure relations between the United States and France when Benjamin Franklin brought 35 barrels of dye on his 1776 visit to Paris. But indigo had a violent cost. During waves of colonization from the 1500s through the 1700s, European plantation owners in Haiti, Jamaica, El Salvador, and South Carolina grew wealth from indigo crops farmed by enslaved workers. In 1800s India, field workers in the Bengal region led the "indigo revolt," rebelling against forced labor conditions under indigo planters from the East India Company. Today, most indigo on the market is synthetic. The top use for synthetic indigo is in manufacturing blue jeans and denim, an industry that uses more than 90,000,000 pounds of synthetic indigo per year.

Indigo's wide-ranging history made our selection of a single textile for this section quite difficult! But our choice emphasized indigo's importance to culture, through the narrative patterns of adire. *Adire*, the

Yoruba word for “tied and died,” is both an artistic technique and a method of communication. Indigo dyeing was mastered in Western Africa over 1,000 years ago, and adire’s sophisticated patterns carry generational lessons. Paired with our sample of *adire* cloth is a small set of “cake” style dye pucks manufactured by Barlow’s around the advent of the American Civil War in the 1860s. Indigo dye provided the “blue” of Union army uniforms, and was at the center of “free labor” debates forwarded by abolitionists, who urged consumers not to purchase any goods produced by enslaved labor. Philadelphia was a central site for free labor fairs and free labor warehouses, many operated by Quakers. This box of Barlow’s indigo was intended for sale at Wiltberger’s Drug Store on North Second Street, only a few blocks away from the current site of our museum; the label reminds us that in the 1800s, dyes were often sold at pharmacies or “chemists’” shops, and many well-known modern pharmaceutical companies were originally dye manufacturers—including Bayer, Pfizer, and Novartis.

Philadelphia’s place in dye history is a crucial one. The Institute is located in the center of Old City, Philadelphia, once a thriving hub of the city’s early industries: tanneries and docks, glasshouses and sawmills. But Philadelphia was also a national and international leader in the textiles trade, the “workshop of the world,” producing a vast variety of fiber-based goods: yarns and woolens, bindings and braids, rope and surgical dressings, suits, chemises, gowns, carpets, blankets, laces, and ribbons. By the year 1900, Philadelphia was home to at least seven hundred textile and dye firms that employed over sixty thousand people. *Bold* offers a glimpse of this bustling industry through a set of surveys produced in the late 1800s by the civil engineer Ernest Hexamer. Between 1865 and 1896, Hexamer made more than 2,000 detailed diagrams of local factories and industrial sites. They were produced for fire insurance companies, but today, these drawings reveal exactly how historical Philadelphia-area dyeworks were built and used. Most sites were located by water—the Schuylkill and Delaware Rivers, Tacony and Pennypack Creeks, and countless more small waterways. Dyeing required thousands of gallons to dye, rinse, and wash raw materials, and shipping of finished goods was often done by boat. This practical choice would pave the way for unanticipated outcomes, including long battles over water management and water pollution.

Indigo display with Barlow’s Indigo Blue Dye Package, 1860s. Courtesy of Science History Institute.

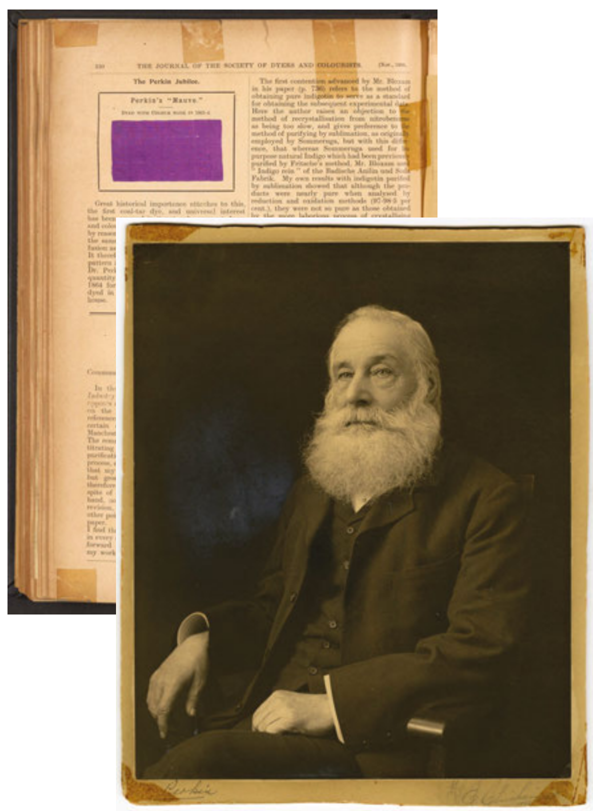


Hexamer General Surveys, Globe Dye and Bleach Works, 1874. Courtesy of the Free Library of Philadelphia.

In the next section of *Bold*, visitors meet the man whose accidental discovery kicked off the synthetic dye boom: William Henry Perkin. In 1856, London-born Perkin was eighteen years old, a student enrolled in the Royal College of Chemistry under the tutelage of August Wilhelm von Hofmann. As Hofmann’s assistant, Perkin had been tasked with examining the potential of

Left: Bold: Color From Test Tube to Textile. Image Courtesy of Science History Institute.

Below: Journal of the Society of Dyers and Colourists, November 1906 (Sample of Perkin's Mauve) and Portrait of William Henry Perkin, 1906. Courtesy of Science History Institute.



coal tar, a sludgy waste product of the coal industry, left behind when fuel was burned for heat and light. Coal tar, when broken down, produced nitrogen compounds called amines. Pekin mixed one of the simplest amines, aniline, with oxidizing chemicals and sulfuric acid, hoping to achieve synthetic quinine—an important drug for treating mosquito-borne illnesses like malaria. His tests didn't succeed. But when he washed out his glassware, a vivid purple stain was left behind. Perkin immediately saw its commercial potential—natural purple dyes were costly and difficult to produce, but his new synthetic color was vibrant and colorfast. After quickly gaining a patent, Perkin left school and established a dyeworks in Middlesex, England. He first called his new shade Tyrian purple, after the most precious purple dye of the ancient Mediterranean world: a color once reserved for royalty. But Perkins' dye became famous under the name mauve, or mauveine. By 1861, mauve was an international fashion sensation. Our exhibit includes a small square of silk fabric colored with a batch of mauveine dye manufactured by Perkin himself. The sample was provided to a journal, published by the UK Society of Dyers and Colourists in 1906, in celebration of the 50th "Jubilee" year of Perkin's Mauve. The bold, bright hue of this silk hasn't faded—probably because it's been safe inside a closed book for more than 100 years!

So what followed Perkins' purple? Countless chemists rushed to follow his example and discover their own coal-tar colors. This is partly due to a legal loophole: Perkin had patented his dye formulas in England, but these patents weren't yet recognized internationally. Chemical firms in France, Germany, and Switzerland quickly started investigating his methods—and soon found success. After mauve came magenta, in 1858. And then methyl violet in 1861, "Bismarck" brown in 1862, and in 1868 alizarin crimson or synthetic madder. Alizarin crimson was the first synthetic dye developed to directly copy or replace a natural vegetable dye; it was the discovery of Carl Graebe, a German organic chemist born in 1841, whose work investigated the hydrocarbon structure of madder dyes. New synthetic dyes were discovered every year between 1875 and 1900, and after the turn of the century this process only accelerated. The discovery of synthetic indigo, which soon replaced the world's most famous natural dye, even helped win German chemist Adolf von Baeyer the 1905 Nobel Prize in Chemistry.

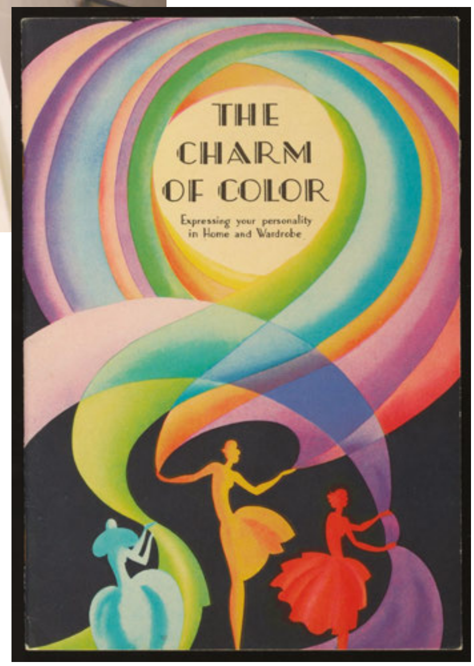
Synthetic colors helped grow the European dye industry into a profitable powerhouse—especially in Germany. One of the most successful German firms was the Badische Anilin-und Soda-Fabrik, or the Baden Aniline and Soda Factory (BASF). Founded in 1865, BASF quickly climbed to the top of the global dye market, where German companies would remain for decades to come: between 1880 and 1914, nearly 75% of the world's synthetic dyes were manufactured in Germany. Our *Bold* exhibit features sample books, trade cards and tins from BASF. Sample books, curiously, weren't designed to sell products to consumers. Instead, they were made by manufacturers to sell raw materials to other manufacturers: for example, dye makers sold raw dyes to textile companies, who in turn sold dyed thread, yarn, or fabric to clothing makers. These colorful artifacts remind us how complicated the world of dyeing is behind the scenes.

With the advent of WWI, the dye industry shifted its center from Germany to the United States. Blockades and boycotts of German products had American chemists scrambling into gear, producing new dyes for manufacturers—and for home dyers as well. RIT Dye, an inexpensive "direct" dye that debuted in 1916, and their competitors Diamond Dyes, Putnam Fadeless Dyes, Tintex, and countless other brands were available to home dyers at pharmacies and department stores. The appeal of these "direct" or basic dyes was their ease of use: the promised "easy" dyeing with no complicated

Synthetic Indigo on Cotton Yarns, c. 1880-1900, Farbwerke vorm. Meister Lucius & Brüning. Courtesy of Science History Institute.

mordant mixtures or long boils. Little knowledge of chemistry was required—only imagination and a fresh sense of style. *Bold* features a large sampling of these home dye packets and samples, as well as a 1928 informational booklet, *The Charm of Color*, produced by the Putnam Fadeless Dyes company to introduce consumers to techniques in dyeing, color theory, and "fashionable" dressing and decorating. This booklet not only showcases Putnam's products, but gives us a glimpse of how colors were marketed, understood, and enjoyed. "Your home is the background for your personality," it reads. "You need not have anything drab, dingy, or faded. Nature has given you the key to your most entrancing color harmonies. It is for you to work out your own symphony by letting color express your individuality—your varying moods—the tempo of your life." The "Charm of Color," according to Putnam, was not complicated, out-of-reach, or expensive. Synthetic

Badische Anilin & Soda-Fabrik Dye Labels (c. 1900) and Dye Tin (c. 1970s). Courtesy of Science History Institute.



Above: Dye advertising in Bold: Color From Test Tube to Textile. Image courtesy of Science History Institute.

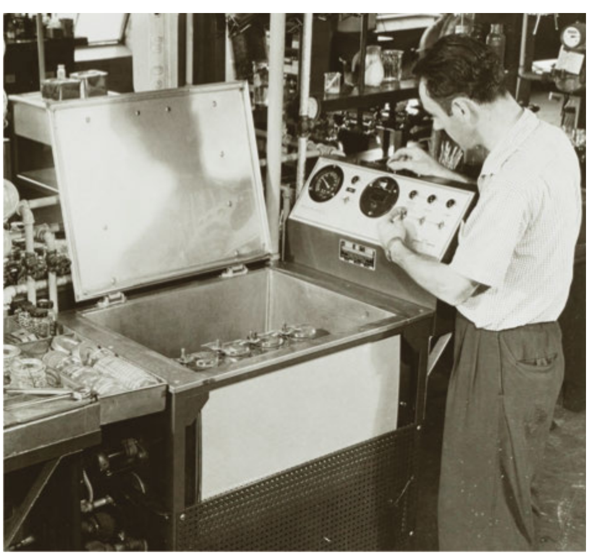
Right: Cover Image of The Charm of Color, 1928, Putnam Fadeless Dyes Company. Courtesy of Science History Institute.

color had become a playground for the 20th century consumer.

With all this innovation in color came great variation in quality. Not every new synthetic was as colorfast and lightfast as its competitors. How to answer the question of quality control? American color chemists responded in part by forming the American Association of Textile Chemists and Colorists (AATCC), a research organization that studied dye strength, light-fastness, and quality. Their research led to the creation of the first national standard test methods and measures for evaluating the durability of textile dyes; more recently their research has explored flammability, mildew-resistance, toxicity and safety in fabric dyeing. The AATCC also established indexes of commercial dyes, which by 1933 already numbered well over 4,000 distinct shades and brands. *Bold* displays jars of AATCC-formulated detergent that clothing makers use in wash tests, a tool that helps create field-wide standards for evaluation.

Quality control and consistency is crucial work in dyeing. In the same section of *Bold*, visitors encounter industrial tools of color analysis, such as an optical DuBoscq type colorimeter manufactured in the early 20th century. The specific colorimeter displayed in *Bold* was owned by a dyeworks in Rensselaer, New York during the 1920s, where it was used to match dye samples and perform quality tests. Its later photoelectric replacement sits nearby in the same gallery, as does a contemporary lightbox used by dye labs to measure metamerism in fabrics: perceived changes in color under varied lighting conditions.

Speciality instruments developed for the dye and textile industries drove innovation and fueled competition between companies vying to create the most



Left: Launder-O-Meter at Althouse Customer Service Laboratory, c. 1960. Photographs from the Records of the Althouse, Bates, and Crompton Chemical Companies. Courtesy of Science History Institute.

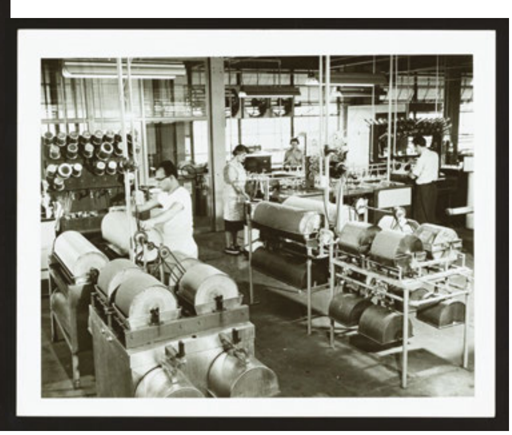
Right: Bausch & Lomb Duboscq Type Colorimeter, early 20th century. Courtesy of Science History Institute.

popular, durable new synthetic shades. *Bold* includes photographs of dye quality-testing laboratories from regional chemical firms, including the former Customer Service and Quality Control Laboratory at the Althouse Chemical Company plant in Reading, Pennsylvania. In various images, visitors will see technicians conducting vat tests with yarn, or gauging the colorfastness of dyes during a wash cycle in the Launder-O-Meter. (Yes, that's really what that instrument was called!) Althouse was founded in 1915 by C. Scott Althouse (1880-1970) as a small, family-owned firm specializing in fabric dyes. In the 1930s, it specialized in fade-resistant dyes for viscose rayon and dyes for DuPont's nylon products.

All of this industrial wizardry helped create synthetic dyes that were long-wearing and vibrant. But these advances came with a cost: *Bold*'s next section explores the "toxic beauty" of synthetic dyes and their effects on workers and our environment. As early as the 1890s, German physicians noticed increased cases of cancer—especially bladder cancer—among workers making synthetic dyes. Ludwig Wilhelm Carl Rehn's 1895 article, "Urinary Bladder Tumors Among Fuchsine Workers," argued that inhaling fumes sent noxious chemicals into the urine and kidneys. Further research proved that widely-used dyes derived from benzidine, naphthylamines, and others could cause tumors in animals and humans. Decades later, as the American dye industry boomed, American workers began to suffer the same ill effects. In 1934, company physicians from major chemical firms—including DuPont—joined

with doctors from across the East Coast for a symposium to determine causes for bladder cancer among dye workers. Studies revealed that 339 out of 2000 DuPont workers exposed to ß-naphthylamine during the years 1919 to 1955 were eventually diagnosed with bladder cancer. Many of the early dyes derived from coal tar were eventually phased out of production. Methyl violet, an aniline dye first synthesized by French chemist Charles Lauth in 1861 and later marketed under the name "Violet de Paris" or "Gentian Violet," was revealed to be dangerously carcinogenic: it's not

Left and Right: Dyeing Technicians at Work in the Althouse Customer Service Laboratory, c. 1960. Photographs from the Records of the Althouse, Bates, and Crompton Chemical Companies. Courtesy of Science History Institute.



Methyl Violet Dye Bottle, early 20th century. Courtesy of Science History Institute.

only a mutagen, but has “mitotic” effects that can alter or disrupt the division of organic cells. Synthetics like these pose a health hazard to humans, but also to other forms of organic life, when they’re released into the environment through the wastewater of dyeing.

