

Unravelling the fate of agrochemical nanoformulations at the leaf interface to predict and manipulate for their bioavailability

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Plants form the largest biomass pool of the critical zone. Their leaves serve as a major interface between the plant and its environment, acting as a surface for atmospheric contaminant deposition but also as an entryway for agrochemical products used in fertilization and plant protection. While foliar delivery of such compounds has been practiced for centuries, the fate of inorganic nanoparticles (NPs) after their deposition on plant leaves remains poorly understood. Unraveling the interactions between NPs and plant surfaces is critical for the on-going active research regarding their use in sustainable agriculture.

This presentation will explore experimental approaches designed to characterize the physicochemical properties of NPs, the anatomical and physiological traits of plant leaves, and the environmental factors—both biotic and abiotic—that can influence NP behavior after deposition. A combination of geochemical methods and synchrotron-based analytical tools provides powerful insights into these processes and will be introduced as part of this presentation. Key research questions addressed here will be: How to study NPs fate at the leaf interface? What are the primary parameters governing NP affinity to leaf surfaces and their ability to cross the plant cuticle? What strategies can be used to target specific leaf organs and ensure the delivery of active ingredients in response to environmental triggers? How can we fine-tune NP properties to enhance their reactivity and bioavailability, making them more effective for plant nutrition?

Understanding NP fate is crucial not only for optimizing beneficial applications but also for assessing potential risks, such as unintended accumulation in non-target plants or releases in ecosystems. Ultimately, these results contribute to advancing our understanding of NP-plant interactions and their implications for innovative and sustainable agricultural practices. Finally, leaves seem more permeable to particle entry than what primarily thought. The approaches discussed here could similarly be applied to studying the deposition, transformation, and bioavailability of atmospheric contaminants on plant surfaces, providing broader insights into the role of leaves as environmental interfaces.