Impact of Natural Organics on the Surface Reactivity of Magnetite Nanoparticles

A.L. SWINDLE[1]*, A.S. ELWOOD MADDEN[1] AND I.M. COZZARELLI[2]

[1]University of Oklahoma, Norman, OK (*correspondance: aswindle@ou.edu, amadden@ou.edu)
[2]US Geological Survey, Reston, VA (icozzare@usgs.gov)

Organic matter is known to readily adsorb to colloidal and nano-scale mineral surfaces in natural environments impacting the surface charge, aggregation, and transport of these materials. As a result, understanding the impact of natural organics on mineral surface reactivity is crucial to gain insight into the environmental fate of both naturally occurring and anthropogenic nano-scale minerals.

In this investigation magnetite nanoparticles with average diameters of 6 nm and 90 nm were synthesized and thoroughly characterized. The sorption of chromate onto magnetite surfaces in the presence and absence of organics was used as a proxy for surface reactivity. A baseline sorption curve was determined in a series of magnetite-chromate sorption experiments conducted at circumneutral pH. The experiments were then repeated with varying concentrations of Suwannee River Fulvic Acid (FA), and organics isolated from leachate-impacted groundwater (LL) from the USGS Norman Landfill Site.

Experimental results indicated that in the absence of FA, 6 nm magnetite sorbed ~92% of the total chromate in solution over an 8 hour duration, while the 90 nm magnetite sorbed ~88% of the total chromate over the same time period. Low concentrations of FA (1 mg/L) had a negligible impact on the sorption of chromate for either set of particles, while the addition of 50 mg/L FA reduced the amount of chromate sorbed by the 6 nm and 90 nm particles to ~76% and ~70% of the total, respectively. The addition of LL (100 mg/L) had a similar impact on the magnetite-chromate sorption dynamic.

These results demonstrate that high concentrations of dissolved organics inhibit the surface reactivity of nanoparticles by reducing the reactive surface area of the particles. Additionally, the initial results indicate that at early sample times the sorption of Cr (VI) is reduced to a greater extent for the 6 nm particles in the presence of FA although the degree of inhibition equalizes over the full 8-hour experimental duration. Future experiments will investigate the response of the same magnetite-chromate system to different types of organics, as well as look at the impact of the organics on the magnetite/Cr(IV) redox system.