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Resolving Nanoplastic Aggregation and Size at Soil-Water Interfaces via Small Angle Neutron Scattering (SANS) and Ultra-SANS (USANS)

The presence of nanoplastics (NPs) in the environment represents a major challenge due to potential soil/water contamination, and the transport of toxic substances. Their relatively small size (1–1000 nm) and high surface reactivity results in a wide range of complex interactions with heavy metals, organic matter, and biological substances. Understanding these interactions involves investigation at complex interfaces, such as those between soil and water. While conventional characterization methods such as microscopy can adequately study plastic particles at the microscale, they often lack the adequate resolution to study them at the nanoscale where challenges such as extremely low NP concentrations and signal interference from the environmental matrix (e.g., soil and organic matter) are prominent. In this study we investigated structure and aggregation behavior of suspensions of NPs derived from mechanically treated plastic films and microparticles of artificial soil, vermiculite (V), in water, as would form near soil-water interfaces, through Small Angle Neutron Scattering (SANS) and Ultra-SANS (USANS) at Oak Ridge National Laboratory. We employed suspensions of NPs composed of different polymeric materials and containing adsorbed biofilm components (e.g., humic acid and proteins) and V in water at different concentrations and ex-situ stirring times. By utilizing neutron contrast matching techniques, we matched out the signal attributable to V or adsorbed biofilm components, giving insight into the particle size distribution, agglomeration, and mobility of NPs under environmentally applicable conditions. The results from this study showed that the NPs formed had two distinct subpopulations: a smaller and a larger NP fraction with mean diameters of ~ 200 and 850 nm respectively. It was also observed that the presence of V in the suspension, while emulating environmental conditions facilitated aggregation and further size reduction of NPs through abrasive forces between particles. Our findings explain the role of soil components in determining NP fate and transport.

Topical Area

Soft matter: polymers, and complex fluids

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