Study on arsenic removal process from water

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Abstract: In this study a novel adsorbent, iron oxide, is used for As (V) or As (III) removal. Some ferric oxides have been reported to be effective for arsenic removal. Ferric oxides powder is a good adsorbent material since it's has magnetic properties and a good adsorption capacity. The main purpose of this study has been focused on to study the relationship between adsorption capacity (ability, performance) and the surface characteristics of the ferric oxide. Prepared sample's capacity was evaluated. The value was 26.1-67.4 mg/g for As (V) and 20.5-47.8 mg/g for As (III). pH dependence was evaluated and when pH increasing, adsorption capacity was decreased. The kinetic was evaluated and about 12 hours reached equilibrium and a capacity of 49 mg/g for As (V) and 42 mg/g for As(III) was gained. The kinetic constants for arsenic adsorption on the ferrihydrite adsorbent's were fitted.

Introduction

Ferrihydrite is an iron oxy-hydroxide known to play an important role in the natural environment and fresher it is, higher the adsorption capacity it has. Its large surface area, strong adsorptive properties, and low cost make it an attractive material for removal of both cationic and anionic impurities from wastewater and drinking water. The use of ferrihydrite to remove arsenic from hydrometallurgical process solutions and wastewaters has received a great deal of attention over a number of years. Ferrihydrite readily adsorbs arsenic (V) in the form of arsenate anion (AsO_4^{3-}), but probably the most effective method of removal of arsenic from aqueous solutions is through coprecipitation of arsenic with ferrihydrite.(1) The main arsenic removal techniques from drinking water are: oxidation, precipitation/co precipitation, coagulation, sorption, ion-exchange and reverse osmosis. Although these methods have been widely employed, they have several drawbacks: high operating and waste treatment costs, high consumption of reagents and large volume of sludge formation. In contrast, adsorption methods are considered to be very important because of their treatment stability, easy operation and compact facility. When the loaded adsorbent can be regenerated properly, the process can be sludge free. Conventional adsorbents used in arsenic removal are activated carbons and alumina, soils and resins which can be coated with different materials like iron or alumina. (The major disadvantages of these techniques are difficult separation (centrifugation or filtering), waste formation (both liquid and sludge) and in many cases poor adsorption capacity.) So in this study I use ferric oxides.

Experimental.

Materials. All the chemicals used were of analytical reagent grade. A 100 mg /l As (V) and As (III) stock solutions were prepared by dissolving $Na_3AsO_4 \cdot 12H_2O$ or As_2O_3 in 1 liter of distilled water. As(V) or As(III) bearing water were prepared by diluting As(V) or As(III) stock solutions to given As concentrations.

Preparation. The iron based adsorbent was prepared by mixing $Fe(NO_3)_3 \cdot 9H_2O$ and KOH for 20 minutes at pH 9.5. In all the process, the mixed solution needs to be intensely stirred. Then the pulp was settled, and supernatant was discarded. And the paste was washed with distilled water for many times until the conductivity lower than 500 $\mu s/cm^2$. Then the paste was oven drying at 45 ^oC to make it dry about 48-72 hours. Also the drying process can be substituted or refrigerated centrifugation. After that prepared samples were powdered by agate mortar.

Isotherm experiments were carried out in 250 ml conical flasks, with a reaction volume of 100 ml, and the initial As(V)/As(III) concentration:

8, 10, 12, 18, 24, 26, 30, 34, 38 mg/l. The adsorbent was fixed at a dose of 300 mg/l. The pH of the suspension was adjusted and kept at pH 5.0 ± 0.1 during the experiment period. These flasks were shaken at 160 rpm and maintained at 25 ± 1 °C for 24 hours. And the solutions were filtered with a 0.45 μm cellulose acetate membrane, then the concentrations of the residual As was analyzed in using HG-AFS.