Even though major environmental regulations have worked to decrease wastewater and runoff pollution from dyeing over time, many former 20th-century dye industry “boom towns” continue to suffer the after-effects. Toms River, NJ, is just one of them. In 1952, Toms River welcomed a massive new chemical plant, operated by the Swiss firm Ciba-Geigy. It produced millions of pounds of dyes and chemicals—and hundreds of new jobs. But local residents later realized that their water was being contaminated. In 1992, company executives confessed to dumping chemical runoff into landfills and local waterways, including carcinogenic benzene dyes. The effects spread for miles, sickening humans as well as wildlife. Millions have been spent on lawsuits and cleanup. To date, more than 10 billion gallons of polluted groundwater have been treated and recirculated, but that work will take another 20 to 30 years to complete. While cases like Toms River have become more isolated on American shores, dye pollution has not been eradicated. Dye manufacturing has shifted in part to the global south, to regions struggling to enforce environmental regulations—in essence ”outsourcing” the problem of dye pollution.

Southeastern China is currently one of the world’s denim capitals; its factories produce more than 300 million pairs of jeans per year and employ more than 220,000 garment workers. But this region also sits at the delta of the Pearl River—one of China’s largest and most vital river systems. So much denim wastewater and chemical runoff—including dyes, bleaches, and other additives—has entered waterways that certain waterways now appear indigo-dark in satellite images. A 2010 study by the environmental nonprofit Greenpeace discovered heavy metals (including cadmium, chromium, mercury, lead, and copper) in 80% of the water and sediment samples taken from the region. Journalist Dan Fagin observed connections between this part of China and places like Toms River, NJ in 2013, writing that, “The reality of 21st-century globalism… is that none of us can pretend that by pushing the chemical industry out of our communities we have stopped enabling its dangerous practices. The [chemical] industry jobs that started in Basel, and then migrated to Cincinnati and Toms River, are now in… coal-rich areas of China.”[1]

Bold’s final section shifts away from stories of toxicity and pollution to the question of sustainability and renewal: in a world of rising landfills and polluted waterways, where over 50% of fast-fashion purchases are discarded during their first year of use, how can individuals and communities make an impact? How

1 Fagin, Dan. “A Cancer Cycle, From Here to China.” The New York Times. January 11, 2013.

can reimagining our relationship to dyes and dyeing become part of a global revolution in fashion? Major international campaigns, such as Greenpeace's Detox My Fashion, the Clean Clothes Campaign (a global alliance of garment workers and health advocates), Fashion Revolution (a fashion sustainability non-profit), and the United Nations Alliance for Sustainable Fashion are working to set new standards for health, labor rights, resource management, and anti-pollution measures in the textile and garment industries. *Bold*'s vision of "sustainable futures" highlights these efforts and features case studies of innovative processes and innovative makers changing the way we think about fast fashion, natural and synthetic dyes, and textile manufacturing.

One case study features Green Matters Natural Dye Company, located in Lancaster County, Pennsylvania. Green Matters was founded to develop natural dye solutions for the fashion industry's manufacturing needs—without sacrificing the health of the planet. One initiative tackles food waste, by collecting avocado pits from commercial use and turning them into tannin-rich dyes. Green Matters also provides consumer education through natural dye tutorials and workshops. Founder Winona Quigley maintains that this work can help individuals "have the power to make their wardrobe more sustainable by understanding how to mend, dye and care for their garments."

Reclaiming traditional dye knowledge is another piece of the sustainability movement. In Japan, *kakishibu* dyeing uses fermented unripe persimmons to create amber-colored fabrics from their sun-reactive tannins. Persimmon dyeing's secret advantage is that it both colors and "finishes" cloth, making it more water-resistant, mildew-resistant, and insect-repellant. It's also non-toxic, unlike synthetic coatings or insecticidal treatments; these unique qualities have inspired eco-conscious designers to seek more solutions from historical methods. *Bold* includes dyecloth and liquid dye from the Onomichi Persimmon Studio in Hiroshima Prefecture, established on the grounds of a former 100-year-old orchard.

In South Korea, indigo is sometimes called the "thousand-year color" for its long history and lasting beauty. Today, indigo is regaining popularity with artists, designers, and consumers: national initiatives such as the Naju-si Natural Dyeing Cultural Foundation, as well as independent companies like KINDIGO, are working to preserve, share, and teach traditional methods. *Bold* features natural dye kits produced and sold by KINDIGO, that encourage home dyers to participate in an organic dye revival by refreshing and personalizing their clothes without contributing to fast-fashion waste.

Natural indigo may be biodegradable and nontoxic, but it currently requires significant resources to grow, in the form of land, water, and labor. One future for natural dyeing may actually lie in the laboratory: vat-grown microbes that can produce high-quality, low-impact natural indigo dyes. Huue, a California-based dye startup co-founded by Michelle Zhu and Tammy Hsu, has begun producing "biosynthetic" indigo for the textile industry through engineered microbes. Genetically programmed to consume simple chemical building blocks—like sugars—these microbes produce an enzyme-based indigo dye. Huue claims its biosynthetic indigo exhibits "five times less toxicity potential" than other synthetic indigos, and can be adopted as "one-to-one" solution for manufacturers. Future combinations of bioengineered dyes and other environmentally beneficial manufacturing standards—such as low-water dyeing and washing techniques—may soon mean that one of the most globally popular garments, blue jeans, is no longer also one of the most environmentally harmful.

The history of humanity's long journey to capture color is still being written. Our drive to imitate the rainbow, and to innovate beyond it, has fueled chemical industry, avante-garde fashion, and creativity in every form. As the painter Andrew Wyeth once remarked, "If one could only catch that true color of nature—the very thought of it drives me mad." We hope that *Bold* will provide visitors with an accessible entry-point to global dye stories and the urgent contemporary conversation around synthetic color and its impacts, but we also hope *Bold* will inspire and fascinate. Color, after all, is a power: so how will you use it?

BOLD: Color from Test Tube to Textile is on view at the *Science History Institute* in Philadelphia, PA through August 2024. Visit sciencehistory.org for further information. https://www.sciencehistory.org/visit/exhibitions/bold-color-from-test-tube-to-textile/

Elisabeth Berry Drago is Director of Visitor Engagement, at the Science History Institute sciencehistory.org

The renaissance and evolving design of radical polymerization

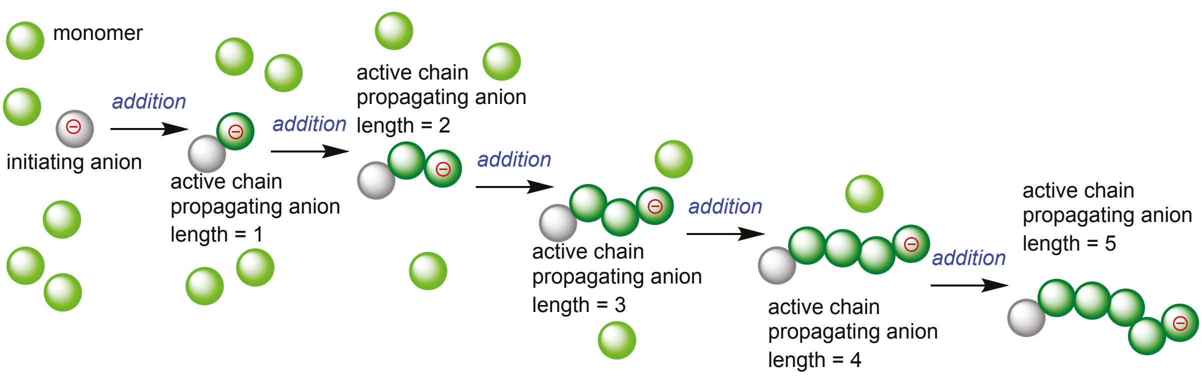
by Graeme Moad

During the 49th World Polymer Congress held 17–21 July 2022 in Winnipeg, Canada, Graeme Moad presented the Stepto Lecture Award [1], describing the mechanism and terminological evolution of reversible deactivation radical polymerization (RDRP) [2-4], including more recent intricate designs through the use of light and electrical propulsion.

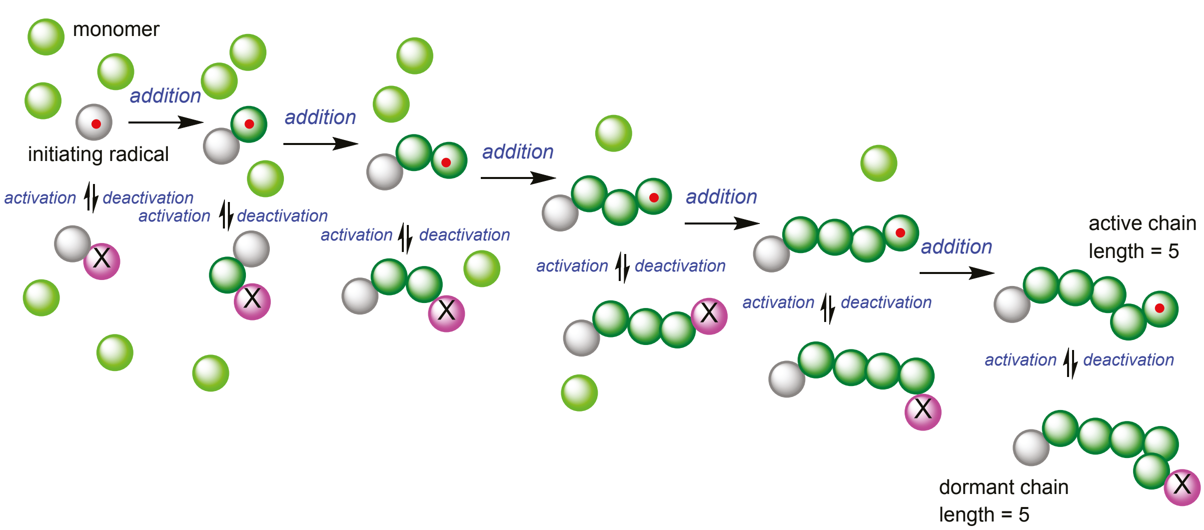
Polymers produced by living chain polymerization (Scheme 1) can have predictable chain length (calculated exactly as the ratio of monomer consumed to number of chains initiated), very low molar mass dispersity and very high end-group integrity. In a living polymerization, chain termination is absent. Despite much argument, this definition is absolute and will not tolerate any compromise.

Polymers produced by reversible-deactivation radical polymerization (RDRP, Scheme 2) can have predictable chain length (approximated as the ratio of monomer consumed to number of chains initiated), very low molar mass dispersity and very high end-group integrity. But they typically are not perfect! Even though they might not be always detectable, chain termination and other side reactions occur.

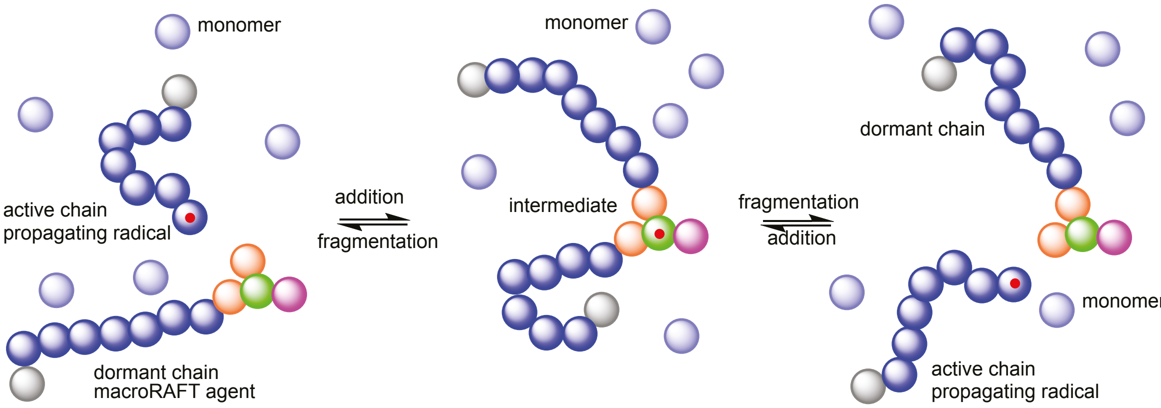
Perfection in chemistry is improbable. Living radical polymerization never was and (probably) never can be. This should not stop people striving for perfection, describing what perfection might look like, and IUPAC retaining the term living radical polymerization. Thus, we strive to achieve living radical polymerization, describe what living radical polymerization might look like, and we retain the term to describe a hypothetical ideal.



Scheme 1. Mechanism for living anionic polymerization. Reproduced from ref [3].



Scheme 2. Mechanism for reversible deactivation radical polymerization (RDRP). Reproduced from ref [3]. Termination reactions, which can occur, are not shown.



Scheme 3. Mechanism for activation–deactivation in reversible addition–fragmentation chain transfer (RAFT). Reproduced from ref [3].

Recent work on reducing incidence of termination during RDRP by manipulating the kinetics of radical polymerization includes taking advantage of:

1. The diffusional characteristics of propagating species.

- Very long chains really don't want to diffuse.
- Ultrahigh pressures slow down diffusion.
-

2. Compartmentalization effects in heterogeneous polymerization.

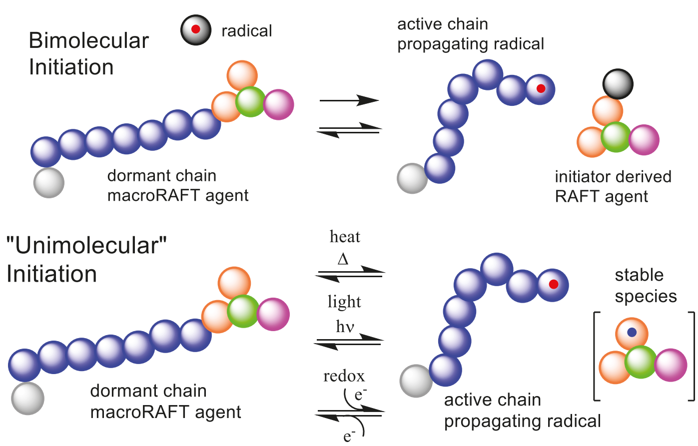
- Single propagating radicals in isolation show a reduced tendency to terminate.

Both strategies have allowed synthesis of low dispersity, high end-group fidelity, polymers by RDRP that can continue to grow to an average molecular weight M_n greater than 10^6 g mol^{-1}. We will return to this topic.

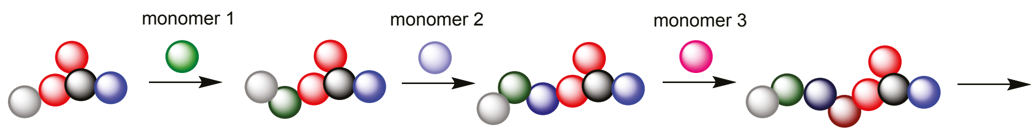
RAFT Polymerization

RAFT (or reversible-addition–fragmentation chain-transfer) polymerization is a RDRP polymerization is a RDRP where activation-deactivation is by reversible-addition-fragmentation chain transfer (Scheme 3). An example is polymerization in presence of an appropriate thiocarbonylthio compound (the RAFT agent), chosen such that chain transfer is very much faster than propagation, and fragmentation and reinitiation are not rate determining. RAFT is then a mechanism for equilibrating polymer chains so that, on average, all chains grow at the same rate and all chains are approximately the same size.

Radicals are neither formed nor destroyed in the RAFT process. Forming polymers by RAFT polymerization requires some form of initiation (Scheme 4). Historically this has, most commonly, involved adding an initiator as a source of radicals (Scheme 4a). However, radicals can also be formed directly from the RAFT agent, thermally, photochemically or in a redox process (Scheme 4b).



Scheme 4. Mechanisms for forming radicals directly from a macroRAFT agent through heating, irradiation, or in a redox process. Scheme 4b is reproduced from ref [3].



Scheme 5. Iterative synthesis of discrete oligomers by RAFT SUMI, by sequential addition, one unit at a time.

Recent Developments in Photoinitiated Reversible Addition Fragmentation Chain Transfer – Single Unit Monomer Insertion (RAFT-SUMI)

These methods are crucial to the success of photoinitiated reversible addition fragmentation chain transfer – single unit monomer insertion (RAFT-SUMI) and the use of iterative photoRAFT SUMI for the synthesis of sequence-defined oligomers [5], wherein the organisation of monomers is precisely defined at the level of the individual units that comprise the polymer chain.

Numerical Simulation of RAFT Polymer Synthesis using a Method of Partial Moments

Numerical simulation of RAFT polymerization is rendered complex by the large number of different polymeric species. In addition to the propagating species and the dead chains formed by their combination, disproportionation, or irreversible side reactions there are the macroRAFT agent and the various intermediates. Expressions were derived to enable rigorous evaluation of the complete molar mass distributions of these, where shorter chains (*e.g.,* N < 200 monomer units) are treated discretely while longer chains (*e.g.,* N ≥ 200 units) are not neglected but are explicitly considered in terms of the partial moments of their molar mass distributions [6]. That for the macroRAFT agent is illustrated in Scheme 6.

This methodology has been applied to compare initiation of RAFT polymerization by conventional methods using an added thermal initiator and direct photoinitiation. It is important to remember that the rate of termination depends on the concentrations of propagating radicals not on how those radicals were generated. Thus, for the same rate of polymerization one has a similar rate of termination.

