

Adsorption, Desorption, and Stabilization Behavior of Arsenic(V) on Al³⁺ Substituted Fe³⁺ Oxides

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INTRODUCTION

Arsenic introduced by natural processes or human activities can result in the contamination of water and soils. Arsenic is so toxic that the removal of arsenic from water is necessary if the water is to be used for human consumption (Nriagu, 2002). Al or Fe hydroxide is commonly used as adsorption agents in water treatment systems (Hering *et al.*, 1996). However, there has been very little attention to Al-substituted Fe³⁺-hydrous oxides, even though this system could offer some advantages in terms of flocculation, and stabilization of flocculated product. Fe and As compounds in contaminated residue from water treatment might transform into soluble forms due to the redox processes of Fe; however, Al hydroxide mineralogy is not strongly affected by redox processes. Understanding the relationship between Al-substituted oxides and As could lead to improved methods of As treatment and disposal. In addition, most of the Fe oxides present in soils are Al-substituted (Schwertmann and Taylor, 1989); therefore, it is essential to know the adsorption and desorption behavior of Al-substituted oxides to fully understand As retention in soils. The objective of this study was to compare adsorption of As(V), flocculation and mineralogy of ferrihydrite and its Al-substituted analogs.

MATERIAL AND METHODS

A series of Al-substituted Fe(OH)₃ samples were prepared at 1:0, 97:3, and 9:1, 8:2, 50:50, and 0:1 Fe:Al molar ratios with a modification of the standard two-line ferrihydrite synthesis (Schwertmann and Cornell, 1991). The samples were freeze-dried prior to x-ray diffraction analysis to identify the mineralogical characteristics of the synthesized oxides.

Adsorption envelopes of As(V) were obtained in 0.1 M NaCl with a As:(Fe, Al)(OH)₃ molar ratio of 0.05: 1. Separate samples were adjusted to give suspension pH values ranging from 3 to 11 by addition of HCl or NaOH. Each sample was shaken for 24 hours. Upon the completion of the reaction, samples were centrifuged and the pH of the supernatant was obtained. The samples were filtered, and As was analyzed by FI-HG-AAS.

Flocculation of 1:0 and 9:1 oxides were compared using 0.01 M CaCl₂ and 0.01 M NaCl at pH 6 and 8. Samples were first plunged for 5 seconds, and then the rates of flocculation were observed.

RESULTS AND DISCUSSION

XRD patterns in Fig. 1 show the Al was incorporated into the poorly crystalline structure up to approximately 20 % molar ratio. The 8:2 oxide resulted in a XRD pattern almost identical to that of ferrihydrite. This pattern is indicative of short-range ordering of the mineral structure, but poor range ordering (Schertmann and Taylor, 1989). This poorly crystalline phase is desirable in water treatment as it provides high surface area. The 50:50 oxide pattern illustrates there is a change in crystal structure of oxide.

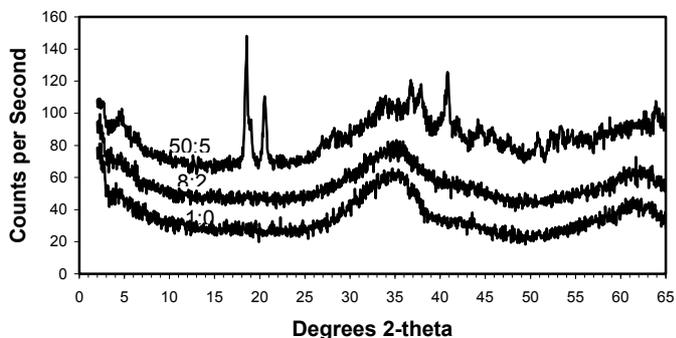


Fig. 1. X-ray diffraction patterns of 1:0, 8:2 and 50:50 oxides.

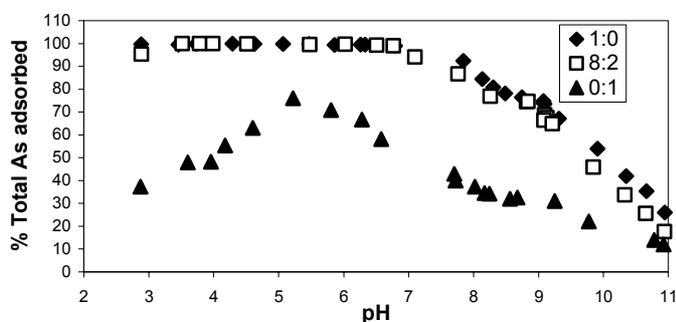


Fig. 2. Adsorption envelope of As(V) with 1:0,8:2, and 0:1.

Adsorption envelopes of 1:0 and 8:2 oxides showed similar trends overall (Fig. 2). Strong retention of As(V) is observed throughout the pH range of 3 to 7. Retention of As(V) started to decrease around pH 7 at both 1:0 and 8:2 molar ratios. The 1:0 oxide resulted in a slightly better As adsorption above pH 7.5. The 1:0 and 8:2 treatments indicated better retention of As compared to the 0:1 oxide, which suggests that the Fe systems (including the mixed Fe/Al systems) were superior to the pure Al system in terms of As(V) adsorption.

Significant differences in flocculation of the 1:0 and 9:1 oxides were not observed in any combinations of CaCl₂ or NaCl and pH 6 or 8.

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