Sorption of Sb(III) and Sb(V) on nanostructured maghemite and implication for environmental geochemistry

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In recent years, antimony (Sb) is widely used in a variety of industrial products including flame retardants, batteries, alloys and catalysts. Elevated concentrations of Sb in soils have also been detected around mining and smelter areas, at shooting ranges. Sb exists in a variety of oxidation states (−III, 0, III, V), with oxidation states III and V being the most common inorganic species in natural environment, where Sb(V) is the predominant species and exists as $Sb(OH)_6^-$ in oxic settings, while Sb(III) primarily occurs as $Sb(OH)_3$, and is more stable and toxic under anoxic conditions between pH 2 and 10. However, very little is known about the mobility of Sb in natural environment. Sorption processes to mineral phases may significantly affect and control the mobility of Sb. Here, synthetic nanostructured microspheres of maghemite were selected as sorbent to adsorb Sb from different pH solutions. The aim is to understand the effect of nanoscale maghemite on the mobility of Sb in natural soils because maghemite occurs as widespread brown or yellow pigment in terrestrial sediments and soils. Our results show that the nano-maghemite exhibits an excellent sorption ability to Sb(III) over a wide pH range, whereas the maximum Sb(V) sorption is found below pH 3. This implies that iron oxide nanominerals present in subsurface soils may exert a preferential immobilization and occlusion for Sb (III) to Sb(V). Moreover, the desorption experiments by eluting of alkali solution show that the sorption efficiency of the nano-maghemite undergoing three sorption/desorption cycles remains almost constant, with satisfied uptake efficiency 90 % for Sb(III), and 80 % for Sb(V) even in the fifth round. In this regard, the magnetic nano-maghemite can also act as a promise scavenger in wastewater treatment in terms of its high removal efficiency to Sb, good reusability, and convenient handling properties.

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