Electrochemically-initiated RAFT polymerization - eRAFT

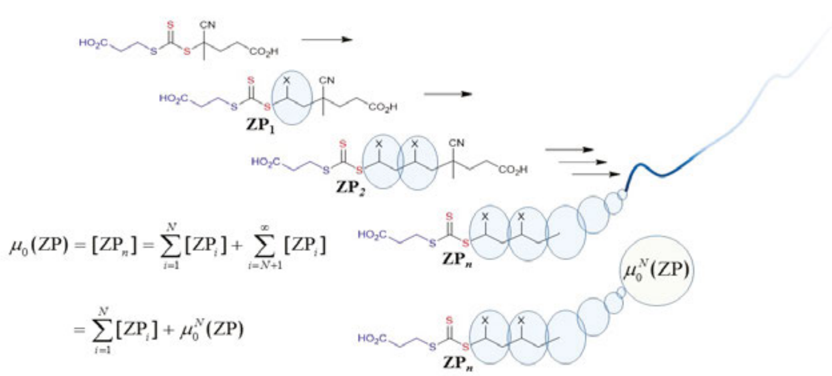
Three methods examined for electrochemically initiated RAFT polymerization (eRAFT) involve:

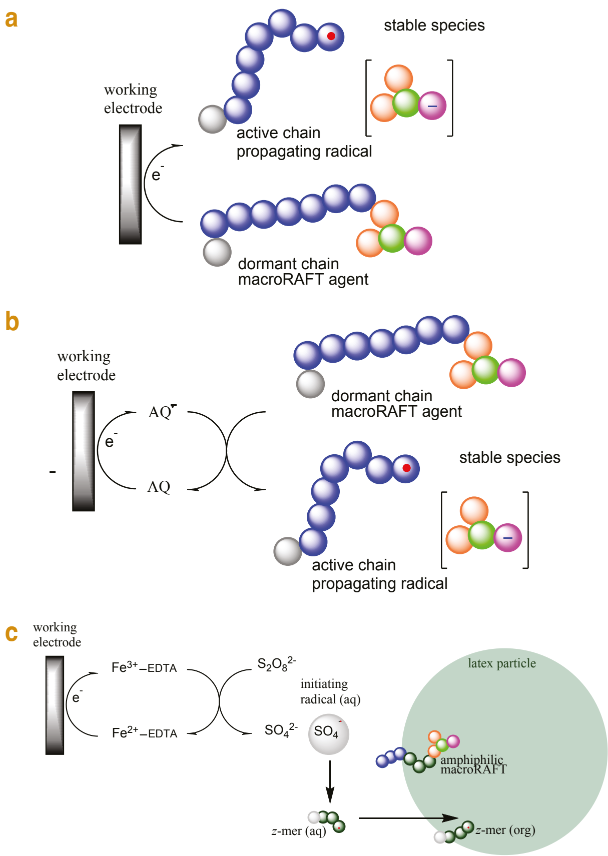
- Direct electrochemical reduction of the (macro) RAFT agent [7]. Low-energy negative ion mass spectrometry and theoretical calculations show that the radical anion formed by electron attachment should give the desired chemistry [8]. However, side reactions at the electrode prevent the being a from becoming method for initiating eRAFT. (see Scheme 7a)
- Mediated electrochemical reduction of RAFT agent [9]. The use of a mediator means that reduction of the (macro)RAFT agent and radical formation occur away from the electrode and mitigate the possibility of secondary reactions. A slow rate of fragmentation of the radical anion intermediate limits the scope of the process. (Scheme 7b)
- Electrochemical generation of initiating radicals (in emulsion polymerization) [10,11]. Our initial experiments on *ab initio* eRAFT in emulsion worked in providing rapid synthesis to a product with low molar mass dispersity but were compromised by poor latex rheology. (Scheme Fig 7c)

Efficient Synthesis of Multiblock Copolymers via MacroRAFT-Mediated Emulsion Polymerization

The last five years have seen major advances in multiblock copolymer synthesis by thermally initiated seeded RAFT emulsion polymerization, which are summarized in a recent review [12]. These developments take advantage of "nanoreactor concept" and the inherent compartmentalization effects to provide optimized conditions for multiblock copolymer

Scheme 6. In the method of partial moments, the macroRAFT agent species (ZP_n) are treated discretely when chain length is smaller than *N* but only in terms of the partial moment [$\mu_x^N(ZP)$] when chain length is longer or equal to *N*. Other polymeric species are treated similarly. Illustration reproduced from ref [6].





Scheme 7. Illustration of eRAFT in Emulsion. Reproduced from ref [10].

synthesis by sequential monomer addition. (Scheme 8) Compartmentalization results in a reduced rates of termination and consequently higher polymerization rates. Higher (near complete) monomer conversions with improved end group integrity obviate the need for purification of intermediate blocks. Thus, we have been able to prepare multiblocks with higher molecular weights, lower molar mass dispersities, unconventional block orders, and defined particle architectures. Colloidal stability of the seed is typically maintained without the use of a surfactant through the use of an amphiphilic macroRAFT, which also provides the basis for the formation of the nanoreactors [13-23].

The marriage of the nanoreactor concept for well-defined multiblock polymer synthesis with eRAFT initiation has produced a further significant breakthrough [11]. (Scheme 9)

Electrochemically-initiated RAFT polymerization – eRAFT in Emulsion

Success is attributed to the compartmentalization effects that act to reduce the impact of bimolecular termination and provide high rates of polymerization even of monomers with a low propagation rate coefficient (k_p), also reduce the irreversible consumption of RAFT agent and passivation of the working electrode. The eRAFT polymerization process was performed at ambient temperature; lower temperatures may be possible. This offers clear advantages when low boiling monomers (*e.g.,* butadiene), temperature-sensitive monomers (*e.g.,* epoxy functional), or systems comprising biomolecules susceptible to denaturation are used. A further advantage of the eRAFT process relates is that initiation can be turned off or on at the flick of a switch or precisely controlled by adjusting current. This temporal control enhances multiblock synthesis by enabling the process to be halted at a chosen conversion (*e.g.,* to remove samples for analysis) or at complete conversion to be restarted for subsequent monomer additions. The process is demonstrated with the one pot synthesis of a triblock, poly(butyl methacrylate)-*block*-polystyrene-*block*-poly(4-methylstyrene) [PBMA-*b*-PSt-*b*-PMS], and a tetrablock, poly(butyl methacrylate)-*block*-polystyrene-*block*-poly(-styrene-*stat*-butyl acrylate)-*block*-polystyrene [PBMA-*b*-PSt-*b*-P(BA-*stat*-St)-*b*-PSt], each block with high monomer conversion (> 95%), low molar mass dispersity ($Đ < 1.115$) as free-flowing, colloidally stable latexes [11].

Outlook

RDRP and RAFT polymerization were invented 30 years ago bringing new life to radical polymerization, then considered a mature technology with few prospects for further development. The renaissance continues, as the methodology continues to evolve, enabling current and future technologies.

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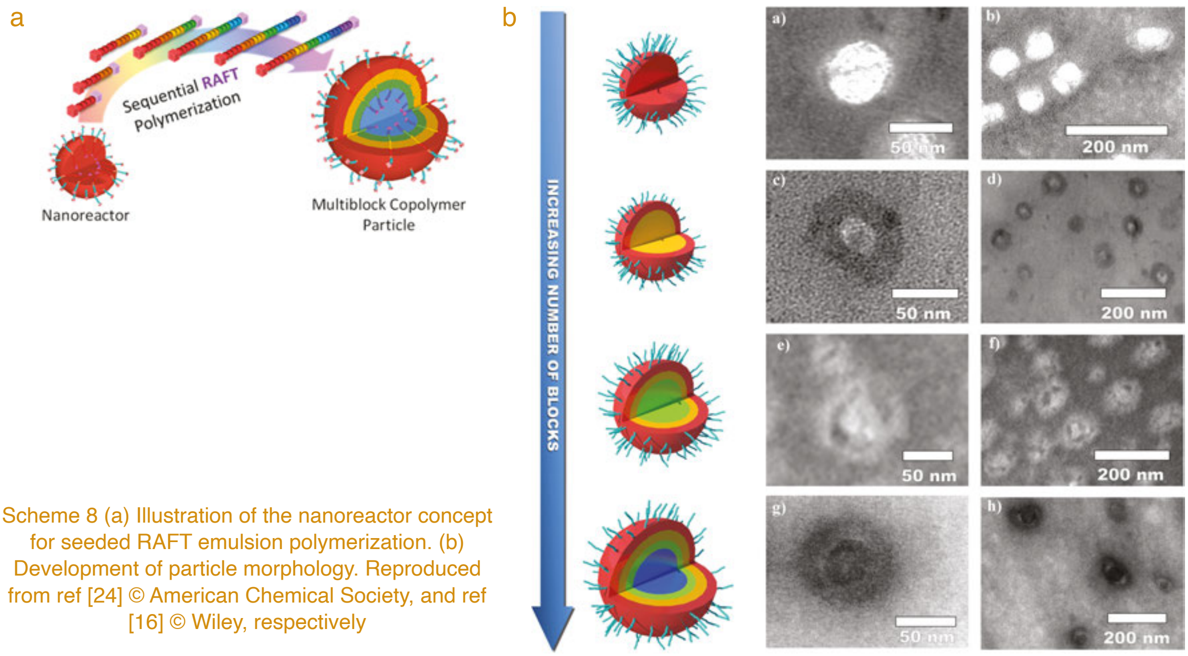

Scheme 8 (a) Illustration of the nanoreactor concept for seeded RAFT emulsion polymerization. (b) Development of particle morphology. Reproduced from ref [24] © American Chemical Society, and ref [16] © Wiley, respectively

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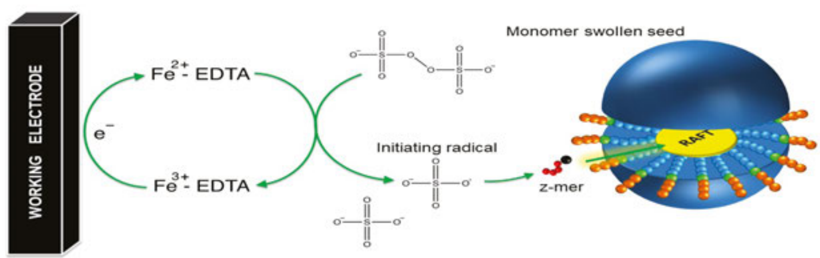

Scheme 9. Illustration of electrochemically initiated seeded RAFT emulsion polymerization. Reproduced from ref [11].

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The Stepto Lecture Award

The Stepto Lecture Award was established in 2016 to honour Bob Stepto, who was a substantial contributor to the IUPAC Polymer Division over several decades, including as Chair of the Commission on Macromolecular Nomenclature (now the Subcommittee on Polymer Terminology) for the period 1991–2000 and then as Chair of the Polymer Division over 2002–05 [1]. Bob was also an outstanding polymer scientist, with over 300 publications to his name, and a friend and mentor to many, both within and outside of IUPAC.

The award comprises a special plenary lecture at Macro meetings. The winner should not only be an exceptional polymer scientist recognized as a true world leader in his or her research field, but—in the true spirit of Bob—should also have made an indelible contribution to the polymer science community beyond the research domain, whether through IUPAC and/or by other means. The inaugural winner of the Stepto Lecture Award at Macro2016 in Istanbul was Michael Buback. Following this, Chris Ober received the Award at Macro2018 in Cairns and Tony Ryan at Macro2020+.

The next Stepto Lecture will be presented in July 2024 during the 50th World Polymer Congress that will take place at the University of Warwick, in Coventry, UK. (www.macro2024.org)

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Graeme Moad's first connection with IUPAC was as an observer at an polymer meeting in Berlin in September 1982. However, his IUPAC career began with the Santa Margaretha Ligure meetings on Radical Polymerization in 1987 and 1996, which saw the birth of what is now the IUPAC Polymer Division Subcommittee for Modeling of Polymerization Kinetics and Processes. In 2001, he was coerced by Bob Gilbert to join the Polymer Division Subcommittee for Polymer Terminology. He has played an active role in both subcommittees since that time. He was a titular member of the Polymer Division 2012-2015, an associate member 2016-2021, a leader or member of various projects, and remains an active member of the Division.

Two Young Observers at the WCC in The Hague Share Their Reflections

by Mattias Wei Ren Kon, Jovern Teo, Fun Man Fung, and Marietjie Potgieter

The IUPAC World Chemistry Congress (WCC) in The Hague attracted delegates from all locations and all ages to share exciting research, new insights and recent developments, and to build new relationships. Among them were two students from a STEM specialisation high school in Singapore who came to present a poster on their research project, Mattias Kon and Jovern Teo. They share their reflections on the experience in this article, conversing with Marietjie Potgieter, chair of the Committee on Chemistry Education.

Marietjie: Most of the members of the Committee on Chemistry Education have regular encounters with younger students, but still your attendance at the IUPAC General Assembly might have surprised a few. Let us start with introduction.

Mattias: My team and I are from Singapore, an island country and city-state in Southeast Asia. We completed our tertiary education diploma at the NUS High School affiliated with NUS (National University of Singapore) which specialises in mathematics and the sciences. Most of us have deep-rooted ties with maths and science stemming from a young age, and various primary school competitions have converged us towards our school where we could thrive in an environment alongside like-minded individuals.

Last year, Jovern Teo, Panshul Sharma, and I collaborated with our research mentors, Fun Man Fung and Yulin Lam in their Organic Chemistry education research as researchers under the SCIENTIA programme. We were brought together by our common love for the subject matter, a desire to contribute to chemistry education to improve the learning experience for our juniors, and of course a drive to step outside of our comfort zone and attempt formal pedagogy research.

SCIENTIA is a programme encouraging the mentorship of NUS High School students in science research by both external researchers and internal teacher mentors. NUS High School believes in the authentic learning experience such innovation provides, and through SCIENTIA we were also able to receive the support of Yun Ling Teh and Sher-Yi Chiam as our teacher mentors.

We were all introduced to Chemistry in Grade 7 through the foundational concepts of periodicity, the elements, and states of matter. Two years later, I concluded that Chemistry was my favourite science and it was what I hoped to pursue further over the upcoming years. To do just that, I was accepted into my school's Chemistry Olympiad training team in Grade 8. Since then, I remained an engaged learner till Grade 12 when all three of us took part in the final selections to represent Singapore in the International Chemistry Olympiad [1,2].

Our experience and exposure to advanced content enabled me to have great fun when learning Chemistry throughout high school. However, despite my pleasant memories doing Chemistry and the welcoming environment of IUPAC, a shadowing experience in healthcare convinced me that perhaps I would prefer to engage and care for others for the rest of my life. Thus, I aim to pursue Medicine at NUS.

Jovern: In our STEM specialised school, I was able to delve into different Olympiads—namely Biology, Chemistry, and Physics - and decided to focus on the Chemistry Olympiad from Grade 9 onward. As the central science, Chemistry interfaces with both Biology (biochemistry, protein folding, chromatography) and Physics (quantum mechanics, material science); and thus, is the most interesting to me. Through the pandemic years, I embarked on previous dry lab research projects such as pandemic modelling and motion tracking controls to seek solutions to life-changing circumstances. We believe a multidisciplinary exposure to research with statistics, programming, and computational science came in useful when our team of three aimed to better analyse and present our findings in this Organic Chemistry pedagogy project which aspires to gamify the learning process.

I feel that education and knowledge empowers, and this applies even to healthcare and well-being. To enhance health literacy, I volunteer actively at community outreach events and coach at-risk residents living with chronic conditions as a health peer for preventive healthcare. Currently, I am challenging myself in a range of medical and healthcare environments like wet lab microbiology research and various clinical patient settings to explore if a medical career rooted in clinical research can be right for me.

From 2024, all our team members have to enlist in the Singaporean military before we embark on our further studies, but we are also committed to following up on our Organic Chemistry pedagogy research while being actively involved in Chemistry Olympiad training and science research mentorship for juniors as time allows.

Mattias Kon (middle row, far right) and the Committee for Chemistry Education at the IUPAC General Assembly 2023.

Marietjie: How did it come about that you submitted a poster abstract for the WCC and what did you expect to gain from it?

Mattias: We came together to work on the development and trial of a digital, multiplayer Organic Chemistry game, ChemPOV [3]. The three of us (Jovern, Panshul and myself) feel passionately about improving the learning experiences of our peers and juniors, and believed in ChemPOV's ability to re-define this. Our mentor, Dr. Fung, encouraged us to submit an abstract to IUPAC WCC 2023. Having been to the American Chemical Society (ACS) Spring Meeting earlier this year, we were hoping this conference would broaden our horizons further. Jovern and I wanted to get to know more chemists from around the world and forge meaningful friendships. Of course, we also wanted to spread the word of ChemPOV to others, obtain valuable feedback from experienced industry experts, and rally support from those who believed in our cause.

I arrived in time for the General Assembly and initially popped by the Committee for Chemistry Education (CCE) to send regards and deliver gifts on behalf of Dr. Fung who couldn't attend the WCC due to academic obligations, but the warm and welcoming environment created by you [Prof. Marietjie Potgieter, CCE Chair], as well as the other key members of the CCE encouraged me to stay on further throughout the weekend. I was even kindly invited to the CCE dinner in which a fellow observer, Aaryan Singh,[1] and I had conversations with numerous CCE members and learned more about their fields of Chemistry. To say it was meaningful and enriching would be an understatement.

