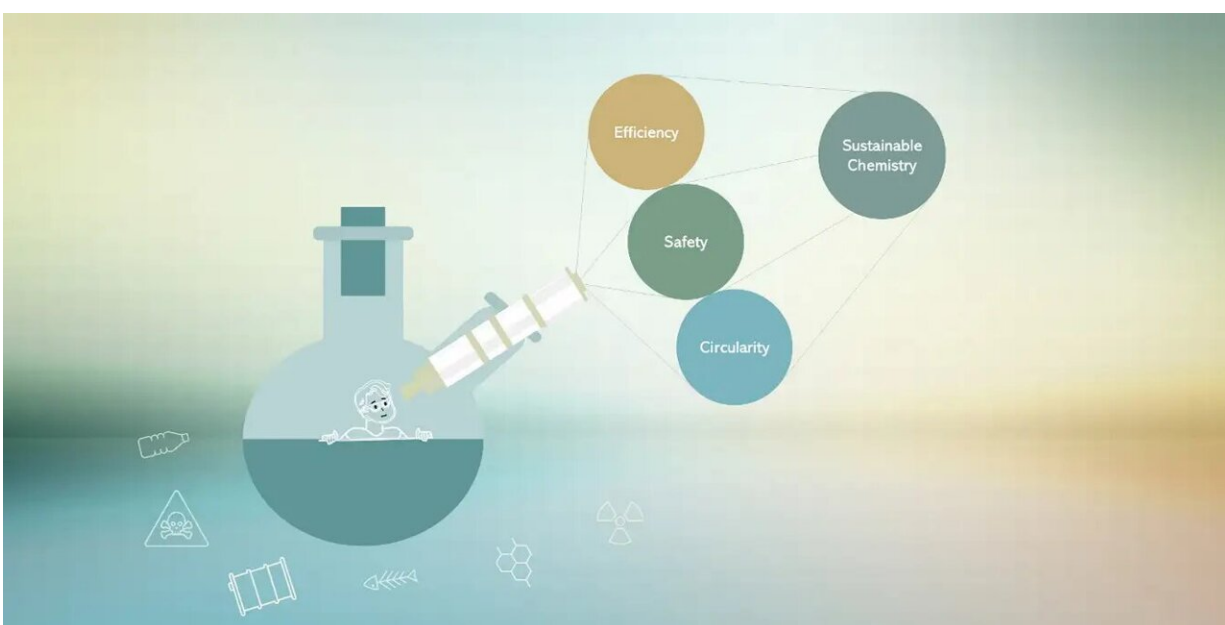


Chemists need to consider the effects of chemistry beyond the lab to combat environmental crises, say researchers

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The future of chemistry in a nutshell: A triple focus of efficiency, safety and circularity is needed to steer chemistry towards sustainability. Credit: HIMS.

In a comment in *Nature Reviews Chemistry*, Ph.D. student Hannah Flerlage and associate professor Chris Slootweg of the University of Amsterdam's Van 't Hoff Institute for Molecular Sciences argue that modern day chemists need to broaden their horizons and consider the effects of chemistry "beyond the reaction vessel and the fume hood." In

order to combat ever worsening environmental crises, and to achieve real sustainability, chemistry needs to develop a combined focus on efficiency, safety, and circularity.

Modern chemistry is "quite literally rubbish," Flerlage and Slootweg write, as it facilitates the path of matter from extraction to pollution. All sorts of waste, both stemming from [chemical](#) manufacturing processes and from their often short-lived end products, have resulted in human health problems and environmental disasters at varying scales.

Admittedly, over the past decades more and more sustainable synthetic methods have become available, minimizing or even eliminating the use of hazardous substances and waste. But, Flerlage and Slootweg rhetorically ask, is chemistry there yet? Their answer: "Not at all."

In their view, chemists have to start looking beyond "cool molecules," and "awesome chemistry." Sure, it can be fun and rewarding to create aesthetically pleasing molecules. But this ignores the role of chemistry in the [modern world](#). As an example, they refer to perfluorocubane, a molecule that in 2022 was designated "Molecule of the Year." Its synthesis might be a stellar achievement, and there will probably be potential future applications. But its structure, containing multiple carbon-fluorine bonds, suggests that perfluorocubane will persist in the environment and bioaccumulate.

Flerlage and Slootweg argue that [modern chemistry](#) needs to take such environmental concerns to heart, and right from the start. They even go so far as to consider it unethical to develop chemistry that will lead to chemical pollution. They call for an end to poorly designed compounds, in particular "forever chemicals" such as per- and polyfluorinated alkyl substances and brominated flame retardants.

Systems thinking

As chemistry is the science of the transformation of matter, not just of the creation of novel molecules, Flerlage and Sloopweg point out the responsibility to develop safe chemistry and chemicals that use the world's resources most effectively and improve sustainability.

This requires an approach of systems thinking that is grounded in the recognition of sustainability as an emergent property, and guided by an understanding of the molecular basis of sustainability. This means that chemistry should not only focus on using [renewable resources](#) and reducing production waste. It also has to consider the life-cycle environmental footprints and overall environmental implications of (novel) chemicals.

As an example, Flerlage and Sloopweg mention drop-in bio-based polymers such as bioPE, which is made from bioethanol. These polymers reduce the use of fossil resources, but don't improve recyclability or biodegradability. And thus they continue to contribute to plastic pollution.

More challenging, more rewarding

In their paper, Flerlage and Sloopweg advocate a triple focus on efficiency, safety, and circularity, both regarding chemical processes (synthesis) and products ([chemical structure](#)). These three core values of modern chemistry are described by the paradigms of green chemistry, safe and sustainable-by-design, and circular chemistry. These must all be complied with simultaneously if chemistry is to make a real contribution to sustainability.

All this will render chemistry more challenging, but also more rewarding, Flerlage and Sloopweg write. "We need to broaden our horizons and consider our chemistry beyond the reaction vessel and the

fume hood: how do the molecules and materials we make interact with the technosphere (industrial systems and society) and the biosphere (nature)?" To them, [chemistry](#) will only have a real and positive impact to sustainability when it fully embraces circular design, life-cycle thinking, human and environmental toxicology, and environmental and social impact assessment.

More information: Hannah Flerlage et al, Modern chemistry is rubbish, *Nature Reviews Chemistry* (2023). [DOI: 10.1038/s41570-023-00523-9](#)

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