

Nanoelectronics Undergraduate Research Fellowship (NURF) 2010 Project Summary

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Project title: Effects of experimental design on size dependent Pb Sorption to Nanohematite in the presence and absence of a microbial siderophore

Mineral nanoparticles are ubiquitous in aquatic environments. Studying mineral nanoparticles, namely hematite, involves different methods of experimentation. Experimental design is a crucial part in any scientific study, but we are discovering that nanoparticles sometimes require new designs and approaches. This study examined the effects of nanoparticle size on Pb(II) sorption to three different size hematite nanoparticles, 3.6, 8.6, and 40nm in the presence and absence of a metal chelating siderophore, desferrioxamine B (DFOB). In many past sorption or dissolution studies using iron oxides such as hematite, goethite, and ferrihydrite, researchers have normalized to mineral mass within the experiment, meaning that the same mass of each mineral sample is used, and then post normalize for surface area mathematically during the post-experiment analysis process. However, because specific surface area can vary dramatically with particle size for nanoparticles, there are concerns that this mass normalized approach may not give directly comparable results, due to differing ratios between sorbate (i.e., metal) and sorbent (i.e., nanohematite) surface sites. In mass normalized studies, the differing ratio between sorbent and sorbate might make it impossible to compare results for nanoparticles of different minerals or different sized nanoparticles of the same mineral.

Previously, no studies had been done to experimentally test whether post-normalization to particle surface area would produce comparable results to experiments that were normalized to surface area within the actual experimental reaction vessels. To directly test the comparability of surface area corrections within the reaction vessels versus post-normalization after the experiments, I conducted Pb sorption experiments using the two different approaches: mass-normalized with post-experiment correction or surface area normalized within the actual experiment. I conducted sorption edge experiments, in which Pb and DFOB concentrations along with solution ionic strength and temperature were kept constant but the pH was varied (from 3 to 9). After preparation, the reaction vessels were left for 24 hours on a rotary shaker for the system to come to equilibrium. After 24 hours, solutions were separated from particles through a filter system and analyzed by ICP-OES for Pb and Fe concentrations. The results showed that experimental results depended upon the manner in which the reaction vessels were set up. Simply correcting for surface area differences after the fact did not provide the same result. When the experiments were run properly, we observed a shift in the adsorption edge for different particle sizes, consistent with changes to mineral surface structure and reactivity as a function of particle size.

Paper: Size dependent Pb sorption to nanohematite in the presence and absence of a microbial siderophore: effects of experimental design on sorption edges.

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