Jovern: Firstly, my motivation for attending the WCC with Mattias was propelled by my desire to appreciate the resources available to professional scientists and observe how they network, collaborate and create. Secondly, I wanted to understand how scientists approach their research goals. Having participated in national and regional science fairs since Grade 8, I feel that student science fairs in general tend to distinguish winners from non-winners, much unlike the nature of professional research. I wished to witness how scientists glean insights from challenges, and proceed with or pivot their research direction in the face of obstacles. Thus, when Dr. Fung shared about IUPAC, I was eager to take part so that I could grow from the experience.

Marietjie: How did you manage to come to The Hague to attend the General Assembly and the WCC (this was surely a costly exercise) and what are your impressions of the experience?

Mattias: My mother was always willing to support me with regards to my interests and financed our trip to The Hague. The IUPAC 2023 planning team did such a splendid job in securing sound partnerships with key hotels that participants like myself were readily able to book good-quality ones at competitive rates.

The General Assembly introduced me to a series of works undertaken by the CCE, and my takeaways were vast. I was introduced to the various branches

1 See Up for Discussion, p. 36

of the CCE dedicated to honouring educators, developing new project ideas, and future event planning (*i.e.* conferences), just to name a few. The one that resonated with me the most was the CCE-supported Community Service Projects. As an avid community service leader and volunteer myself, I felt extremely strongly towards the lovely work pioneered by both Prof. Supawan Tantayanon of Thailand and Prof. Zuriati Zakaria of Malaysia, Small-Scale Chemistry in the context of underprivileged children in rural parts of Asia [4].I believe that as a Chemistry student, imparting the beauty of Chemistry to others who are less able to access it is among the most fulfilling tasks one can undertake. I would hope to be able to one day support this initiative, and it would mean a lot to me.

The WCC was extremely professional, extremely international, and unexpectedly, extremely comforting. Everyone around the building appeared so enthusiastic to approach one another and exhibit our shared love for Chemistry. Although everyone was new to us, the IUPAC community is so inherently supportive that many of whom we just encountered were willing to drop by our Poster Presentation and offer us feedback. One of them was Dr. Yvonne Choo from Xiamen University Malaysia, a fellow member of the International Young Chemists' Network (IYCN), who I first met on Day 1 of the General Assembly [5,6].

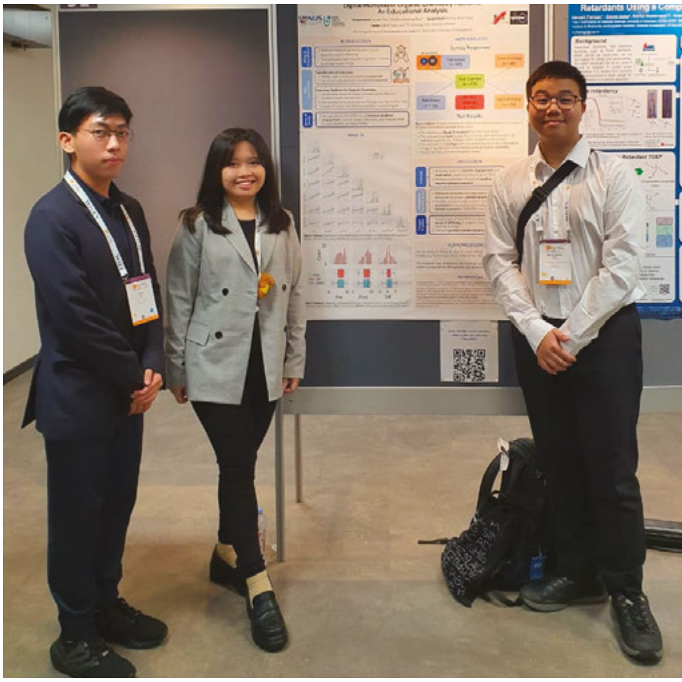
This was surprising to me because I feel that Singaporean culture does not actively encourage stranger-stranger interactions, and our society is considerably more conservative regarding pleasantries and informal communications. I felt at home striding into the World Forum every morning, and the people at IUPAC are truly the ones who have made my experience such a memorable one.

Jovern: I convinced my parents to visit their close friends who live in The Hague. They were most kind to put us up at their home which was serendipitously just minutes away from the congress venue. Like Mattias, my parents are greatly supportive of my interests. Furthermore, the win-win proposition that 'child attends conference while parent does sightseeing with friends' sweetened the deal. I took full advantage of the excellent cycling infrastructure and amazing summer weather by cycling or scooting across the Scheveningse Bosjes park daily. As the WCC was equipped with world-class amenities, I was able to leave my scooter at the luggage hold area for the day. I really cherished my time there experiencing Chemistry as a professional while commuting like a local resident.

Overall, the congress was fun. It was in the Goldilocks Zone in terms of set-up—not too big, not too small, but just right—so it was convenient transiting between different sessions. Exploring the enjoyable talks in computational science, education, sustainability efforts, and biology enabled me to develop a more thorough grasp of emerging innovations and recognize chemistry's foundational importance to practical solutions in the real world.

For example, Prof. Grzybowski's work on AI-generated synthetic pathways for complex natural products accelerates drug discovery at an unforeseen pace [7]. It was further adapted to upcycle chemical waste with positive knock-on impacts to green initiatives. To me, this was a fascinating testament to the potency of interdisciplinary synergies. There was also an openness about admitting to mistakes in hypotheses or project processes. I feel this best highlights the true spirit of scientific inquiry, where unanticipated results are in fact the truly desirable discoveries as they teach you about something you don't already know.

I found the plenary talks accessible and informative, helping me gauge my interest in evolving trends across various fields, such as polymer design, catalysis, and more. The youth program presented valuable perspectives into the diverse career paths stemming from a scientific education. It explored seldom-discussed mental health challenges and even showcased diverse opportunities accommodating various capacities and



Jovern Teo and Mattias Kon with Dr Yvonne Choo of Xiamen University Malaysia at our poster.

age profiles within research groups all over the world. Finally, I had the incredible opportunity to connect with new individuals and explore exciting locations. I paid the Shell Energy Transition Campus in Amsterdam a visit as part of the IUPAC WCC program, and after the concluding day of the congress, I enjoyed Scheveningen Beach alongside newfound friends from the International Younger Chemists Network (IYCN).

Final Words

Mattias and Jovern: The IUPAC WCC was the first scientific conference we participated in on our own. We experienced both the in-depth theoretical side of Chemistry and were able to meet many new people. We want to thank our school, our research mentors, and our parents for their support and the opportunity to go overseas. We also want to thank IUPAC for the wonderful conference and Chemistry International for this opportunity to share our story.

Acknowledgements

Mattias, Jovern, and Fun Man would like to convey our gratitude to NUS High School, NUS Faculty of Science, and NUS IT for their support, especially Assoc. Prof Yulin Lam, Dr. Yun Ling Teh, Dr. Sher-Yi Chiam, and Panshul Sharma.

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Jovern Teo (third row, middle) with fellow IUPAC participants at the Energy Transition Campus Amsterdam (pict by Nine Gerrits, KNCV junior project manager).

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The 2024 IUPAC-Richter Award Goes to Craig M. Crews

Craig M. Crews has been awarded the 2024 IUPAC-Richter Prize in Medicinal Chemistry. Crews is a Professor in the Department of Molecular, Cellular and Developmental Biology and Professor of Chemistry and Pharmacology at Yale University. His discovery and implementation of the PROteolysis TArgeting Chimeras (PROTACs) technology for removing specific unwanted proteins revolutionized the field by identifying a new method for affecting protein function. The fact that this technology has been widely adapted and investigated not only within the pharmaceutical industry, but also in academia, demonstrates the significance and impact of this work. While no drugs have yet been approved, several are in development and these molecules are progressing, because they are effective and safe. He also played a key role in the discovery of carfilzomib, an approved proteasome inhibitor for the treatment of multiple myeloma. The acceptance lecture will be held in Rome, Italy (1-5 September 2024) at the XXVIII EFMC International Symposium on Medicinal Chemistry.

This year marks the tenth occasion of the IUPAC-Richter Prize, which was established in 2005 by IUPAC and Richter PLC. Awarded biannually, the awardee is announced by IUPAC, following nominations and the decision of an independent international selection committee. The lecture in which the prize is awarded occurs alternatively in Europe and in the United States. The awardee receives a prize of USD$ 10 000, which is sponsored by Richter PLC, and a plaque, presented by IUPAC. The previous awardees are: 2006: Malcolm FG Stevens (UK), 2008: Jan Heeres (Belgium), 2010: Arun Ghosh (USA), 2012: Stephen Hanessian (Canada), 2014 : Helmut Buschmann (Germany), 2016: Michael Sofia (USA), 2018: Peter Grotenhuis (USA), 2020: John Macor (USA), 2022: Michael E. Jung (USA).

https://iupac.org/what-we-do/awards/iupac-richter-prize-medicinal-chemistry/

Science as a Global Public Good

In December 2023, the International Science Council (ISC) appointed 100 new Fellows, in recognition of outstanding contributions to promoting science as a global public good. Among them is former IUPAC President, now Past President, Professor Javier García Martínez, and former Bureau member Professor Ghada Bassioni. The Fellowship is the highest honour that can be conferred on an individual by the ISC. Together with the 123 individuals that were appointed in 2022, the new ISC Fellows will support the ISC Council in its mission at a critical moment for science and sustainability for science as we enter the UN's International Decade of Sciences for Sustainable Development (IDSSD) in 2024.

The new Fellows include eminent social and natural scientists, engineers, and thought leaders who have made impactful contributions to science and society. They

Javier and Ghada in September 2022, during the 9th IUPAC International Conference on Green Chemistry, in Athens hail from different countries and regions, disciplines, sectors, and career stages; having been nominated by ISC Members and existing Fellows, and by partners.

Ghada Bassioni a Egyptian chemist and Global Young Academy (GYA) alumnus, reacted to the announcement also by recognizing her IUPAC involvement; she observed that “Science makes a substantial contribution to our comprehension of the world and provides solutions and answers that help millions of people worldwide. Being part of IUPAC has enriched me with so many different experiences and has taught me that when it comes to scientific matters, one person’s reasoning overrules the opinion of a thousand. I look forward to continuing my scientific journey within the ISC community and amplifying the voice of science.”

During his IUPAC presidency, Javier García Martínez became intimately familiar with the ISC mission. Reacting to ISC honour, he commented that: “Being an ISC Fellow is not only a great honor, but above all a commitment to create a better, fairer and more sustainable future through evidence-based decisions and international cooperation. At IUPAC, we work toward this goal every day, thanks to our international network of volunteers and side by side with other scientific unions and academies around the world.”

See ISC detailed release <https://council.science/current/blog/isc-appoints-100-new-fellows/>

IUPAC Emeritus Fellows 2022-23

The Divisions of IUPAC may award the status of Emeritus Fellow to former members of the Divisions and its erstwhile Commissions and Subcommittees who have made outstanding contributions to IUPAC and, through chemistry, to the chemical sciences in general. The appointment of Emeritus Fellow reflects the member standing as a scientist and continuing service to the divisions and to the Union.

The IUPAC bio of each Fellow is presented online. The range of expertise they represent is remarkable. Averaging 30 years of membership to IUPAC, the contribution of each and every Fellow is invaluable for the Union. IUPAC is grateful for their dedication and service.

The next class of Emeritus Fellows will be presented at the end of the current biennium. The 2022-23 class of Emeritus Fellows is pictured on right.

The 2022-23 class of Emeritus Fellows includes:

Janos Fischer

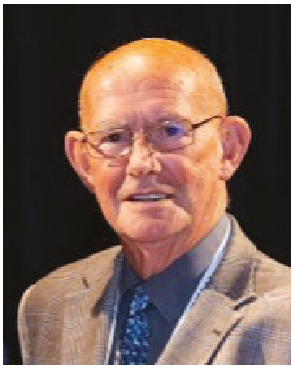
Jan Labuda

Lars Öhrström

M. Clara F. Magalhães

Willie Peijnenburg

Ken Racke



Jan Reedijk

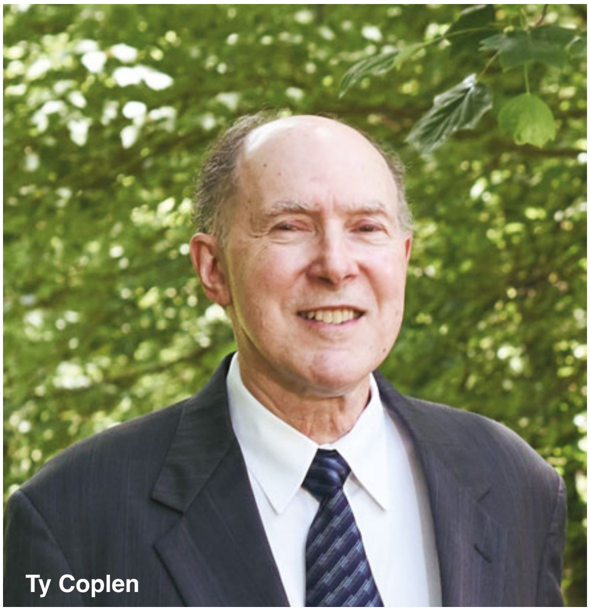
Nicola Senesi

- Janos Fischer (Hungary) (Chemistry and Human Health Division)
- Jan Labuda (Slovakia) (Analytical Chemistry Division)
- M. Clara F. Magalhães (Portugal) (Analytical Chemistry Division)
- Lars Öhrström (Sweden) (Inorganic Chemistry Division)
- Willie Peijnenburg (Netherlands) (Chemistry and the Environment Division)
- Ken Racke (USA) (Chemistry and the Environment Division)
- Jan Reedijk (The Netherlands) (Inorganic Chemistry Division)
- Nicola Senesi (Italy) (Chemistry and the Environment Division)

For more details, see https://iupac.org/who-we-are/emeritus-fellows/

Ty Coplen received a US Presidential Rank Award

Ty Coplen, a long time member of IUPAC and in particular of the Commission on Isotopic Abundances and Atomic Weights, has been presented with one of the 2023 Presidential Rank Awards (PRA) chosen by President Joe Biden. The PRAs are one of the most prestigious awards in the career civil service, recognizing the important contributions of public servants across the US federal government.


Ty Coplen

On December 7, 2023, USGS hosted a live, virtual Honor Awards Ceremony. David Applegate, the Director of the U.S. Geological Survey presented the awards with the following citation:

Tyler Coplen's wide-ranging research uses isotope measurements to study water resources, environmental quality, paleoclimatic research, and forensic science, resulting in more than 200 peer-reviewed publications and one patent. In 1978, he started the Reston Stable Isotope Laboratory of which he is now the director within the Water Resources Mission Area's Laboratory and Analytical Services Division. From 2009 to 2013, he served as lead for the USGS and Department of the Interior on the National Science and Technology Council's Subcommittee on Forensic Science, advising the White House Office of Science and Technology Policy and other bodies of the Executive Office of the President on forensic science in homeland and national security and in the criminal justice system.

To see the presentation, visit https://www.usgs.gov/honor-awards

One World Chemistry—IOCD Call for Volunteers

The International Organization for Chemical Sciences in Development (IOCD) is committed to working in partnership with others to ensure that chemistry fulfils its potential of contributing to sustainability for people and for the physical and biological systems of the planet. A new orientation, "One-World" Chemistry has been proposed, which recognises the interconnectedness of human, animal, and planetary health and embraces the need for chemistry to adopt systems thinking and crossdisciplinary working to tackle the planetary challenges.

IOCD is currently seeking volunteers for a range of roles. Opportunities include:

- Working Groups: joining an existing Working Group or establishing a new one
- Creating an activity on mentoring and professional development in the chemical sciences
- Evaluating essays in the framework of the IOCD annual Essay Competition
- Fundraising for the organization's operations
- Internal governance, organization, and management work, communications and external relations.

See details at iocd.org.

2024 Franzosini Prize and Balarew Award—Call for Nominations

In 1989 the Subcommittee on Solubility Equilibrium Data (SSED) inaugurated the Franzosini Award to assist a promising young contributor to the Solubility Data Project. In 2023 the Franzosini Award was renamed the Franzosini Prize and elevated to an award in recognition of outstanding and sustained contributions to the field of critical evaluation of data in solubility and related chemical equilibria. At the same time the Balarew Award was inaugurated to recognize an Outstanding Young Scientist working in the field of critical evaluation of solubility and/or related chemical equilibria.

Franzosini Prize Announcement

Nominations are invited for the Franzosini Prize, awarded in recognition of outstanding and sustained contributions to the field of critical evaluation of data in solubility and related chemical equilibria. The application can only be made by a sponsor(s). Each nomination form should be completed online and accompanied by a letter of support providing a brief statement of the nominee's achievements supporting their nomination, including a list of recent publications.

Winners of the Franzosini Prize will be announced during the International Symposium on Solubility and Related Equilibrium Processes (ISSP), in Novi Sad, Serbia, 9-13 September 2024. Each will give a research presentation during the ISSP. A brief description of their work will be published in *Chemistry International* and on the IUPAC website.

