Innovate beyond PFAS

New proposed legislation on "forever" chemicals is under consideration in Europe and the United States, where per- and polyfluoroalkyl substances (PFAS) are a hot topic for regulators and lawmakers. On both sides of the Atlantic, regulation of widely used PFAS has been complex and evolving. Their presence in hundreds of different products—from nonstick cookware to food packaging to firefighting foam—and their persistence in food, drinking water, and the environment have resulted in a pollution problem of unprecedented scale. Recently, for example, it was reported that 45% of the tap water in the United States contains at least one type of PFAS. Because these compounds are so chemically stable that they do not degrade in the environment (including in the human body), PFAS seriously challenge long-established ideas of how chemicals can be used, assessed, and regulated, and it remains to be seen whether the new regulations will solve this problem.

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Chemicals assessment traditionally has been centered around toxicity and physical hazards such as flammability. Chemicals that are carcinogenic, mutagenic, or toxic for reproduction (so-called CMR chemicals), as well as chemicals with high acute toxicity such as many neurotoxicants, stand out as particularly hazardous substances that should be avoided by all means. Chemicals of intermediate toxicity (including many PFAS), by contrast, have not been seen as an outstanding concern. However, this view turns out to be deceptive and dangerous if such chemicals are very persistent, as is the case for PFAS. Persistence has been seen as a property that merely indicates the presence of a chemical in a given environment. It may seem that persistent chemicals are inert and thus relatively benign. However, they still have many ways to interfere with an organism's physiology and cause adverse effects. Therefore, persistence is a property that makes the toxicity of any chemical much worse because it leads to—as long as uses and corresponding emissions are ongoing—ever-increasing concentrations, and toxic effects will manifest at some point. In other words, persistence acts as a multiplier of toxicity. This insidious aspect of persistence has been underestimated in chemicals assessment for a long time, and now in the case of PFAS, it has hit home.

The implications are substantial. One aspect is that chemicals that are only moderately toxic, but highly persistent, cannot be used in open and dispersive applications as has been the case for PFAS, but have to be used in closed systems, such as industrial equipment without any leaks or vents (which is required for highly toxic chemicals). Another aspect is that persistence does not carry sufficient weight in the assessment and regulation of chemicals. Persistence should be seen as a direct element of chemical hazard. The current approach of treating persistence only as a factor that modulates exposure to a chemical is not adequate. Under this approach, low persistence leads to lower estimated exposure and, thereby, a rating of lower risk in current chemicals assessment, whereas high persistence does not lead to a "red flag."

Accordingly, the way forward should include changes to the established system of chemicals assessment and regulation that go beyond the case of PFAS. For the specific problem of PFAS, it will be necessary to develop PFAS-free alternatives for many of the current PFAS uses. In general, this is possible for the vast majority of cases. Even for challenging and demanding uses such as fire-fighting foams for jet-fuel fires, it has been possible to develop fluorine-free alternatives. Research is also underway, for example, in the area of battery development, and PFAS-free options are already available.

However, we may be suffering from a "lock-in" of PFAS use in many applications as a result of their high performance and versatily. This has made them convenient as a choice in materials development and as components in industrial processes. Yet, it is clear that alternatives to PFAS can be found, and the lock-in of PFAS actually may be a roadblock to innovation. Innovation beyond PFAS should be a call to arms to chemists, material scientists, product designers, and process engineers, but also downstream users of chemicals in many sectors who have to define product requirements. Alternatives are technically feasible in a wide range of cases and offer a pathway toward a more sustainable chemistry and a safer world.

–Martin Scheringer

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