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Improving the detection of microplastics and plastic additives in the aquatic environments

(Amélioration de la détection des microplastiques et additifs plastiques dans les milieux aquatiques)

Keywords : microplastic, plastic additive, LC-QqQ, LC-QToF, GC-Orbitrap

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Context

Microplastics are now ubiquitous in the environment and are raising growing concern due to their potential effects on human health and ecosystems. However, studying these effects presents numerous scientific and methodological challenges. One of the main difficulties lies in distinguishing the specific effects of plastic particles, polymers, and the additives they contain. Indeed, microplastics are composed of various polymers that can undergo chemical and physical transformations over time, influenced by environmental factors such as UV exposure, mechanical abrasion, and interaction with contaminants present in water or soil. Moreover, plastic additives, which are intended to give certain properties to polymers (such as flexibility, thermal stability, or flame retardancy), can migrate out of plastic matrices and cause toxic effects distinct from those of the plastic particles themselves. This complexity makes it difficult to precisely identify the biological and chemical reactions triggered by microplastics in different environments.

Moreover, the lack of standardized protocols for the detection and characterization of microplastics complicates the analysis and comparison of results on an international scale. Currently, identification techniques such as FT-IR and Raman spectroscopy are the most commonly used, but they have notable limitations, particularly for very small particles (< 20 µm) and when plastics are degraded or mixed with other organic components. Additionally, microplastic sampling relies on various strategies (filtration, sedimentation, centrifugation), leading to methodological discrepancies that make it difficult to reliably assess their presence and distribution in the environment. Establishing harmonized protocols is essential to enable consistent data comparison across different laboratories and studies. As for the analysis of plastic additives, techniques mainly based on mass spectrometry (MS) remain underdeveloped compared to the number and diversity of molecules potentially present in the environment (Wiesinger et al. 2021).

Objectives and methods

The objective of this thesis is to overcome the numerous challenges related to the chemical characterization of microplastics and plastic additives.

A major research focus concerns the study of additive release from different types of polymers. A selection of polymers synthesized in the laboratory will serve as a basis for testing their behavior in relation to release processes. These experiments will provide a better understanding of how additives migrate into the environment depending on physicochemical conditions (pH, temperature, UV exposure, etc.) and help assess their potential bioavailability to living organisms.

As a preliminary step, a precise inventory of the compounds used in polymer manufacturing will be conducted. Based on the initiative of the European Chemicals Agency (ECHA), a database of plastic additives can be established, taking into account their physicochemical properties and compatibility with available analytical techniques. This classification will help identify additives that can be analyzed using GC-HRMS (gas chromatography coupled with high-resolution mass spectrometry) as well as LC-HRMS (liquid chromatography) for more polar or thermolabile compounds.

Furthermore, an assessment of potential contamination from laboratory consumables and instruments will be carried out to evaluate their contribution to the signals detected in GC-HRMS and LC-HRMS. This analysis will help optimize experimental protocols by minimizing background contamination and ensuring greater reliability of the results.

Finally, the developed methods will be tested and applied to the investigation of microplastics and plastic additives in water samples collected from Crépieux and the OTHU site (Observatory for Urban Hydrology). The objective is to quantify the presence of these contaminants in aquatic environments subjected to different anthropogenic pressures and to identify potential sources of pollution.

This combined approach, ranging from polymer characterization to their detection in natural environments, will provide new insights into the environmental fate of plastic additives and, in the longer term, their ecotoxicological impacts.

Skills

The candidate will have applied knowledge of analytical chemistry, in particular **liquid and gas chromatography coupled with mass spectrometry**, with a strong taste for **applications to environmental issues**. He or she will be required to develop and implement various analytical techniques.

References

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