Contribution ID : **246** Type : **Oral**

Light on the details: exploring the nano-silver behaviour at the plant-soil interface

Thursday, 19 November 2020 10:30 (30)

Over the past decade, significant advances have been made towards understanding the fate and impact of engineered nanomaterials (ENMs) in the environment, driven by concerns over their unique nanoscale properties and their increasing abundance in the market [1]. Synchrotron-based X-ray Absorption Spectroscopy (XAS) has played a key role in these advances, giving insights to the chemical speciation of common ENMs in environmental matrices, a key determinant of the potential fate and effects in the environment. The speciation of commonly studied metal-based ENMs (Zn, Cu and Ag) determined by XAS in the environmental matrices to which they are likely to released, often resemble their non-nano (ionic) counterparts (for example [2-4]). In these cases, understanding the transformation from nanomaterial to dissolved form helped to predict impacts. However, this is not always the case, for example sulfidation of Ag in waste streams results in different speciation which have been shown to alter environmental fate and toxicity. XAS has been vital in demonstrating this and has consequently, together with an array of analytical and predictive tools on their behaviour, transport and fate, have greatly advanced our understanding of ENMs and their potential impact on the environment.

However, while our general understanding has greatly advanced, the exponential rate at which nanotechnology is expanding precludes the case-by-case experimental assessment of every nano-enabled product. Therefore, there is a need for predictive tools that enable stakeholders, such as manufacturers, regulators and consumers, to assess the potential fate and impact of their ENM products in the environment. Furthermore, an understanding of how ENMs interact with the environment to which they are released (e.g. varying soil characteristics, interactions with biota) needs to be improved [5]. Recently, as part of a purposely designed experiment towards the development of such tools within the European NanoFASE project [6], we examined the speciation, kinetics and the distribution of silver nanomaterials (nano-Ag) in three different soils cropped with wheat. In particular, there was a focus on resolving the nano-Ag behaviour at the soil-plant interface via operationally defined regions of proximity and interplay with the plant roots. We will present the key results from these experiments, demonstrate how XAS was used at two different facilities to provide complementary insights, and finally give some consideration to how the results improve our understanding towards future exposure assessment tools.

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Session Classification : Session 3 - Earth, Atmosphere & Environment

Track Classification : Earth, Atmosphere and Environment