

IUPAC Announces the 2023 Top Ten Emerging Technologies in Chemistry

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

The 2023 finalists are (in alphabetical order):

- Artificial muscles
- Biological recycling of PET
- Chloride-mediated removal of ocean CO₂
- Depolymerisation
- GPT language models in chemistry
- Low-sugar vaccination
- Phage therapy
- Photocatalytic hydrogen
- Synthetic electrochemistry
- Wearable sensors

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

The 2023 Top Ten Emerging Technologies in Chemistry are further detailed in a feature article published in the October issue of *Chemistry International (CI)* [see page 14]. Fernando Gomollón-Bel, the author of that feature concludes by suggesting that “instead of considering chemistry the “central science,” we should consider it the “connecting science”—one

that catalyses collaboration across disciplines and encourages industrial innovation.” He also noted that “sustainability remains a universal subject throughout the “Top Ten” selections—the uttermost purpose of the initiative is still to ensure a sustainable future, advancing our society, and improving our quality of life. We need creative chemistry solutions for a better world, therefore let us work together to identify the most imaginative ideas and innovations and guarantee growth, as well as access to basic rights—including renewable energy, fuels, food, and pharmaceuticals for all.”

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

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

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

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

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

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

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

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

Main achievements of the winners

Professor **Xile Hu's** group has made many outstanding scientific discoveries in the field of Green Chemistry, particularly in Green Catalysis and Green Energy. In the area of green catalysis, they have developed new catalytic methods and catalysts that are based on earth-abundant elements for organic synthesis. In the area of green energy, Hu and his team have developed a number of novel earth-abundant electrocatalysts for the hydrogen and oxygen evolution reactions (HER and OER), which are the two half-reactions for water splitting, the main route to green hydrogen. They have made significant contributions to highly active earth-abundant catalysts for the hydrogen oxidation reaction, the key cathodic reaction in fuel cells. They have also invented superior anion exchange membranes (AEMs) for next-generation membrane water electrolyzers and fuel cells. They have demonstrated record-setting efficiencies in AEM electrolyzers



and fuel cells. His group has made breakthrough catalysts and systems for CO₂ and CO electroreduction. Their work is not only of fundamental value but has significant potential in industrial applications. For example, a startup company, NovaMea SA, has been founded based on their work in green energy. Follow his work at <https://orcid.org/0000-0001-8335-1196>

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



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



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

Zhe Zhuang works on advancing the field of C–H functionalization reactions of native substrates using practical oxidants and catalysts. He has developed a range of C(sp³)–H functionalization reactions that utilize inexpensive and industry-compatible oxidants, namely tert-butyl hydrogen peroxide and sodium percarbonate, with the potential for large-scale manufacturing. In contrast to traditional multi-step synthesis approaches, his methodologies enable the streamlined, one-step synthesis of biologically significant scaffolds from readily available starting materials, such as aliphatic carboxylic acids and amines. The utility of these protocols has been demonstrated through their applications in late-stage functionalization of natural products and pharmaceutical compounds, as well as in total synthesis endeavors. For example, he has developed a method for the direct synthesis of β -lactones from readily available aliphatic acids. This approach yields a versatile intermediate for constructing diverse compound library in medicinal chemistry and serving as a covalent warhead in drug discovery. The use of inexpensive and practical tert-butyl hydrogen peroxide in water, combined with the ease of product purification without the need for column chromatography, render this reaction scalable and potentially amenable to tonne-scale manufacturing.

The IUPAC-Zhejiang NHU International Award, managed by the ICGCSD, is presented every two years.



Look for the announcement of the next call in 2024 ahead of the 2025 IUPAC World Chemistry Congress that will take place in Malaysia. For further information about the IUPAC-Zhejiang NHU International Award, see <https://iupac.org/what-we-do/awards/>.

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

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

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

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