

Tracing the fate and the transformation of silver nanoparticles in the environment

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The principal objective of this work was to develop and demonstrate new methodologies to characterize the full range of matter states resulting from metal nanoparticle transformation in relevant media. In this investigation, we couple asymmetric flow-field flow fractionation to optical absorbance (UV-Vis) and scattering detectors (static and dynamic) and to an inductively coupled plasma mass spectrometer (ICP-MS). With this combination of detection modes it is possible to determine the mass isotopic signature of AgNPs as a function of their size and optical properties, providing specificity necessary for tracing and differentiating labeled AgNPs from their naturally occurring or anthropogenic analogs. The methodology was then applied to standard estuarine sediment by doping the suspension with a known quantity of isotopically enriched ¹⁰⁹AgNPs stabilized by natural organic matter. The mass signature of the ¹⁰⁹AgNPs was recorded as a function of the measured particle size. We observed that AgNPs interact with different particulate components of the sediment, and also self-associate to form agglomerates in this model estuarine system. Secondly, we demonstrate unprecedented fractionation of metal nanoclusters (NC) with core diameters near 1 nm and with high resolution using A4F. We apply our methodology to a model system, poly(N-vinyl-2-pyrrolidone)-protected, AgNPs with an excess of glutathione (GSH). The temporal evolution of the initial, AgNP distribution in the presence of excess GSH results in the appearance and persistence of a continuum of matter states (e.g., Ag⁺, nanoclusters and NPs) that were successfully fractionated with A4F.