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X-ray imaging and X-Ray Absorption Spectroscopy applied to Environmental Nanotechnologies

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Engineered nanomaterials (ENMs) have become a fast-growing economic sector. As a consequence of the many debates concerning their safety, efforts are developed at international and national levels to develop a code of ethics for a safe and responsible development of ENMs. A sustained growth of the nanotechnology industry will rely heavily on the characterization of risks to the environment (water and soil resources, trophic transfers, biodiversity) and human health that may be posed by ENMs in relevant exposure conditions (low doses, mid-/long-term, trophic and transgenerational transfers, etc.)

In this regard, physical-chemists, (micro)biologists, and ecologists need to conduct meaningful experiments to study the environmental risk of ENMs with access to relevant mechanistic data across several spatial and temporal scales (Auffan et al. 2019). Experimental devices as mesocosms that can be tailored to virtually mimic any ecosystem appear as particularly well-suited (Auffan et al. 2014) for the determination of the (bio)degradability, (bio)distribution, (bio)transformation, and impacts of ENMs. However, adhering to environmentally relevant exposure scenarios implicitly represents a technical challenge since it requires to explore the localization and the speciation of a target chemical element at relevant and consequently low doses in complex matrices, which is critical in the fields of environmental and biogeochemistry sciences (Carboni et al. 2021).

These past few years, the significant improvement of X-ray imaging (2D and 3D) and X-Ray Absorption Spectroscopy techniques in term of detection limit and resolution (spectroscopic and spatial) helped us to determine unambiguously and with greater precision the speciation and distribution of the probed metal composing ENMs in sediment, biota, aged nanomaterials... The positive impact of these techniques will be discussed based on examples dealing with the behavior and fate of TiO_2-, CeO_2- and Ag-based ENMs in ecologically relevant conditions and obtained both on synchrotron beamlines and laboratory apparatus.

References

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