Silver nanoparticles: Effects on microbial denitrification

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Nanoparticles (d < 100 nm) are increasingly common in consumer technology. Nanosilver particles, in particular, are used for their well-known antimicrobial properties in a wide range of consumer products ranging from socks to washing machines. These particles kill gram negative bacteria by disrupting the cell membrane [1]. Bacteria-driven nutrient cycles in soils and sediments may be impacted by the introduction of nanosilver particles via discharge from water treatment plants and/or sludge amendments on agricultural land. Nanosilver could possibly threaten the (de)nitrification cycle in soil-water environments. Choi *et al*. [2] reported in a recent study that the nitrification process was suppressed in solution systems when the aerobic bacteria were exposed to nanosilver particles (1 mg/L) [2]. However, our preliminary experiments showed no antibacterial effect on anaerobic denitrifers at nanosilver concentrations as high as 5 ppm, while dissolved silver exposure at 1-5mg/L showed the complete inhibition. This suggests that solubility and stability of nanosilver particles in the soil systems might be controlling the toxicological effects on denitrifiers. This research will further explore the antibacterial effects of nanosilver particles on denitrifiers under various redox conditions prior to anaerobic denitrification experiments, as well as the fate of silver nanoparticles in soil-water environments. Both saturated soil and solution systems will be used to assess the solubility/stability of nanosilver with respect to the overall antimicrobial effects.

[1] Sondi and Salopek-Sondi (2004) *J. Colloid Interface Sci.* **275**, 177-182. [2] Choi *et al*. (2008) *Water Research* **42**, 3066-3074.

Adsorption of strontium at nano- and micro-crystalline titanium-dioxide interfaces: Interpreting surface speciation using charge distribution and the MUSIC model

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The surface speciation of specifically adsorbed ions at metal (hydr)oxide surfaces is dependent on mineral surface structure and solution chemistry. Theoretical simulations and X-ray techniques provide molecular-scale detail of adsorption complexes and mineral surfaces. Whereas, the effects of solution chemistry on ion adsorption, particularly pH, are best investigated using macroscopic experimental techniques. Surface complexation models (SCM) provide a framework for integrating molecular-scale detail with macroscopic experimental results. Such integrated approaches have been applied successfully to better understand the specific adsorption of ions onto various micro-crystalline metal (hydr)oxide phases. For example, potentiometric titration data, X-ray measurements and theoretical calculations for the adsorption of Sr^{2+} on micro-crystalline rutile (α-TiO_2) have been integrated successfully using the MUSIC model in combination with the charge distribution (CD) model.

The surface reactivey of nano-crystalline materials have not been studied as exteinsively, thus fewer compariable integrated studies have been performed. This contribution will present adsorption results of Sr^{2+} on nano-crystalline anatase (TiO_2). The sorption of Sr^{2+} was studied as a function of nanoparticle size (3–40 nm diameter), pH and loading in NaCl media at 25°C. Moreover, the experimental solution conditions were selected carefully so as to evaluate Sr^{2+} sorption on nano-particles relative to compariable macroscopic phases. The development of proton charge curves with the adsorption of Sr^{2+} were similar for all nano-samples, when normalized to their respective pH_{znpc} values. Furthermore, the charging curves for Sr^{2+} sorption on the nano-sized anatase were similar to compariable adsorption curves for micro-crystalline rutile. Adsorption charging curves change as funtion of surface loading, suggesting a change in surface speciation. All experimental results were rationalized using a CD-MUSIC model combination. Moreover, the SCMs for Sr^{2+} sorption on rutile were used to help constrain all nano-crystalline anantase modeling efforts.