Balarew Award Announcement

Nominations are invited for the Balarew Award for an Outstanding Young Scientist working in the field of critical evaluation of solubility and/or related chemical equilibria. The application can only be made by a sponsor(s). Each nomination should be completed online and accompanied by a letter of support providing a brief statement of the nominee's achievements, supporting their nomination, including a list of recent publications.

Winner of the 2024 Balarew Award for Outstanding Young Scientists will be announced during the International Symposium on Solubility and Related Equilibrium Processes (ISSP). The winner will also give a research presentation during the ISSP. A brief description of the work developed by the awardee will be published in *Chemistry International* and on the IUPAC website.

The Nominations deadline for the Franzosini Prize and the Balarew Award is **31 May 2024**. Self nominations are not accepted.

For details, see https://iupac.org/2024-franzosini-prize-and-balarew-award-call-for-nominations/

InChI Changing Pace

The InChI Trust announces 2024 to be a year of transition for the International Chemical Identifier (InChI), which is already showing noticeable delivery.

In 2021-2023, the InChI Trust decided to significantly invest in creating additional roles for outreach and technical direction—spending from its reserves to accelerate InChI development and transition this to a more open and transparent model. This was followed by the sad passing of Igor Pletnev, the primary developer, in late 2021. Since then, much progress has been made transitioning the existing code to a GitHub environment, developing additional understanding of the code, fixing bugs and creating testing protocols that build on previous practice. This work has taken place at RWTH Aachen, supported by the NFDI4Chem project and the Volkswagen Foundation. The next "new" version of InChI—rebuilding the current version 1.06, cleaned-up and with additional bugfixes, is in testing and will be available for the IUPAC InChI Subcommittee and CPCDS to approve soon. The code now lives on GitHub; the Trust is also working through the governance needed for this new development model aligned with IUPAC.

In parallel, much has been achieved by the Working Groups and the IUPAC InChI Subcommittee in agreeing on the scientific requirements for extensions of the standard, and for implementation investigations to inform our technical roadmap.

The roadmap below covers both extensions to core InChI, and to InChI applications (RInChI (R for Reactions), MInChI (M for Mixtures), the web demo, and the resolver). Additional Working Groups are still considering their requirements.

In addition to the development resource at RWTH Aachen, the InChI projects will also be supported by cheminformatics expertise from a new position at the Beilstein Institute. The InChI Trust is very grateful for this in-kind support from these organisations, and partnerships such as these are a fantastic way to achieve step-changes in speed of delivery, building on the core financial support from the Trust's members, and input from IUPAC's expert volunteers.

Having drawn on the reserves to catalyse these activities, the Trust now needs to reduce its annual spend so this is covered by core revenue. Given the focus on the technical roadmap for 2024-2025, support towards technical oversight, coordination and planning is the first priority, and roles in other areas are being reduced. This refocus will enable the delivery of InChI enhancements that have been long desired by the user community and grow partnerships and member contributions that support further scientific activities to push the standard forward.

Quick links to noteworthy updates:

- The InChI code and releases—from the latest beta back to 1.03—are now available on GitHub, and future developments will be based on this refreshed and active codebase: https://github.com/IUPAC-InChI/InChI. Thanks to all who contributed to this fantastic effort.
- The Open Education Resource paper has been published in *Chemistry Teacher International*: https://doi.org/10.1515/cti-2023-0009. Thanks to Bob Belford and his working group. (See more p.32)

For updates, see https://www.inchi-trust.org/

IUPAC Standards Online—Free Access

IUPAC Standards Online is a database built by De Gruyter from IUPAC's standards and recommendations, which are extracted from the journal *Pure and Applied Chemistry* (PAC). "Standards" are definitions of terms, standard values, procedures, rules for naming compounds and materials, names and properties of elements in the periodic table, and many more. The database is the only product that provides for the quick and easy search and retrieval of IUPAC's standards and recommendations which until now have remained unclassified within the huge *Pure and Applied Chemistry* archive.

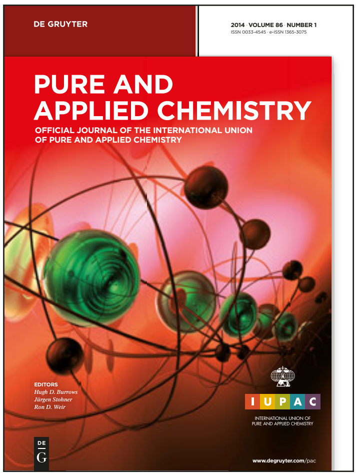
Secure your free access to IUPAC Standards Online until 31 December 2024.

Simply go to this page: https://www.degruyter.com/accessLink/IUPACdb2024 for activation. You will need a user account on degruyter.com to access the database; you will then have free access to all articles until the end of the year.

https://cloud.newsletter.degruyter.com/degruyterandiupac

PAC Open for Submissions

IUPAC and De Gruyter are pleased to announce that *Pure and Applied Chemistry (PAC)* now invites submissions of research articles and review articles.



By inviting the global community to submit their research to *PAC*, the journal supports IUPAC's mission to advocate the free exchange of scientific information, unite chemists worldwide, and ultimately advance pure and applied chemistry. Publication of IUPAC's formal Recommendations and Technical Reports remains by invitation only.

All submissions to *PAC* can be made via the online submission site. Detailed instructions for authors can be found on the journal homepage.

PAC is the flagship journal of the International Union of Pure and Applied Chemistry (IUPAC). *PAC* advances chemistry worldwide by publishing:

- IUPAC formal Recommendations and Technical Reports: This is where you will find the very latest IUPAC recommendations on data standards, nomenclature, and terminology. Next to the IUPAC Colour Books, PAC is the only authoritative source for IUPAC recommendations, which are published after an exceptionally rigorous review process to provide standards that you can trust.
- Research and Review articles that explore critical areas of development in chemistry
  PAC articles identify dynamic areas of chemistry with significant impact on global advancement. This is your source to remain at the forefront of chemistry.
- Special issues on emergent and topical concerns in the chemical sciences
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PAC provides the best examples of practical open chemistry, as a part of IUPAC's mission to provide the common language for chemistry and support the free exchange of scientific information.

For details, see https://www.degruyter.com/pac

Teaching Ethics and Core Values in Chemistry Education—Call for Papers

In October 2015, the The Hague Ethical Guidelines were adopted by OPCW and were endorsed by IUPAC 4 May 2016. In line with that development, attention has been focused on formulating core values for chemists, focusing specifically on the ethical aspects of the use of chemical knowledge, as well as the use of chemicals within the environment. There are many examples of misuse of chemical knowledge, as demonstrated in the TV series *Breaking Bad* focusing on the production of illicit drugs. Within chemical industry the use of (micro)plastics, the use and production of pesticides is another issue. Within education, codes of academic conduct have always played an important role. Recently more attention has been given in education to ethical use of chemical knowledge and the relationship between the use of chemically produced compounds, and the production of chemical compounds and the environment. This is demonstrated for example by the development of Green Chemistry.

A special issue devoted to education and outreach activities concerning ethical issues in chemistry is planned for *Chemistry Teacher International*. We are looking for good practices in the teaching and learning about ethics related specifically to the use of chemical knowledge, and the use of chemically produced compounds. This may be related to the use and production of chemical weapons, but also to the use of chemical knowledge related to the production of illicit drugs and undesired consequences of the production and/or use of materials and agrochemicals. The responsibility of each individual having obtained chemical knowledge should be made clear.

We are looking for articles of about 5000 words describing ways in which these issues are introduced in the classroom. In the article an analysis and evaluation of the effects of the introduction should be given. The article should be an invitation for other lecturers to use the described activities as a starting point in their own situation. In addition a review of literature about teaching ethics in chemistry will also be welcomed.

This special issue will be published in December 2024 and will constitute an outcome of IUPAC project 2023-026-2-050. For more information contact Jan Apotheker, J.H.Apotheker@rug.nl

https://iupac.org/teaching-ethics-and-core-values-in-chemistry-education-call-for-papers/

Inorganic Chemistry Division—Feb 2024 Newsletter

The Spring 2024 Newsletter of the Inorganic Chemistry Division is now available. It was compiled thanks to Division II members' input. Please keep sending your items, including pictures, or suggested topics for future issues, via email to the Newsletter Editor: Dan Rabinovich <D_RABINOVIC@uncg.edu>

Download PDF from https://iupac.org/inorganic-chemistry-division-feb-2024-newsletter/

Information about new, current, and complete IUPAC projects and related initiatives.
See also www.iupac.org/projects

InChI Open Education Resource

The InChI Open Education Resource (OER) (https://www.inchi-trust.org/oer/) is designed to provide educators and other interested parties with resources, training material, and information related to InChI. Currently, the OER contains over 100 materials collected from various sources and provides users with search, filtering, and sorting functionalities to locate specific records. New relevant materials can be suggested by anyone, allowing the scientific community to share and find InChI-related resources.

A (open access) paper published online 3 Jan 2024 in *Chemistry Teacher International* (https://doi.org/10.1515/cti-2023-0009) describes the InChI Open Education Resource (OER).

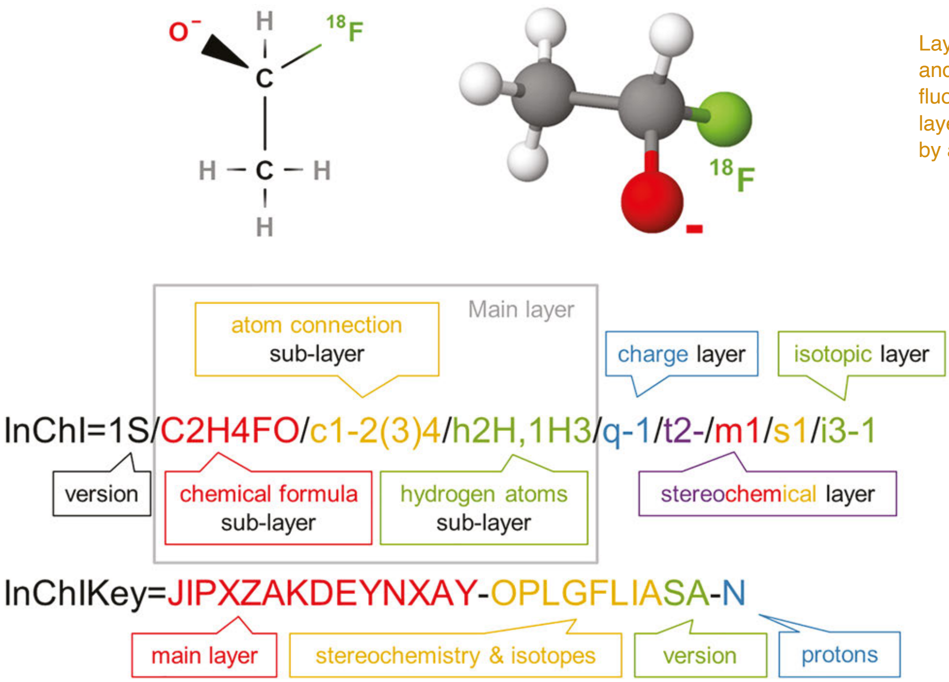
The paper shows how to use the InChI OER tag taxonomy to filter content, and demonstrates two resources within the InChI OER; the ChemNames2LCSS Google Sheet and the InChILayersExplorer, an Excel spreadsheet that breaks an InChI into its layers. While the InChI OER is of value to a broader chemistry community, this paper seeks to reach out to chemical educators and provide them with an understanding of InChI and its role in the practice of science.

For more information and comment, contact Task Group Chair Robert E. Belford <rebelford@ualr.edu> | https://iupac.org/project/2018-012-3-024

The Gender Gap in Chemistry—Building on the ISC Gender Gap Project

"Gender Gap in Chemistry, Still?!", one outcome of IUPAC project 2020-016-3-020 is published in the *Journal of Chemical Education* and co-authored by Hsiu-Yi Chao, John J. H. Lin, Mark Cesa, and Mei-Hung Chiu; https://doi.org/10.1021/acs.jchemed.2c00650 (7 Feb 2024)

The purpose of this study is to investigate differences between women and men in chemistry, as reflected in their responses to a global gender gap survey. The survey was conducted in 2018; responses from 1343 valid participants across the globe were collected and analyzed. The main results show that first, women were more likely to list their parents and themselves as important influences in their university studies than men. This result was consistent regardless of the Human Development Index (HDI, an index developed by the United Nations assessing the development of a country) and employment sectors. Also, men students reported more positive relationships and support from their advisors or supervisors than women. More women than men indicated that they had personally encountered sexual harassment at school or work. Also, in general, more men than women indicated that they had never experienced discrimination in the assessment or evaluation of their achievement across different HDI regions and in different employment sectors. Men



Layers for the standard InChI and InChIKey of (1*R*)-1-(^{18}F) fluoroethanolate. Note: each layer or sublayer is separated by a forward slash.

reported having more research resources than women. More women than men indicated that their careers had influenced their decisions about their children, marriage, or long-term partnership across high and low HDI regions and employment sectors. Finally, women submitted fewer journal articles than men in the past five years, and this gender difference was also seen in respondents from both high and low HDI regions and working in industry. In contrast, by employment sector, the gender differences were relatively small.

For more information and comment, contact Task Group Chair Mark C. Cesa or Mei-Hung Chiu <mhchiu@ntnu.edu.tw> https://iupac.org/project/2020-016-3-020

Medicinal Chemistry in Drug Discovery & Development, India

A new project of the Chemistry and Human Health Division supports the objective of the Medicinal Chemistry/Drug Discovery & Development India (MCADDI), which is to build and optimize a basic drug discovery & development course for industrial and academic scientists, including medicinal chemists, in India and other South Asian countries. The success of the 2019 program, partly supported by a IUPAC grant, and the feedback from the Industry and Academic groups, post COVID break of 4 years, strongly encourages the task group to continue our theme of applied chemistry education in relation to drug design and development. Biocon Academy (Bangalore, India) has generously agreed to host this event again in 2024 and will provide the access to their facility for the faculty and attendees. This 5-day course will broaden the focus of the program compared to the 2019 Course by adding new lectures on the use of special chemistry topics such as Heterocyclic and Fluorine Chemistry in Drug Discovery, and adding a lecture on antibody-drug conjugate (ADC) discovery and development.

The first part session of the course will be focused on the fundamentals of drug discovery and the second part will be focused on the application of new technologies in the drug discovery and development process. The 2024 program will dedicate a full day session to the discovery and development of biologic drugs, including antibodies, antibody-drug conjugates and therapeutic proteins. The increase in medicinal chemistry employment in Indian and southeast Asian pharmaceutical companies, and in Contract Research Organizations (CROs) collaborating with US and European companies, has created a vital need for chemists to acquire state of the art knowledge of medicinal chemistry and other closely related disciplines.

The performance and value of the MCADDI courses (2013, 2015, 2017, 2019) has been assessed by the participants and faculty, and has received positive feedback from both industrial and academic scientist in India. The 2024 course will also be assessed to determine whether to continue in the same format, or evolve the course further in order to meet the needs of Indian and Southeast Asian medicinal chemists. The desired outcome will be to enroll a new and broader set of drug discovery scientists from industry and academia. The number of participants would be about 100-120 from academia and industry, similar to the attendance in 2019, and the goal is to provide participants with a strong introduction to the fundamentals and practice of medicinal chemistry in drug discovery, including the use of tools such as computer-assisted drug design (CADD) and automated synthesis. The task group is planning to actively seek the participation of scientists from other South Asian countries such as Singapore, Malaysia, South Africa, *etc.*

For more information and comment, contact Task Group Chair Neel Balu Balasubramanian or William J. Greenlee https://iupac.org/project/2023-033-2-700

Advanced Technologies for Carbon Sequestration and Capture

This new project, building on the insights of the 'Harmonizing Carbon Sequestration Measurement' project (2022-010-2-600), aims to evaluate the efficacy of innovative carbon sequestration technologies. Originating from identified knowledge gaps in the previous project, it seeks to address issues on CO_2 emissions understanding, consistent accounting systems, and the necessity for novel mitigation measures.

The project will generate a state-of-the-art technical report on global carbon sequestration and capture (CSC) technologies. Key objectives include assessing the techno-economic aspects of promising CSC systems, evaluating recent advances in technologies like direct carbon capture and novel biofuels, employing expert judgment to evaluate credible CSC system models, and providing an impartial analysis of challenges and opportunities in CSC.

The project adopts a multidisciplinary approach, involving a systematic literature review, interdisciplinary analysis, critical evaluation, and technical expertise. It aims to synthesise recent insights, stimulate collaboration, and promote partnerships among technology providers and industries globally. Collaboration is anticipated across various IUPAC Divisions, ensuring a comprehensive review encompassing peer-reviewed articles, research papers, patents, and industry reports.

Critical evaluation includes criteria recommended by the harmonizing carbon sequestration measurement project, considering factors such as cost-effectiveness, scalability, energy efficiency, regulatory compliance and sustainability. The global perspective ensures relevance to an international audience, utilizing IUPAC's recognition and reach to disseminate findings and foster collaboration among diverse stakeholders and facilitate impactful global collaboration.

For more information and comment, contact Task Group Chair Diane Purchase <D.Purchase@mdx.ac.uk> | https://iupac.org/project/2023-023-1-600

Terminology and Symbolism for Mechanochemistry

Classical solution chemistry seems not to fit properly in the new paradigm of green chemistry, which is crying out for a drastic reduction in the use of solvents, improved atom-economy, energy and cost efficiency. Mechanochemistry fits this role.

