Preferential Adsorption of Lead Ions on Mn-Substituted Goethite Particles

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α-FeOOH (goethite) is a good sorbent mineral existing in the natural environment. The adsorption of metal ions onto the surface of goethite particles can be interpreted as a chemical reaction occurring at specific surface sites. Hydrous metal oxides exhibit amphoteric behavior in water. The hydroxyl groups on the goethite surface can uptake and release protons, resulting in a generation of surface charge due to proton transfer reactions. For goethite-particle suspensions with metal solutions, proton is the predominant surface-potential determining ion. Metal-ion adsorption on the goethite surface is therefore influenced by the solution pH. The adsorption onto the goethite surface increased from zero to almost 100% over a narrow pH range, approximately 2 pH units, as found for heavy metals such as Cu, Pb, Ni, Co, and Mn (1). The adsorption of these metal ions as a function of pH differs each other. However, the adsorption order of goethite for heavy metal ions is determined only by the solution pH. Since the incorporation of foreign metals into goethite can influence not only the crystallization conditions of goethite particles but also their physicochemical properties. We focused on the preferential adsorption of lead ions onto the surface of Mn-substituted goethite particles.

Mn-substituted goethite, α-(Fe, Mn)OOH, was prepared by adding a KOH solution to mixed solutions of $Fe(NO_3)_3$ and $Mn(NO_3)_2$ with their appropriate proportions. The prepared solution was subsequently aged at 333 K for different hours. The precipitates were filtered and dried in vacuum at ambient temperature for 24 h. The dried sample of 1 g was suspended in a 100 ml 3M H_2SO_4 solution using an ultrasonic bath to eliminate ferrite particles adhered to the goethite particles. The filtrated sample was washed with distilled water, and dried in air at 343 K for 48 h. The concentration of Fe and Mn ions in the final product was determined by dissolving these particles into aqua regia and analysing the concentration of Fe and Mn in a diluted solution by atomic absorption spectrometry. Solutions of Pb^{II}, Cu^{II}, and Zn^{II} were prepared by dissolving $Pb(NO_3)_2$, $Cu(NO_3)_2$, and $Zn(NO_3)_2$ in distilled and deionized water, and pH of each solution was adjusted by adding a 0.05 M NaOH solution. 50 mg of the α-(Fe,Mn)OOH sample was suspended in 15 ml of a 1 mM solution containing each metal ions. The adsorption experiment was made for a mixed solution of Pb(II), Cu(II), and Zn(II) each concentration was kept at 1 mM. The sample solution was put in a glass vial and kept at 303 K for 3 h in a water bath incubator, and the suspension was centrifuged in 10 ml glass tubes at 3500 rpm for 30 min. Each supernatant solution was diluted to appropriate concentrations and analyzed for the metal ions by atomic absorption spectrometry.

Adsorptive ability of α-FeOOH particles was not significantly affected by the aging time during their synthetic process (Fig. 1), which means the adsorption order for the heavy metal ions was not influenced by the particle size. However, solid solutioning of Mn into the α-FeOOH lattice enhanced the preferential adsorption of Pb(II) to Cu(II), as shown in Fig. 2. X-ray diffraction patterns of goethite particles showed that line sharpening in 110 reflection occurs by the incorporation of Mn into the goethite lattice regardless of its concentration. This result shows that the morphological change of α-(Fe, Mn)OOH particles does not affect the adsorptive property. The increase of Pb(II) adsorption with increasing Mn content can be explained by the synergetic effect of the surface electric potential and the lattice distortion of the goethite lattice.

REFERENCE

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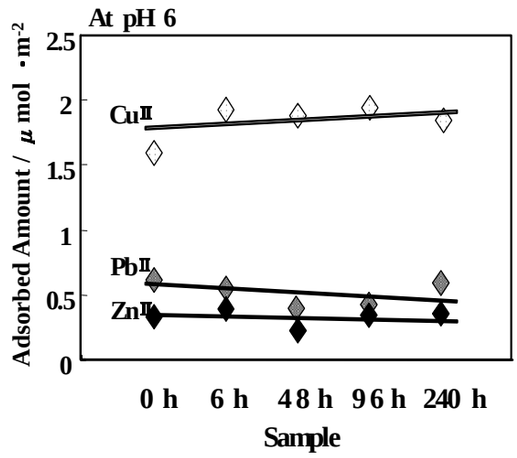

Fig. 1 Adsorptive ability of Goethite particles

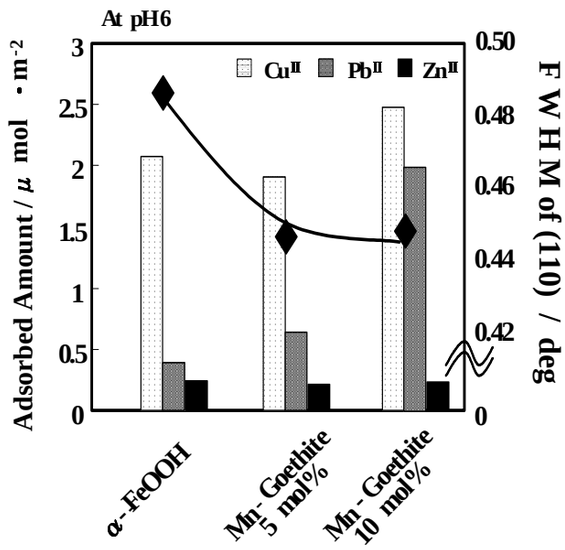

Fig. 2 Comparison of the adsorbed amount of heavy metal ions among α-(Fe,Mn)OOH particles and full width at half maximum for 110 reflections.