



Effect of pH and Ionic Strength on Adsorption of As (III) and As (V) using Magnetite

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Effect of pH and ionic strength on adsorption of As(III) and As(V) using magnetite

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Abstract

Arsenic adsorption on the magnetite was investigated as a function of pH and ionic strength. The adsorption of As(III) was independent of ionic strength, whereas higher As(V) adsorption was resulted in alkaline media at higher ionic strengths. The point of zero charge (PZC) of the magnetite was 6.0. PZC shifted to an acidic side in the presence of As(III) and As(V). The presence of As(V) was more sensitive to changes in the PZC than that of As(III). Zeta potentials indicated negative values in the acidic pH region. These results suggest As(III) and As(V) form the inner-sphere complexes on the magnetite.

Keywords: adsorption of arsenic, zeta potential, point of zero charge, ionic strength, magnetite

1. Introduction

Arsenic is well-known highly toxic and carcinogenic element. Concentrations of arsenic greater than 10 $\mu\text{g}/\text{dm}^3$ safety level provided by World Health Organization (WHO) guidelines are detected in the groundwater of many regions of countries around the world, such as Argentina, Bangladesh, Chile, China, India, the United States and Vietnam (Smedley and Kinniburgh, 2002). Many researchers have focused on removal of arsenic using ferric oxides and hydrous ferric oxides as adsorbents. We focused on magnetite being one of iron oxides and found the magnetite adsorbed both As(V) and As(III) (Ohe et al., 2005, Siple et al. 2009). Magnetite interface on adsorption of As(III) and As(V) has been hardly investigated. In present study, adsorption of As(III) and As(V) on magnetite was compared at different pHs and various concentrations of electrolyte.

2. Experimental

2.1 Synthesis of magnetite and its characterization

Magnetite was synthesized using co-precipitation method. 1 M NaOH was added in a mixed solution of 0.2 M $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ and 0.1 M $\text{FeCl}_2 \cdot 4\text{H}_2\text{O}$ until pH 11 under N_2 gas and

then was freeze-dried after washing by deionized water. The synthetic solid was identified using X-ray refraction detector. A BET surface area was obtained by N_2 adsorption. Particle sizes were measured using laser diffraction particle size analyzer.

2.2 Adsorption test and zeta potential measurement

The adsorption tests were carried out by a batch method at 303 K. Ionic strength was prepared using NaCl. A 15 cm^3 of an aqueous arsenic solution containing 1 or 100 mM NaCl solutions various initial pH was added to 10 mg of the magnetite. The samples were shaken for 24 h and then filtered through a 0.45 μm membrane filter. Arsenic in the filtrate was measured with inductively coupled plasma atomic emission spectrophotometer. Adsorption percentage was calculated by difference of initial and equilibrium arsenic concentrations.

Zeta potentials were measured by electrophoresis method using Nano Particle Analyzer. The effects of coexistence of As(III) and As(V) on zeta potential of the magnetite were investigated using a sample solution contained 10 mM NaCl solution and either As(III) or As(V) of their different concentrations. A 60 mg of the magnetite was added to the sample solution of about pH 10 and then zeta potentials at

each pH were measured.

3. Results and Discussion

The synthesized solid was identified as magnetite by XRD. The specific surface area of the magnetite was 88.6 m²/g and the mean particle size was 37.7 μm.

The effects of ionic strength on adsorption of As(III) and As(V) were shown in Fig. 1. Adsorption of As(III) was

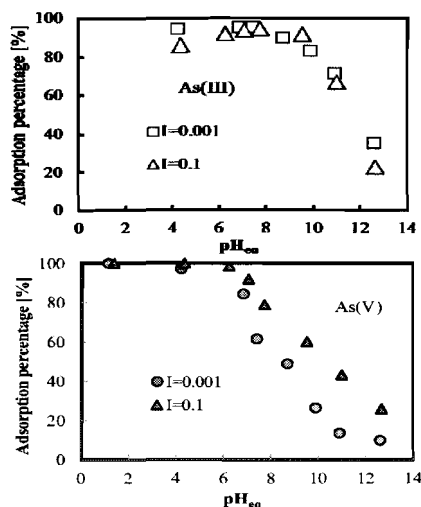


Fig.1 Effect of ionic strength(I) on adsorption of As(III) and As(V).

independent of ionic strength. It was found that the increase of ionic strength from 0.001 to 0.1 causes that the pH beginning to decrease adsorption percentage shift to a high pH side and increased the adsorption of As(V) on the magnetite. The adsorption of As(V) by outer-sphere complexation is strongly affected to ionic strength and is inhibited by competitive adsorption of coexisting anions which form outer-sphere complexes through electrostatic forces. On the other hand, the adsorption of anions by inner-sphere complex formation either is hardly affected to ionic strength or indicates more adsorption at the high ionic strength (McBride, 1997). In the alkaline pH region, As(V) adsorption increased with increasing ionic strength. The adsorption of As(V) by an inner-sphere complex formation increases the surfaces negatively charged of the magnetite which leads to adsorption of cations. The increase of NaCl concentration in the solution can provide more Na⁺ cations which are available to electric charge neutralization on the surfaces. This promoted As(V) adsorption.

3.1 Point of zero charge

The shift of point of zero charge (PZC) of amorphous iron oxides with increase of ionic strength was caused by strong adsorption of As(III) or As(V) and formation of inner-sphere surface complex (Goldberg and Johnston, 2001). According to Ooi (2010), the zeta potentials in the acidic pH region and

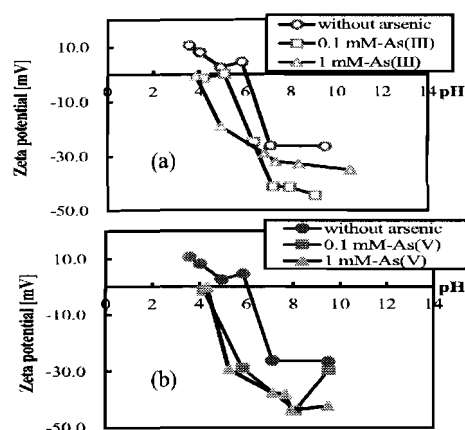


Fig.2 Zeta potential of the magnetite as a function of pH in 0.01 M NaCl solution of 0.1 or 1 mM (a) As(III) and (b) As(V).

high concentration of salt were negative values since anion such as SO₄²⁻ was adsorbed to surface hydroxide groups on a metal oxide by a ligand exchange reaction. Zeta potentials of the magnetite as a function of pH in 0.01 M NaCl solution with different concentrations of As(III) and As(V) were shown in Fig. 2. The PZC of the magnetite was 6.0 and the surface charges were found positive value at pH<PZC and negative value at pH>PZC. The zeta potentials of the magnetite decreased in the presence of As(III) and As(V) which indicated that the surface of magnetite was negatively charged after As(III) and As(V) adsorption. The presence of As(V) was more sensitive to changes in the PZC than that of As(III). These results suggested As(III) and As(V) form inner-sphere complexes on the magnetite. These results support influence of ionic strength on adsorption of As(III) and As(V).

4. ACKNOWLEDGEMENT

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