Mechanochemistry studies the effects of mechanical energy forces on physicochemical changes and transformations. Rapidly growing, it has applications in various areas of research, including organic synthesis, materials science, nanotechnology, catalysis, and green chemistry. In 2019, IUPAC acknowledged mechanochemistry as one of the top ten technologies for a more sustainable future, recognizing its potential as an environmentally friendly option for developing new processes and materials.

Nevertheless, the expansion of mechanochemistry and the wide range of materials, equipment, methods, and practices involved, have made obvious the lack of standardization and clarity in its terminology and symbolism. The ScienceDirect overview of the subject alone contains over twelve descriptions that provide definitions of mechanochemistry. Curiously, although the IUPAC Compendium of Chemical Terminology (the Gold Book) describes a mechanochemical reaction as one “induced by the direct absorption of mechanical energy,” it leaves undefined just what constitutes “mechanical energy,” and there is only one reference to mechanochemical processes, namely relating to polymers and functional polymeric materials. Detailed terminology pertaining to mechanochemistry and related disciplines is lacking.

With the support of IUPAC, this initiative will establish uniformity in the terminology and classifications employed in mechanochemistry. Additionally, standardized symbolism will be proposed to facilitate communication within the mechanochemical community. The project, which involves multiple stakeholders, will result in recommendations that will contribute to a more organized development of the subject and enhance its visibility and credibility as a distinct and important branch of chemistry.

For more information and comment, contact Task Group Chair Evelina Colacino <evelina.colacino@umontpellier.fr> https://iupac.org/project/2023-034-2-100

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/

Definition of Materials Chemistry

Materials chemistry is focused on the design, preparation and understanding of innovative materials with useful properties. It is an emerging area of research where definitions are not well established. This document defines the area of materials chemistry for the benefit of chemistry communities and the general public worldwide interested in this discipline. This *provisional* recommendation defines the term "materials chemistry" as "Scientific discipline that designs, synthesizes and characterizes materials, with particular interest upon processing and understanding of useful or potentially useful properties displayed by such designed materials."

This Recommendation and its definition of materials chemistry is based on the IUPAC Technical Report of P. Day, L. V. Interrante and A. R. West [PAC. 81,1707 (2009); https://doi.org/10.1351/PAC-REP-09-03-02)]. The definition proposed there is continuously and gradually accepted within the chemistry community, confirming the authors' intention that "… in publications where a definition of materials chemistry is required, the proposed definition be used ….". However, some inconsistent understandings of materials chemistry persist among parts of the worldwide community, where some scientific journals have not been an exception, which may lead to contextual confusions. This Recommendation reflects findings in the 2009 Technical Report as well as the development since. The most prominent examples demonstrating the growing impact of materials chemistry upon interdisciplinary communities are the official scopes of two scientific journals, *Chemistry of Materials* (ACS Publications, ISSN: 0897-4756) and *Journal of Materials Chemistry* A, B & C (RSC Publications, ISSN 2050-7496). The scopes of both journals state that materials chemistry comprises "… focus on the preparation or understanding of materials with unusual or useful properties ..." and "… new understanding, applications, properties and synthesis of materials ...". This focus is topical, required, and applied from points of view of research, development, and application. It is implicitly of direct effect on society, as evidenced by subjects and contents of the majority of papers appearing in these journals. The definition of materials chemistry, and relevant understanding of this growing sector of pure and applied chemistry, is promoted also by the IUPAC, cf. the link to Materials Chemistry Education on the webpage <https://iupac.org/materialschemistryedu/>. The rule is that a new definition is endorsed in an IUPAC Recommendation. Only a verified and increasingly accepted definition is recommended and further promoted to the broadest audience possible through the worldwide network of IUPAC. Understandings (and definitions) of core areas of chemistry need to be clearly formulated and agreed upon in communities of chemists as well as in general public. This concerns also the emerging area of materials chemistry. Inconsistent understandings or definitions in education and research make the communication difficult. Thus, an agreed-upon and unified definition of "materials chemistry" may prevent confusions and provide common language in this area.

Comments by 31 July 2024

Corresponding author: Milan Drábik <milan.drabik@uniba.sk>

How Young Are You?

by Aaryan Singh and Marietjie Potgieter

During the IUPAC General Assembly in August last year, the Committee on Chemistry Education (CCE) saw the participation of young observers. (see also feature p. 22). One of them was even younger than usual: Aaryan Singh was only 17 year old. While Aaryan's participation might have appeared surprising at first, it was welcome by all in The Hague where the GA took place. Soon after the GA, Aaryan and CCE chair Marietjie Potgieter wanted to immortalize their first encounter by holding a short virtual interview. This short account is shared here with the hope of inspiring others to take part regardless of their age and experience.

Marietjie: Please tell us a bit about yourself…

Aaryan: Well, I just turned seventeen years old and am in my penultimate year of high school.

Home for me is Brewood, a small tranquil village in a county called Staffordshire in the centre of England.

Both my parents are anaesthesiologists, and they were the ones who initially sparked the scientific curiosity within me and have always supported me immensely with my academic pursuits. I have one older brother, who is nine years older than me, and even though we wind each other up, I look up to him massively. In my free time I love racquet sports, especially tennis and squash, and when I get the time, I am doing a little bit of songwriting as well.

Marietjie: What are your academic goals?

Aaryan: I received my IGCSE scores last year and I was very pleased. I am now focused on the International Baccalaureate in which I am pursuing higher level chemistry, physics, and mathematics. After that, I would like to go to university to get a degree and specialise in chemistry, before then pursuing higher education by doing a masters, followed by a PhD. I am interested in nanotechnology and electrochemistry at the moment, but I am so early on in my chemistry career that it may very well change. For me I know in the future I would like to be heavily involved in chemistry education, regardless of my job, just because I see how meaningful and rewarding the work is.

In the near future, having just joined, I am looking forward to becoming an active member of the International Younger Chemists Network (IYCN), a non-profit organisation that works closely with IUPAC, that has a very reputable mentoring program, and is currently a leading organisation for sustainable chemistry.

Marietjie: What is your dream for the future?

Aaryan: My dream is for students of all ages, all over the world, to have the same access to scientific opportunities. In my eyes, the direction humanity moves in will be heavily dictated by the cohort of our future scientists. We need scientists from all different countries and backgrounds to achieve the diversity of thought required for new innovation, which is necessary to tackle the challenges in the world at the moment.

I have already taken small steps in that direction. I have established a Science Outreach team within my region, who I have personally trained, and we run frequent workshops and events for children from all socio-economic backgrounds. Members of the CCE including Professor Uday Maitra have given me advice on these workshops that I would not have been able to acquire if it were not for connecting with them in the General Assembly (GA) in the Hague. However, I would like to do much more. That of course being why I am drawn to the CCE.

Marietjie: How did you first come across the CCE?

Aaryan: I have been part of the UK's Royal Society of Chemistry (RSC) since I was 12. Recently though, I wanted to gain an insight into what chemistry education was like on a global scale so, of course, the logical next step was to become a member of IUPAC and I have not looked back since. Once I was a member, I got in touch with yourself and you warmly welcomed me into the CCE as a young observer, inviting me to a virtual CCE meeting, in which I was introduced to the CCE team and then after that to the GA in The Hague, which has been one of my best experiences in my life. From this experience, I would recommend any fellow chemist to not hesitate to contact members of the appropriate Committee or Division of IUPAC that they are interested in, as everyone is amicable and approachable.

Aaryan: May I ask, what do you think young chemists can do to contribute to the CCE (what value do they bring)?

Marietjie: The participation of young chemists in all the activities of the IUPAC is vital for the organisation to remain relevant and focused. Young chemists bring energy, originality, surprising perspectives, and enthusiasm for the power of chemistry to solve difficult problems. They have little hesitation to ask troubling questions, or to reach out to sister disciplines for collaboration, and they instil a sense of urgency in established chemists to find solutions for the big challenges facing the planet.

Marietjie: Have you attended many IUPAC events?

Aaryan: Actually, this was my very first chemistry conference ever. I was slightly nervous as I thought I may not fit in in the presence of so many distinguished chemists; however, it was quite the contrary because although I was the only person still in high school, I quickly connected with other young observers including undergraduate and master's students.

Looking forward, I cannot wait for the 2024 International Conference on Chemistry Education, which is to be held in Pattaya, Thailand. It was wonderful to meet with the conference chair, Supawan Tantayanon, in The Hague and from what she mentioned— the extensive talks and exhibitions planned, and the theme of the "Power of Chemistry Education for Advancing SDGs"—this is an event for all young chemists to put on their lists, including students and young teachers.

Marietjie: Did you enjoy your time in The Hague?

Aaryan: Yes, absolutely. From the weather and beaches, to the cobbled streets and palaces, the only inconvenience was that I had many close incidents of being bulldozered by cyclists, especially the ones on their phones.

Marietjie: What was your overall impression of the GA and the Congress?

Aaryan: Amazing atmosphere! What stood out to me most was the representation from all over the world, shown through the colourful dresses and dapper suits. With such marvellous opportunities to connect with fellow chemists, I was in awe of the integration of ideas and knowledge all under one roof. During the CCE meetings, contributions from young observers were always encouraged and I enjoyed the visit from President Martínez, who came to each of the divisions to hear what our concerns were for the future. I felt privileged that he made time to speak to me personally as well and really listened to my thoughts and ideas, which just goes to show how much IUPAC as a whole respects and cares for young chemists.

During a session at the GA, I presented in front of many distinguished professors in the field of chemistry education, which pushed me outside of my comfort zone, and encouraged me to think about the global challenges the world of science education is facing at the moment, an area I am still reflecting on.

Aaryan Singh and Marietjie Potgieter at the IUPAC GA/ Congress in The Hague in August 2023

After the GA was the World Chemistry Congress. This saw nearly two thousand chemists assemble, all with the same passion, and with such variety of speakers flying into the Netherlands, the occasion was a must attend event for all.

Aaryan: I have a final question for you. If you could go back to the start of your chemistry education career, what advice would you give yourself?

Marietjie: Volunteer your time and get involved in meaningful learning opportunities and outreach activities outside of your regular curriculum that are aligned with your personal dreams and your passion. Do not wait to be called or invited. Sign up and show up! This is likely to pay off richly for your personal development and in your future career.

The Etymology of Chemical Names

Alexander Senning. *The Etymology of Chemical Names. Tradition and Convenience vs. Rationality in Chemical Nomenclature.* De Gruyter, 2019. https://doi.org/10.1515/9783110612714. ISBN: 9783110611069. eBook ISBN: 9783110612714

Reviewed by Edwin C. Constable and Richard M. Hartshorn

Etymology is the study of a word's origin and the evolution of its meaning. Chemical etymology is as much about the history of our science as it is about linguistics, and it is surprising how sparse the literature is in this regard. Crosland's 1962 *Historical Studies in the Language of Chemistry* [1] was a ground-breaking work and is complemented by Senning's more tabular work *Elsevier's Dictionary of Chemoetymology. The Whies and Whences of Chemical Nomenclature and Terminology* from 2007 [2]. Alexander Senning has now delighted us with a new volume entitled *The Etymology of Chemical Names. Tradition and Convenience vs. Rationality in Chemical Nomenclature*. This labour of love and treasury of hidden gems was published shortly before his death in 2020.

Before commencing a detailed review, it is appropriate to answer two questions: for whom is this book written? And for whom is it not written?

We believe that this book will be of value to any chemist with an interest in the language they use to communicate their science. On the one hand, this book is an invaluable reference for matching materials identified by a trivial or common name (for example, ixoric or tariric acids) with a definitive chemical identity. On the other hand, *The Etymology of Chemical Names* is a sourcebook regarding the origins of chemical names that you always wondered about, but never had time to research. If you are intrigued why picric acid (from the Greek *pikros* meaning sharp or bitter) was also called lyddite (after the town of Lydd in Kent, United Kingdom, where it was manufactured in the early part of the last Century), then this book is for you. Herein lies the charm and possibly the minor irritation of this book. For us, it is a book to pick up and browse. It is no coincidence that it is next to *Brewer's Dictionary of Phrase and Fable* on my bookshelf … this is a book you open for the sheer pleasure of encountering some new and hidden gem of information rather than one to read from cover to cover. It is more likely to be found in institutional libraries than on the shelves of practicing chemists. It is also not primarily for the historian of science looking for a structured discussion of the historical and philosophical development of nomenclature, although, it is an essential companion to the classical works of Partington [3,4] and Crosland [1].

The book comprises 20 chapters of various lengths. The second chapter is devoted to trivial and semi-trivial names and occupies about a third of the book. This catalogue runs from Aaptamine to Zyzzine, giving the IUPAC name and occasional trivia about the compound and the origin (or origins) of its name. The information is organized by the origin of the name (smell, shape, property, *etc.*), which is etymologically logical but a hindrance in practical usage. To research a particular compound, you need to know the origin of the name! To find lewisite, the chemical warfare agent, you need to know that it is named after Winford Lewis (Eponyms and demonyms) rather than the Isle of Lewis (Toponyms) and recognise that it differs from the mineral lewisite. In this respect, the easy searchability of the electronic version of the book provides distinct advantages over the printed publication. An enormous amount of information is provided in the form of off-the-cuff comments that enrich and enhance the text. The section on ambiguous names should be *de rigueur* reading for all chemists.

The chapter entitled "Rudimentary systematic nomenclature" encompasses the semi-systematic names used by chemists, despite the strictures of IUPAC, and proceeds, often anecdotally, to develop specific aspects and identify how chemists subjectively link classes of compounds. This highlights the challenges that IUPAC faces in developing a systematic nomenclature for compounds that are "obviously" related but whose Preferred IUPAC Names (PINs) have little in common. The role of IUPAC is developed in subsequent chapters which give extensive listings of acceptable (and unacceptable) names for natural products, their IUPAC names and PINs, together with a thought-provoking summary of the evolution of the recommendations for the nomenclature of organic chemistry.

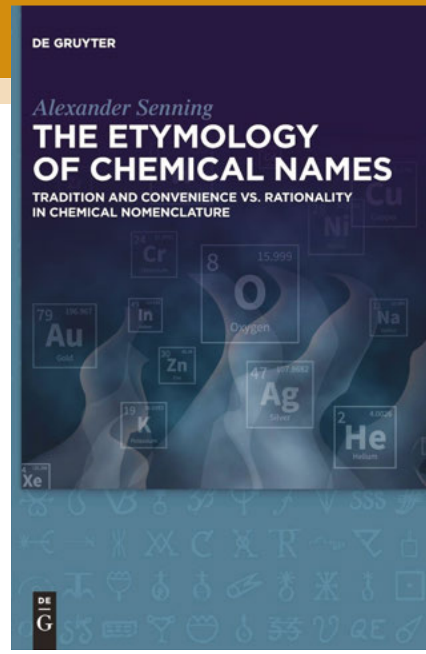
While both the IUPAC "Red Book" [5] and the "Blue Book" [6] are mentioned in the introduction, the inorganic community is subsequently largely ignored, except for a chapter concerning element names and the periodic table and another addressing mineral names. The former topic is well-documented elsewhere [7], but Senning provides a good one-stop source for the history and prehistory of the elements, whilst avoiding transatlantic debates about caesium, cesium, aluminium and aluminum. Several versions of the periodic table's long, medium and short forms are presented, although, unfortunately, the necessities of production split some over multiple pages. The author includes a remarkably concise and complete discussion of the terms used in connection with the periodic table. The book also contains a short section on elements that never were, and the interested reader is directed to the authoritative and comprehensive work of Fontani *et al* [8]. There is a section on mineral names which, as the author says, "… have been coined with little regard for euphony as perceived by English-speakers." The collection of these names is useful, although, once again, the presentation is based on etymological origin making it more suited to electronic searching.

The book also introduces the reader to Chemical Abstracts Service (CAS) nomenclature and registry numbers, with taxol used as an example to demonstrate the differences between the CAS and IUPAC systems. This topic is covered more extensively in Bünzli-Trepp's *Systematic Nomenclature of Organic, Organometallic and Coordination Chemistry. Chemical-Abstracts Guidelines with IUPAC Recommendations and Many Trivial Names* [9].

Several chapters that may be less interesting to the general reader are devoted to natural products. However, some chapter titles are a little misleading and "The naming of lipids and lipid constituents" is used as an excuse to discuss the exotic and etymologically diverse naming of the carboxylic acids. Similarly, the chapter on terpenes delights and informs the reader about their names' linguistic complexity and etymological origins. However, we wonder how many of these elaborately derived names are used in common parlance. The first sentence of the chapter "On the naming of carbohydrates" says it all: "IUPAC's glycose nomenclature comes in three versions, each suitable for a different purpose." The author subsequently collects trivial names of carbohydrates and their nasty semi-systematic derivatives. As always, the reader is often left wanting to know more: sedoheptulose is apparently named after the stonecrop *sedum acre*; but why? Our favourite names are primeverose or swietenose (really! Look it up). The same treatment is given to amino acids and their shorter condensation products. In addition to the well-known compounds, exotic creatures such as willardiine are included, and the text abounds with dry comments such as "Abrin … Not to be confused with abrine" – as if one would even think of confusing the two!

