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Simulating the Stability of Colloidal Amorphous Iron Oxide in Natural Waters

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Abstract

Anecdotal evidence suggests that there are more than 800 commercial products containing manufactured nanomaterials in commercial production and that this number is expected to increase in an exponential fashion. Unfortunately, existing standardized test guidelines designed to assess the environmental mobility of commercial products are not likely to be directly applicable to insoluble nanomaterial suspensions in natural waters. This work describes findings from an ongoing effort designed to assess the utility of the historical Derjaguin-Landau-Verwey-Overbeek (DLVO) theory of colloidal particle stability when used in conjunction with legacy Diffuse Layer (DLM) and Triple Layer (TLM) electrostatic surface complexation models. Due to the availability of data, colloidal amorphous iron oxide was selected as a test substrate and the likelihood of its forming stable suspensions over a pH range of 4 to 10 was assessed in simulated 0.7 M seawater, 0.1 M diluted seawater, world average river water, continental U.S. average groundwater and 50th percentile midwestern U.S. rainwater. Findings from the work included: 1) legacy surface complexation models are likely to overestimate the diffuse layer potential (and stability) of smaller, nanosized colloidal particles, 2) both DLM and TLM models predict unstable iron oxide suspensions in the 0.7 and 0.1 M seawater systems and both models predict stability in most of the rainwater simulations, 3) the DLM diffuse layer potential estimates generally exceeded the TLM values and there was not agreement concerning stability assessments in the simulated river and groundwaters, 4) the major ions present in natural waters are likely to have a profound impact on system-dependent diffuse layer potentials and 5) findings from both models were at least qualitatively in agreement with observations reported in the literature.