

Natural organic material characteristics affect the environmental behavior of manufactured nanoparticles

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Rapid development and expansion of nanotechnology and growing use of nano-products have raised numerous safety concerns among the public and scientific community. Potential release of nanoparticles (NPs) into the environment is predictable through point and/or non-point sources. Environmental parameters such as pH, ionic strength, and natural organic material (NOM) profoundly affect their environmental behavior in aquatic systems. This in turn will influence the biological interaction and potential toxicity of NPs in the environment. In this study we examined how the physico-chemical characteristics of NOM affect the colloidal behavior of C60 fullerene and α -aluminum oxide NPs as two model NPs. Three structurally different humic acids and tannic acid were used as model NOMs. Aggregation behavior of NPs and structural characterizations of the adsorbed NOM on Al₂O₃ NPs were studied using DLS, AFM, TEM and DRIFT techniques. Fullerene suspension had a negatively charged surface over a wide range of pH, while Al₂O₃ had pH dependent charge with ZPC of 7.9. Surface charge of pure fullerene suspension decreased to more negative values after addition of any type of NOM, leading to a more stable colloidal system. Surface charge of Al₂O₃ NPs also decreased with the addition of NOM, which enhanced the colloidal stability at pH near or above its ZPC. However, below ZPC the presence of free NOM decreased stability of the colloidal Al₂O₃ system due to charge neutralization as well as bridging flocculation. Early stage aggregation kinetics studies were conducted by addition of varying concentrations of Ca²⁺ to the NPs suspensions. Addition of Ca²⁺ to the fullerene + NOM and the NOM-coated Al₂O₃ NPs systems increased zeta potential almost uniformly for all types of NOM. Critical coagulation concentration (CCC) was calculated for each NP and NOM pair combination. The CCCs increased with increasing molecular weight and decreasing polarity of NOM. Our data clearly showed that high molecular weight NOMs promoted the colloidal stability of fullerene + NOM system and the NOM-coated Al₂O₃ NPs through steric stabilization. This is in agreement with the DRIFT spectra of NOM-coated Al₂O₃ NPs showing higher aliphatic content in the complexes prepared with high molecular weight NOMs. However, low molecular weight NOMs also enhanced colloidal stability of fullerene and NOM-coated Al₂O₃ NP suspensions but mainly through electrostatic repulsion. In contrast to NOM-coated Al₂O₃ and fullerene systems, we observed that the presence of free long chain polymeric materials in NOM destabilized the colloidal suspension of pure Al₂O₃ NPs in acidic pHs. The plausible mechanism could be the coiling of long molecular

chains of NOM followed by NPs entrapment. NPs aggregate size would be a determining factor in their fate, mobility and sedimentation in aqueous systems, which will consequently affect their biological interactions. This study highlights the effect of physico-chemical characteristics of NOM on the aggregation of NPs through modification of their surface properties.

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