International non-proprietary names for drugs, ISO common names for pesticides and other agrochemicals, and common abbreviations and initialisms are also covered. These relatively specialized areas are covered with brevity. Unfortunately, the section on abbreviations is, of necessity, neither complete nor polylingual. For example, the abbreviation PET, for polyethylene terephthalate, is commonly seen on food containers in Switzerland but is absent from the list.

The book draws to a close with a miscellany of chemical and related terms, which will provide material for innumerable quizzes and quiz shows, and finishes with two final two chapters entitled "Trivial chemical names with disputed etymology" and "Some chemical names without known etymology."



Overall, this is a book that chemists will find of great use in answering questions about the origins of their daily vocabulary. Is there anything that the book does not do well? The emphasis is on organic compounds, and the title promises inorganic chemists more than it delivers. Even though the trivial names of organic compounds far outnumber those of inorganic species, an opportunity has been missed to educate and inform the reader about such inorganic oddities as reineckate. Having said this, the vexed question of the nomenclature of minerals is addressed very well, as is the identification of names for inorganic compounds from the early historical period.

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IUPAC Green Book—New Abridged Version

Quantities, Units and Symbols in Physical Chemistry*:*
4th Edition, Abridged Version
edited by Christopher M A Brett; Jeremy G Frey; Robert Hinde; Yutaka Kuroda; Roberto Marquardt; Franco Pavese; Martin Quack; Juergen Stohner; Anders J Thor
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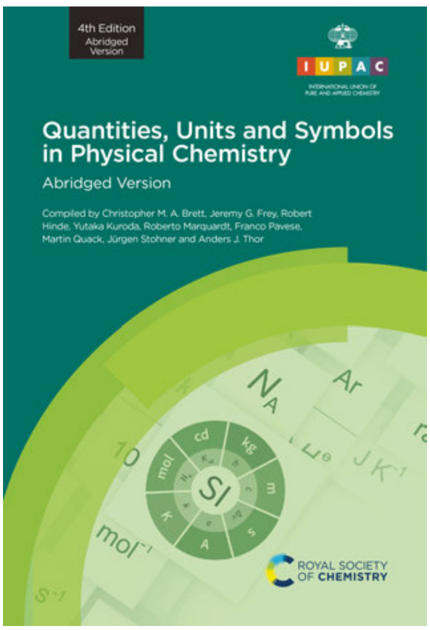

The first IUPAC Manual of Symbols and Terminology for Physicochemical Quantities and Units was published in 1969 with the objective of "securing clarity and precision, and wider agreement in the use of symbols, by chemists in different countries, among physicists, chemists and engineers, and by editors of scientific journals." Subsequent revisions have taken account of many developments in the field and were also substantially expanded and improved in presentation in several new editions of what is now widely known as the "Green Book of IUPAC." This abridged version of the forthcoming 4th edition reflects the experience of the contributors and users of the previous editions. The book has been systematically brought up to date and provides a compilation of generally used terms and symbols with brief, understandable definitions and explanations. Tables of important fundamental constants and conversion factors are included.

In this abridged guide, the more specialized and complex material has been omitted; retaining, however, the essence of the Green Book. It is particularly intended to be suitable for students and teachers but it should also be useful for scientists, science publishers, and organizations working across a multitude of disciplines requiring internationally approved terminology in the area of physical chemistry. It now includes the most up to date definitions and constants in agreement with the "new SI" as established by agreement on the International System of Units in Paris in 2019. It should find the widest possible acceptance and use for best practice in science and technology.

See originating project 2007-032-1-100 or
https://iupac.org/what-we-do/books/greenbook/

IUPAC Blue Book—Updated release

When the so-called IUPAC Blue Book "**Nomenclature of Organic Chemistry** (IUPAC Recommendations and Preferred IUPAC Names 2013)" was last published in 2014, it greatly expanded the coverage of the previous edition (1979) and included for the first time recommendations for a preferred IUPAC name (PIN) for those needing a consistent name. Still and for use in general nomenclature, alternative unambiguous names were included.

That edition of the Blue Book was prepared over many years and inevitably was not totally consistent. Since its publication, corrections, changes, and modifications have been listed on the following webpage: https://iupac.qmul.ac.uk/bibliog/BBerrors.html. A html version of the whole book including all corrections, changes and modifications has been prepared; it also includes a PDF of each chapter and a combined PDF of the whole book. A first revision was released on 1 April 2022.

A new version—version 3—includes many small corrections and improved wording of the text that have been recognised since the last revision of the pdf of the book. The two most significant changes are an expansion of P-16.5.4 on the use of brackets and of the definition of a cyclophane in P-52.2.5.1. The latest revision was released on 6 Dec 2023 (as BlueBookV3.pdf) and is available at https://iupac.qmul.ac.uk/BlueBook/PDF/

The web version has been prepared and is maintained by G. P. Moss, School of Physical and Chemical Sciences, Queen Mary University of London, UK. Please return questions to g.p.moss@qmul.ac.uk

https://iupac.org/what-we-do/books/bluebook/

Group picture of the participants in the inaugural Presidents´ Forum during the 52nd IUPAC General Assembly in The Hague on August 22, 2023.

The Presidents' Forum: Advancing Chemistry through Global Cooperation

by Javier García Martínez

During our past General Assembly in The Hague, IUPAC took a significant step forward in fostering international cooperation among chemical societies by launching the inaugural Presidents' Forum. This initiative aims to bring together the leaders of chemical societies and federations from around the world to collectively address key issues in chemistry, with the goal of fostering mutual cooperation and increasing the global impact of chemistry for the betterment of humankind and the planet.

The creation of the Presidents´ Forum was one of the ideas included in the final report of the Review Group, which was approved first by IUPAC Executive Committee and then by our Bureau in 2021 [1]. As stated in this document, the Presidents´ Forum is an opportunity for "IUPAC to exercise its convening role in global chemistry to show leadership and coordination of international initiatives". From a more personal experience, I would say that over the years I have observed that many presidents of chemical societies regularly attend IUPAC General Assemblies but don't have a dedicated platform to interact, share projects, and explore opportunities for collaboration. Therefore, this global forum is an opportunity to create a space where like-minded leaders can come together across geographical boundaries and institutional affiliations and take advantage of their presence at our General Assembly. The Presidents' Forum aims to foster a spirit of camaraderie, efficiency, and collaboration among peers who share a common passion for the advancement of chemistry.

The purpose of bringing together the presidents of chemical societies from around the world goes beyond mere formality; it is an avenue for substantive dialogue, knowledge sharing and strategic planning. At the core of this initiative is the desire to enhance the collective impact and effectiveness of the chemical societies in their quest to continue to contribute to improving human well-being while creating a more sustainable future through chemistry. The essence of the Presidents' Forum encapsulates a shared mission to promote chemistry's central role in the advancement of society.

It is important to understand that the Presidents' Forum stands apart from the routine business of the IUPAC Council. While the Council meeting remains an integral part of the IUPAC General Assembly, made up of IUPAC National Adhering Organizations, which in many cases are not the chemical societies of those countries, the Presidents' Forum is an autonomous meeting, organised under the umbrella of IUPAC, but with an independent focus. This distinctiveness is essential to maintain an atmosphere conducive to open and frank discussion, not constrained by formalities. The Presidents' Forum is designed to facilitate candid exchanges of information, innovative ideas, and collaborative projects. This inclusive platform seeks to harness the collective wisdom of leaders who recognize the transformative potential of chemistry in shaping our world.

During our last General Assembly in The Hague, I had the privilege of welcoming more than 30 representatives of chemical societies and federations from around the world to the first Presidents' Forum on 22 August. I opened the meeting by introducing this initiative, outlining its objectives and emphasising the significance of the occasion. Each delegate introduced themselves by name and the organisation they represent, demonstrating the diversity of the chemical societies present. This introductory session laid the foundation for a constructive and inclusive dialogue.

A key issue discussed during the Forum was the adoption of FAIR data principles in chemistry. I took the opportunity to stress the importance of translating data into standardised digital formats, especially in the age of artificial intelligence and data science. The need for interdisciplinary frameworks and interoperability in line with the FAIR principles was underlined. The challenge of creating common standards for digital management across research groups and data science communities worldwide was highlighted [2]. Participants raised concerns about data security and ethical considerations. I clarified that international efforts involving stakeholders such as companies, research organisations and the European Union are already underway to address these concerns. In particular, I mentioned the WorldFAIR project, on which we are working with CODATA (the Committee on Data of the International Science Council) and RDA (the Research Data Alliance) to develop a set of case studies to advance the implementation of the FAIR data principles. This initiative was highlighted as a crucial step forward, not only for chemistry, but also for the wider scientific community.

After some discussion on how to involve the various chemical societies in this initiative, we talked about the establishment of the UN Intergovernmental Panel on Chemicals, Waste, and Pollution Prevention. I took the opportunity to present the purpose and work of the Panel, emphasising its focus on sound chemicals and waste management and pollution prevention. Participants shared their insights on challenges related to definitions of hazardous waste and the need for consensus to reduce pollution. I then invited the Presidents' Forum participants to remain in contact with their governments to coordinate action at the national level, and outlined IUPAC's role in proposing panel members and its efforts to contribute to the effective and impactful functioning of this UN initiative. I encouraged participants to learn more about this UN initiative and to read the article I wrote for *Chemistry International* on this new panel [3].

Delegates also raised concerns about the state of chemistry education, in particular the declining number of students in STEM subjects and the public perception of chemistry in different countries. Participants highlighted initiatives aimed at countering negative stereotypes and promoting chemistry as an essential discipline for societal progress. The need for chemical societies to work together and share resources to address challenges and increase the attractiveness of

Participants of the inaugural Presidents´ Forum discuss the various issues included in the agenda´s meeting.

A moment of the Presidents´ Forum in which the representative of the Italian Chemical Society, Gianluca Farinola, asked a question to IUPAC President Javier García Martínez.

chemistry education was recognised. In this regard, Uday Maitra from India proposed that IUPAC create and curate a website to serve as a database and repository of the activities of the various chemical societies and federations, a proposal that received unanimous support.

The meeting, which lasted an hour and a half, was the first step in establishing a more direct and collaborative relationship between IUPAC and the various chemical societies and federations. Its inaugural meeting marked a significant step towards global cooperation among chemical societies and was a momentous event in the history of chemistry. Reminiscent of the meetings of the International Association of Chemical Societies (IACS) in the early 20th century, it is the first time that the presidents of chemical societies have come together to discuss issues of common interest. This landmark event heralds a new chapter of unity and cooperation, paving the way for future interactions that will foster cross-border partnerships, synergistic projects and lasting friendships to facilitate the exchange of ideas, address critical issues and collectively steer the field of chemistry towards a more impactful and harmonious future. As chemistry continues to play an essential role in shaping the world, the Presidents' Forum stands as a beacon of unity and cooperation to further its progress.

The unprecedented times in which we find ourselves make the Presidents' Forum even more relevant. As a global community, we face challenges and opportunities that require collective wisdom, collaborative innovation and unity of purpose. The inaugural session of the Presidents´ Forum was indeed an historic meeting, where we not only discussed critical issues, but also planted the seeds for a more collaborative and impactful future for the world of chemistry.

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IUPAC's Role in the International Year of Basic Sciences for Sustainable Development and the Closing Ceremony

by Javier García Martínez

IUPAC played a pivotal role in the International Year of Basic Sciences for Sustainable Development (IYBSSD), which marked a global celebration of the crucial importance of fundamental science in achieving the Sustainable Development Goals and, more generally, in creating the solutions we need to advance towards a more sustainable future [1]. IUPAC's efforts throughout the IYBSSD, culminated in an inspiring and festive Closing Ceremony, held at CERN on 15 December 2023, in which I had the opportunity to highlight the transformative power of chemistry in addressing global challenges and the key role that IUPAC has played in IYBSSD [2].

IUPAC's Commitment and Contributions to IYBSSD

As a founding partner of the IYBSSD, IUPAC actively championed the role of chemistry in sustainable development but also designed, organized, and carried out many initiatives. Thanks to our volunteers who have worked tirelessly to create a series of very successful activities that filled the IYBSSD with content [3].

A good example of such initiatives is the annual Global Women's Breakfast (GWB) which in 2022 reached over 30,000 people from 78 different countries with 407 individual events, and in 2023, over 390 events were held in 77 different countries, with Morocco, Rwanda, Slovenia, Sudan, Tanzania, the United Arab Emirates, and Vietnam participating for the first time. This IUPAC activity greatly contributes to raising awareness of the many challenges that women have to overcome in their workplace. Thanks to this IUPAC annual activity that we organize coinciding with International Day of Women and Girls in Science, we are contributing to creating a global network of female scientists and their male allies and empowering them worldwide [4]. The GWB has been one of the flagship activities of the IYBSSD and was highlighted on several occasions during the Closing Ceremony including in the video that was made specifically for this purpose. https://www.youtube.com/watch?v=fIboHB0qRV4

Similarly, the Global Conversation on Sustainability that IUPAC jointly organizes with IYCN is an annual, one-day umbrella event that brings together independently organized events around the world to focus on sustainability for the common good. The first edition was held on 25 September 2022 and has already been a great success, with hundreds of GCS events taking place around the world. This year, this IUPAC-IYCN initiative continued to grow, showcasing different activities, promoting actions, implementing sustainable practices, and creating awareness of the role of chemistry in solving our most pressing issues. Individuals, organizations, and institutions across the world took part and organized their own events contributing to creating a global network commitment to build a more sustainable future thinking globally but acting locally [5].

But our IUPAC volunteers have organized many

Javier García Martínez

other activities during the IYBSSD and beyond [3] including the Periodic Table Challenge, the Capacity building of chemistry instructors teaching with hands-on small-scale experiments in high schools in Asia, and the Top Ten Emerging Technologies in Chemistry [6]. This activity highlights fascinating chemistry technologies hovering between the discovery stages of laboratory work and commercial realities. It is a very successful initiative that features specific technologies that show tremendous potential to improve the way we produce, recover and reuse goods, chemicals and energy. And of course, in the important field of education, the use of system thinking as a way to introduce chemistry concepts to students and to connect the molecular world with important societal and environmental aspects that are usefully overlooked [7]. During the IYBSSD, our volunteers have organized a series of webinars, meetings, and conferences to introduce System Thinking in chemistry education and to familiarize chemistry educators with this new educational tool [8].

IUPAC President's Address at the Closing of the IYBSSD: Recognizing Chemistry's role in building a more sustainable future

At the Closing Ceremony of the IYBSSD, I participated in the first panel with members of representatives from other international organizations. During my speech, I highlighted chemistry's key role in building a more sustainable future, from the discovery of reusable plastics to the transformation of CO_2 into solar fuel and raw chemicals for the industry. I emphasized the transformative power of chemistry, highlighting the urgency of reimagining our relationship with the planet at molecular scale, an idea captured by the concept of circular chemistry [9]. This is a paradigm shift that means designing every molecule and process so that everything we produce can be recovered and reused. This means a fundamental change in the way we think of, teach, do research, and apply chemistry; but also both an opportunity and a need if we want chemistry to continue providing us with goods, wealth, and jobs while reducing our impact on the environment. During the panel we discussed how this can be achieved and the importance of international collaboration, the contribution of all sciences—including social sciences—and the key role that early career scientists should play in this new circular chemistry, without which there will be no circular economy.

The Closing Ceremony was focused on how early-career scientists can more effectively contribute to creating solutions for our global challenges. So, I took this opportunity to mention that IUPAC Council recently approved the incorporation of the International Younger Chemists Network in the structure of IUPAC as a Standing Committee [10]. The attendees received this news enthusiastically, as I had the opportunity to observe. Representatives from both International Scientific Unions and National Academies mentioned this to me afterward. Early-career scientists are not only the future of science but also its present, and they significantly contribute to its advancement, make some of the most important discoveries, and are the founders of many start-ups that are taking the solutions from the lab to the market. Half of the world's population is under 30—but they have little say over the decisions that shape their future. In fact, only 2.6% of parliamentarians globally fall within this age group. Young people are the ones who will suffer or enjoy the consequences of our decisions, and bring fresh ideas, a new perspective, and their own view on many critical issues to the table. I am very excited about what the incorporation of IYCN into IUPAC will bring to the future of our organization and to the global chemistry community and I was thrilled to share the vision and courage that our Council showed during our latest General Assembly incorporating this global network of early-career scientists into IUPAC.

During the Closing Ceremony of the IYBSSD, it is worth noting that a representative from the Global Young Academy (GYA), Hiba Baroud, read a Statement endorsed by 30 National Young Academies, on the key role of basic science in building a more sustainable future which includes a series of actionable steps to connect fundamental science with sustainable development [11]. In her remarks, Baroud reminded us that "Early- and mid-career researchers around the globe, and especially in low- to middle-income nations, are now at a significant disadvantage as compared to previous generations of researchers operating in high-income nations. While low- to middle-income economies have witnessed the largest increase (+ 36 %) in researchers' density since 2014, they still account for only 0.2 % of the world's researchers. This lack of opportunity severely limits global access to the potentially life-changing research talent that may reside in these regions."