To investigate the influence of pH on the As adsorption, experiments were carried out in 250 ml vessels, containing 25 mg/l As(V), respectively, with 300 mg/l adsorbent and a total suspension volume of 100 ml. And the equilibrium pH was adjusted in the range of 3 to 10 at an experiment period of 24 hours. During the experiment, samples were shaken at 160 rpm, and the temperature was controlled at 25 ± 1 °C. After reaction, the final pH values were recorded, and the solutions were filtered with a 0.45 μm cellulose acetate membrane, and the

concentrations of the residual As were analyzed.

In order to evaluate the adsorption rate, the kinetics experiments were performed at room temperature (21-25 ^oC). Some amounts stock solution was added in 2000 ml to make a total volume of 1500 ml, with initial As concentrations of 25 mg/l. Then, 0.45 g of ferrichydrite was added to obtain a 300 mg/l suspension. Further the pH of the mixed suspended solution was adjusted and maintained at 5.0 ± 0.1 throughout the experiment by addition 0.05 M HCl or NaOH. The suspension was mixed with a magnetic stirrer at an agitation speed of about 160 rpm. Approximately 5 ml aliquots were taken from the suspension at 0, 30 min, 1 h, 4 h, 8 h, 12 h, 24 h, 30 hours. The samples were immediately filtered through a 0.45 μm cellulose acetate membrane. The concentrations of residual As were analyzed by HG-AFS.

Results and Discussion

Prepared Ferrihydrite's sample. Prepared adsorbent's adsorption capacity was presented Figure 1.
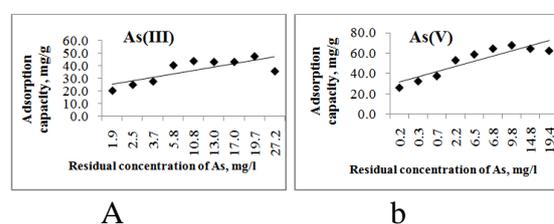
A   b

Figure 1. Adsorption isotherm.
a. As(III);   b. As(V).

The value was 26.1-67.4 mg/g for As(V)and 20.5-47.8mg/g for As(III).
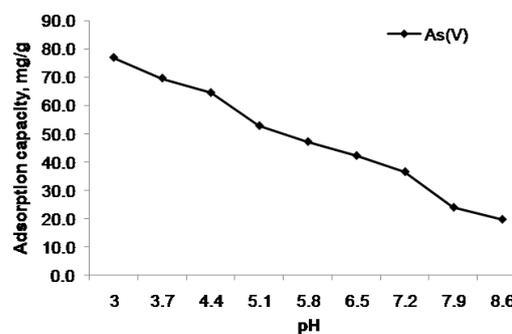
Figure 2. Effect of pH.

pH dependence was presented Figure 2 and when pH increasing adsorption capacity was decreasing.
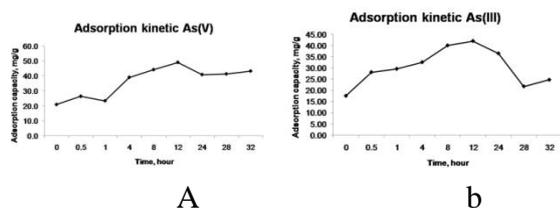
Figure 3. Adsorption kinetics.
a. As(V);   b. As(III).

The kinetic results are presented Figure 3 and about 12 hours reached equilibrium and a capacity of 49 mg/g for As(V) and 42 mg/g for As(III) was gained.

The kinetic constants for arsenic adsorption on the ferrihydrite adsorbant's were fitted and showed following Table 1.

Initial concent rations, 25 mg/l	Pseudo-first-order model			Pseudo-second-order model		
	K_1, 1/min	q_e, mg/g	R^2	K_2, 1/min	q_e, mg/g	R^2
As(V)	0.039	21.58	0.803	0.0041	43.48	0.995
As(III)				-0.00047	25	0.933

Table 1. Kinetic constants for arsenic adsorption on the ferrihydrite adsorbent. As shown in the table, the result of the study is approved accurately.

Conclusion

An iron based inorganic adsorbent was used for both As(V) and As(III) removal. In terms of adsorption pH range and adsorption capacity, the new adsorbent demonstrated the probable result. The adsorption mechanism, however, requires further studies.

References.

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