What´s Next? The Decade of Basic Sciences for Sustainable Development

In August 2023, the United Nations General Assembly adopted a resolution proclaiming 2024-2033 as the International Decade of Sciences for Sustainable Development [12]. This represents a new opportunity for IUPAC to continue raising awareness about how chemistry contributes to our sustainable development, but is also central to the discovery and implementation of the solutions needed for a transition to fossil fuel-free energy sources. Chemistry must work towards the reduction, recovery, and reuse of waste; to fight climate change and new illnesses; while providing clean water, food, and goods to a growing population [13]. The organizations that made possible the IYBSSD, led by UNESCO, are already working on the activities, structure, and timing of the DBSSD.

Since, the Opening of the IYBSSD at the UNESCO Headquarters in Paris on 8 July 2022, which former IUPAC President, Nicole Moreau, IUPAC Past President, Chris Brett, and myself attended [14], IUPAC has significantly contributed, not only as a founding partner, and member of the Steering Board but also with many activities that highlighted how chemistry is creating the solutions we need to achieve the Sustainable Development Goals.

IUPAC will continue to provide the verified data, standardized methods, and educational resources that the scientific community needs to carry on with its work while being the international platform for chemists from all around the world. Activities such as the IYBSSD constitute a great opportunity to work with others to create the solutions we need to tackle our most pressing challenges and highlight the importance of basic sciences to make better decisions and public policies based on evidences.

Chemistry in general and IUPAC in particular have a key role to play in creating a sustainable, prosperous, and fair future for all. Only if we are able to reimagine the way we design molecules and processes for recovery and reuse, *i.e.* making circular chemistry possible, we will be able to continue contributing to improving our quality of life while reducing our impact on the environment.

Over 400 events were organized in more than 70 countries, by the 53 partner organizations, during the IYBSSD. IUPAC has played a significant role in making this International Year a great success and promoting the public awareness and image of chemistry worldwide. The Decade of Basic Sciences for Sustainability is a new opportunity to continue highlighting how chemistry plays a central role in building a better more sustainable future and I am sure I can count on all of you to fulfill this opportunity and continue working with others, especially early-career scientists, towards this key objective.

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Thailand Younger Chemists Network

Thailand's first initiative to create bonds among early-career chemists across institutes

by Chanat (Jay) Aonbangkhen

Inspired by the International Younger Chemists Network (IYCN), the European Young Chemists' Network (EYCN) of the European Chemical Society (EuChemS), and the Malaysian Young Chemists Network (MYCN), **Thailand Younger Chemists Network** (TYCN) was successfully inaugurated in 2023, making it the first early-career chemists networking platform in Thailand, initiated by the Chemical Society of Thailand (CST).

TYCN is a network of chemical science professionals, based in Thailand, working together to empower early-career chemists in Thailand through vibrant networking, mentorship, and professional development opportunities, catalyzing collaborations and research advancements in diverse fields of chemistry for a sustainable future, both locally and globally endorsed by the Chemical Society of Thailand (CST). With the enthusiastic support from the CST board committee, especially our project advisors (Supawan Tantayanon, Vudhichai Parasuk, and Supa Hannongbua) and the leadership of Chanat Aonbangkhen (the Chair and Co-founder of TYCN), TYCN was successfully launched at Mae Fah Luang University in Chiang Rai, as a part of PACCON 2023 (Thailand's Pure and Applied Chemistry International Conference). Joining the launch in 2023

was Torsten John, the chair of IYCN, and in 2024, the IUPAC Past-President, Javier García Martínez.

Prior to the official launch, a group of young chemists in Thailand was already nucleated by the CST as a hub of young talents in Thailand.

TYCN first activity was participation in the organization of Small-Scale Chemistry laboratory in September 2022 at KSL River Kwai Park & Resort in Kanchanaburi province, Thailand, which is a chemistry summer camp for high school students and teachers across Thailand. The camp provided a hands-on experience for over 200 participants to learn various experiments using miniature and easily-accessible chemistry educational kits developed by Supawan Tantayanon and the CST team. Through a rally across the naturistic park, participants learned about renewable resources, alternative energy sources and locally sourced produces. The camp also emphasized the importance of sustainable chemical processes and its impact on the environment by encouraging them to think critically about the role of chemistry in creating a more sustainable future and exploring how chemistry can be used to address environmental challenges, such as pollution and waste management. This summer camp was sponsored by both public and private sectors, including Dow Thailand Group, Khonkaen Sugar Industry PLC, and the Office of the Basic Education Commission (OBEC), Ministry of Education.

TYCN team comprises a growing number of chemists from diverse backgrounds and different institutions around Thailand such as Chulalongkorn University, Chiang Mai University, Chulabhorn Royal Academy, Chulabhorn Research Institute, Chulabhorn Graduate Institute, Kasetsart University, KhonKaen University, Prince of Songkla University, Silpakorn University, Vidyasirimedhi Institute of Science and Technology (VISTEC), and professionals from the chemical industry, such as Merck Thailand Company Limited.

With the core missions to empower early-career chemists and promote research for a sustainable future, the team has successfully hosted the 1st Merck-CST-TYCN Symposium in 2023 (at Mae Fah Luang University, Chaing Rai) and the 2nd Merck-CST-TYCN Symposium in 2024 (at BITEC Hall, Bangkok), thanks to the CST and Merck Thailand Company Limited, for the generous financial support, and also GibThai and VFoods Company for the grand opening gifts at the symposium.

During the symposium, three key events were organized:

- Merck-CST-TYCN for Sustainable Future Award Talk
- TYCN Rapid-Fire Talks
- TYCN Panel Discussion

Merck-CST-TYCN for Sustainable Future Award is the award for distinguished young chemists whose innovative work has significantly contributed to a sustainable future, based on the UN's Sustainable Development Goals (SDGs). The Merck-CST-TYCN for Sustainable Future Award Talk offers the chance for the award recipients to talk about their works and inspires other chemists to work towards a sustainable future using chemistry. The previous recipient of this award in 2023 was Chayasith Uttamapinant (VISTEC), who worked on the engineering of a polyethylene terephthalate hydrolase from the human saliva metagenome. This year the award was given to Thanthapatra Bunchuay (Mahidol University) who worked on supramolecular

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(Chulabhorn Graduate Institute), Committee member

chemistry approaches to design functional materials for sustainable development.

TYCN Rapid-Fire Talks seminar invited new early-career chemists to network by sharing their research interests with the audience in an expeditious fashion within 1-3 minutes. Over the past two years, Thai graduate students, researchers, and new lecturers from different institutes in Thailand (*e.g.* Chulalongkorn University, Chulabhorn Research Institute, VISTEC, Silpakorn University, Chiang Mai University, Prince of Songkla University, Walailak University) and students and postdocs from abroad (MIT, the University of Cambridge, etc.) have also participated.

For the highlights, the TYCN Panel Discussion is a session where distinguished professionals shared their success stories and early-career advice with everyone in the TYCN symposium. Many outstanding chemists from Thailand and abroad have been invited to share their career wisdom. Distinguished scientists who have joined the panel discussion include David MacMillan (Nobel Prize Laureate in chemistry, 2021), Javier García Martínez (former IUPAC President), Pimchai Chaiyen (President of VISTEC), Tirayut Vilaivan (Vice Dean of Research, Faculty of Science, Chulalongkorn University), Poonsakdi Ploypradith (Expert Scientist, Laboratory of Medicinal Chemistry Chulabhorn Research Institute) and Anyanee Kamkaew (Head of the Chemistry Department, Suranaree University of Technology), as well as Sorathep Rattanayotsakun (Senior researcher at Siam Cement Group or SCG Company).

Today, TYCN serves as a vital platform, connecting Thai early-career chemists across different institutes, fields of chemistry, and industries, while providing crucial networking support for young chemists, facilitating seamless transitions into independent careers. Join us in forging a path of innovation and impact, shaping the future of chemistry both locally and globally!

Follow us at https://www.facebook.com/TYCN2022

Feature Articles Wanted

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

Solubility Phenomena and Related Equilibrium Processes

It is our great pleasure to cordially invite you to the **21st IUPAC International Symposium on Solubility Phenomena and Related Equilibrium Processes (ISSP21)** which will be held at the University of Novi Sad in **Novi Sad, Serbia, 9-13 September 2024**. The ISSP is an established biennial IUPAC symposium organized by the Subcommittee on Solubility and Equilibrium Data.

The ISSP is committed to gather international experts on solubility studies, or related subjects, to exchange scientific research and technological applications within the academic, scientific and technical communities. This symposium addresses the general importance of solubility phenomena and associated physical properties in a variety of settings ranging from green chemistry to nuclear waste disposal, always envisaging applications for sustainable development. The conference will cover the wide range of topics: Aqueous Solutions; Biofuels; Computer Assisted Equilibrium Calculation; Deep Eutectic Solvents; Environmental Equilibrium Processes and Applications; Fluid Phase Equilibria; Molten Salts; Ionic Liquids; Nuclear Wastes; Solution Chemistry Complex Equilibria and Solubility Phenomena in Pharmaceutical applications.

After a very successful two online conferences in Los Alamos, USA and in Bragança, Portugal, this year ISSP will have a regular format (in-person) and will continue to celebrate creativity, diversity, and friendship among its participants, promoting the exchange of ideas and fruitful interactions.

A workshop on Data Analysis will be also held during the ISSP21 and the Franzosini Prize and the Balarew Award will be presented during this event.

For important dates and additional information, visit https://issp2024.pmf.uns.ac.rs/

Chemistry: a solution for global changes

The Congress of Chemistry Costa Rica 2024 is an event organized by the five Costa Rican public universities (UNA, UCR, ITCR, UNED, and UTN), as well as the College of Chemistry of Costa Rica, the National Laboratory for Nanotechnology (LANOTEC) and the Chamber of Industries of Costa Rica. The first edition of the Congress was held successfully in 2022, with more than 175 participants, including researchers, students, public sector representatives, and industry representatives. The 2024 edition will be held 23-26 July 2024, at the Auditorium Cora Ferro Calabrese at the National University (UNA) in the beautiful city of Heredia, Costa Rica, 10 km away from the capital city San José.

The event will be the place for exchanging relevant scientific information and strengthening national and international relationships between public, private, and academic sectors. During these days, the scientific program will cover many topics, including metrology, nanotechnology, materials science, energy production, environmental chemistry, teaching chemistry, and many more. All theses topics are held together under the motto "Chemistry: a solution for global changes". The Scientific Programme will include several plenary lectures by internationally renowned scientists, as well as oral presentations and poster sessions.

Also, the 3rd Costa Rican Biophysics Symposium will be a joint event during the Congress of Chemistry, allowing all participants to learn about cutting-edge research in biophysics and related fields of study.

More details at https://eventoscqcr.com/congreso/index_eng.html

Mark Your Calendar

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

2024 (starting 1 April)

21-27 April 2024 - African Training School on Green Chemistry and Environmental Sustainability - Benguerir, Morocco

Chair: Youssef HABIBI, Professor & Director of Sustainable Materials Research Center, Mohammed VI Polytechnic University, Benguerir, Morocco, Youssef.habibi@um6p.ma
https://susmat.um6p.ma/greenchemafrica/

27-31 May 2024 - Polymers for our future - Madrid, Spain

POLY-CHAR 2024, Co-chairs: Araceli Flores and Peter Shuttleworth, poly-char2024@fgua.es
https://www.poly-char2024.org/ Co-chair: Aldrik Velders, Wageningen University; ecb@tfigroup.com
https://www.ecb2024.com/

20-22 Jun 2024 - Frontiers in Chemical Technology - Colombo, Sri Lanka

Second International Conference on Frontiers in Chemical Technology,
Conference Chair: Namal Priyantha; Secretary: Sameera R Gunatilake, Faculty of Science, University of Peradeniya, Peradeniya (20400), Sri Lanka, ranmal@ichemc.edu.lk • https://fct.ichemc.ac.lk

23-28 Jun 2024 - Nano-Applications - Manchester, NH, USA

Impactful Nano-Applications for Sustainable Food Production
Melanie Kah, co-chair, University of Auckland, New Zealand, melanie.kah@auckland.ac.nz
https://www.grc.org/nanoscale-science-and-engineering-for-agriculture-and-food-systems-conference/2024/

24-28 Jun 2024 - Polymers for Sustainable Future - Prague, Czech Republic

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

30 Jun - 3 Jul 2024 - Biotechnology - Maastricht, The Netherlands

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

30 Jun - 5 Jul 2024 - XVI Postgraduate Summer School on Green Chemistry - Venezia, Italia

General information: secretariat@gssd-foundation.org • https://www.greenchemistry.school/

1-4 Jul 2024 - MACRO2024 - Coventry, UK

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

14-19 Jul 2024 - Photochemistry – Valencia, Spain

29th IUPAC Symposium on Photochemistry
Symposium co-chairs: Gonzalo Cosa <gonzalo.cosa@mcgill.ca> and Maria Marín <marmarin@qim.upv.es>
https://www.photoiupac2024.com/

15-19 Jul 2024 - Chemistry Education - Pattaya, Thailand

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

23-26 Jul 2024 - Congreso de Química Costa Rica - Heredia, Costa Rica

Chemistry: a solution for global changes
Chair of the IAB and of the Local Organizing Committee: Carlos Vega Aguilar, Carlos.vegaaguilar@ucr.ac.cr
https://eventoscqcr.com/congreso/

Mark Your Calendar

29 Jul - 2 Aug 2024 - Soft Matter - Raleigh, North Carolina, USA

8th International Soft Matter Conference (ISMC2024) - Blurring Boundaries Between Fields
Contact: Daphne Klotsa, Department of Applied Physical Sciences, University of North Carolina in Chapel Hill, dklotsa@email.unc.edu • https://soft-matter.com/ismc2024/

11-16 Aug 2024 - Novel Aromatic Compounds - Toronto, Canada

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

18-22 Aug 2024 - Physical Organic Chemistry - Beijing, China

26th IUPAC International Conference on Physical Organic Chemistry
Chair: Jin-Pei Cheng, Centre of Basic Molecular Science (CBMS), Tsinghua University, Beijing, China; icpoc26@mail.tsinghua.edu.cn • https://www.icpoc26.tsinghua.edu.cn/

9-13 Sep 2024 - Solubility Phenomena - Novi Sad, Serbia,

21st International Symposium on Solubility Phenomena and Related Equilibrium Processes
Chair: Slobodan Gadžurić, University of Novi Sad, Faculty of Sciences, NoviSad, Serbia; slobodan.gadzuric@dh.uns.ac.rs; contact: issp2024@dh.uns.ac.rs • https://issp2024.pmf.uns.ac.rs/

18-20 Sep 2024 - Isoprenoids - Naples, Italy

The 25th Congress on Isoprenoids
Contact/Chair: Orazio Taglialatela-Scafati, University of Naples Federico II, Naples, scatagli@unina.it; contact: secretariat@isoprenoids25.org • https://isoprenoids25.org/

25 Sep 2024 - 3rd Global Conversation on Sustainability - virtual

A joint project between the IYCN and IUPAC • https://www.gcs-day.org/

7-12 Oct 2024 - General and Applied Chemistry - Sochi, Russian Federation

XXII Mendeleev Congress on General and Applied Chemistry
Contact: Yulia Gorbunova, Professor A.N. Frumkin Institute of Physical Chemistry and Electrochemistry of RAS; yulia@igic.ras.ru or MendeleevCongress@mesol.ru • http://mendeleevcongress.ru/

24-29 Oct 2024 - Green Chemistry Towards Carbon Neutrality - Beijing, China

10th IUPAC International Conference on Green Chemistry
Zhimin Liu, Program committee chair, liuzm@iccas.ac.cn • https://greeniupac2024.org

19-21 Nov 2024 - Chemistry, a lever for sustainable development of African countries - Dakar, Senegal

Annual Days of Chemistry of Senegal & 9th FASC Congress (FASCIJACS 2024)
General contact: Modou Fall; modou.fall@ucad.edu.sn, PO Box 15756, Dakar-Fann, Senegal, Tel: +221775557200 • https://csc.ucad.sn (under Congrès and FASCIJACS 2024)

Save the dates!

11 Feb 2025 – IUPAC Global Women Breakfast – Global all around and Virtual

In 2025, the GWB will actually be held on the International Day of Women and Girls in Science
https://iupac.org/gwb

13-18 Jul 2025 - IUPAC World Chemistry Congress 2025 - Kuala Lumpur, Malaysia

https://iupac2025.org/

GREEN SCIENCES FOR SUSTAINABLE DEVELOPMENT FOUNDATION

Ca' Foscari University of Venice
Department of Environmental Sciences, Informatics and Statistics

IUPAC

GREEN CHEMISTRY POSTGRADUATE SUMMER SCHOOL

In memory of Professor Pietro Tundo

30th of June - 5th of July 2024

Venice, Italy

Photo: Dorian Mongel / unsplash

Organizers:
Francesco Trotta Chairman
Fabio Aricò
Aurelia Visa
Mirabbos Hojamberdiev
Graziana Gigliuto Secretary

Topics:
Benign synthesis routes
Green catalysis
Alternative solvents
Renewable and green raw materials
Green chemistry for energy
Clean processes
Green Chemistry education

Info:
www.greenchemistry.school
www.gssd-foundation.org

Contacts:
postmaster@pec.gssd-foundation.org
secretariat@gssd-foundation.org

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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