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Analysis of continuous adsorption of arsenic(V) from water with polyacrylamide cryogel column containing iron hydroxide oxide nanoparticles

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Abstract

The continuous removal of As(V) from water was investigated with the adsorption column packed with polyacrylamide(PAA) cryogels containing FeOOH nanoparticles. The break through point of As(V) from the column decreased with an increase in the flow rate of the feed aqueous solution. The adsorption amount of As(V) per weight of FeOOH nanoparticles in the cryogel column increased with an increase in the inlet As(V) concentration and was higher than that of the batch adsorption experiment. The structure of the adsorption spices of As(V) on FeOOH nanoparticles in the cryogel was also analyzed by X-ray photoelectron spectroscopy (XPS).
Keywords: Arsenic adsorption, Cryogel column, FeOOH nanoparticles, Adsorption spices

1. INTRODUCTION

Arsenic with high toxicity is harmful to the environment and the human body (Hotta, 2006). It is know that As(III) has higher toxicity than As(V). It is necessary to develop adsorbent to effectively separate and remove arsenic from wastewater and environmental water.

Adsorbents for the removal of arsenic are almost invariably based on bulk or supported particles of transition metal oxides and hydroxides.

Cryogels are hydrogels whth ich have supermacroporous structure with interconnected pores. The preparation of the composite materials of cryogels with solid micro/nano-particles is investigated (Kurozumi *et al* 2016). In this work, polyacrylamide (PAA) cryogels containing iron hydroxide oxide (FeOOH) particles was prepared by particles addition method and used for column adsorption of As(V) from aqueous solution. The adsorption property of As(V) from aqueous solution with the cryogel column were investigated. The adsorption states of As(V) on FeOOH nanoparticles in the cryogel was also investigated with ESCA spectrum analysis.

2. EXPERIMENTAL

2.1 Column adsorption of As(V)

The PAA cryogels containing FeOOH particles were prepared by the same manner of the previous paper [1]. The prepared cryogels were freeze-dried, chopped into small pieces, and putted into syringe as an adsorption column. The aqueous solution containing As(V) at pH 7 was flowed to the column using a micro-tube pump. The effluent from the column was collected with fraction collector. The concentrations of As(V) in the solutions were measured with ICP-AES (Shimadzu, ICPS-8100). The adsorption amounts of As(V) on the adsorbents were calculated based on the FeOOH content of them.

2.2 Analysis of the adsorption species od As(V) with XPS

The adsorption spices of As(V) on the surface of FeOOH nanoparticles in the cryogel were analyzed by X-ray photoelectron spectroscopy (XPS) on AXIS ULTRA2 (Kratos Analytical Ltd) with the 500 mm Rowland circle monochromated Al Ka X-ray source.

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3. RESULTS and DISCUSSION

The PAA cryogel containing FeOOH particles is shown in Figure 1. The cryogel had a red brownish color and a macroporous structure. The cryogel also showed a highly water permeable property. Many white spots observed in Figure 1(b) were FeOOH particles. The PAA cryogel containing FeOOH particles was cut into a small piece and was put into a syringe to use for adsorption column.

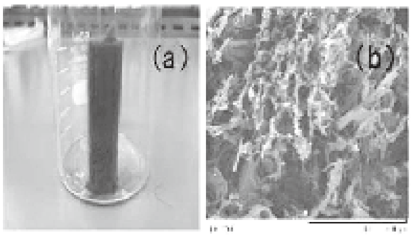

Fig. 1 Observation of the cryogel containing FeOOH particles. (a) external appearance, (b) surface by SEM.

The column adsorption experiments of As(V) with the cryogels were carried out under the condition of Table 1. The break through courves of the column adsorption of As(V) are shown in Figure 2. The break point of the As(V) adsorption decreased with an increase in the flow rate of the aqueous solution.

The adsorption amounts of As(V) in the PAA cryogel column were observed by the integration of breakthrough curve in Figure 2. The relationship between the adsorption amount and the inlet concentration of As(V) is shown in

Table 1 Experimental condition of the column adsorption of As(V)

Run	Initial As(V) [ppm]	Flow rate [ml/h]	FeOOH content [mg/g-drygel]	Adsorption [mg/g-FeOOH]
1	86.2	4.54	0.205	124
2	50.8	4.03	0.297	119
3	44.0	3.94	0.259	64.9
4	39.4	6.06	0.259	37.1

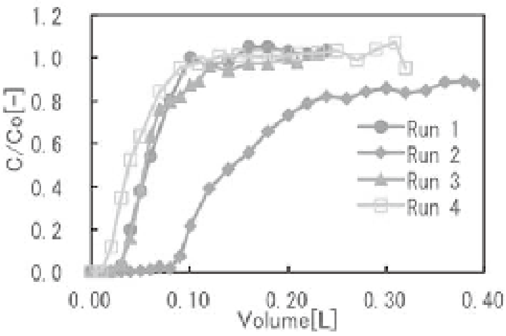

Fig. 2 Break through curves of the column adsorption of As(V) under the condition in Tabel 1.

Figure 3. The adsorption amount of As(V) per weight of FeOOH nanoparticles in the cryogel column increased with an increase in the inlet As(V) concentration and was higher than that of the batch adsorption experiment.

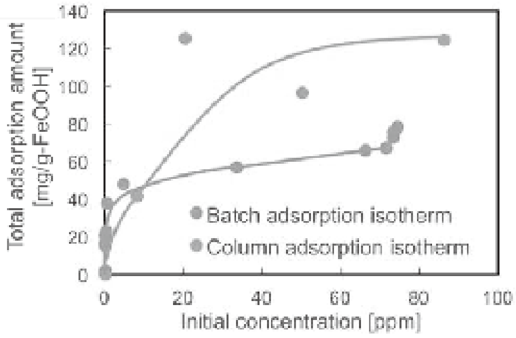

Fig. 3 Relationship between total adsorption amount and initial concentration of As(V).

The adsorbent surface after adsorption was analyzed by XPS. The wide scan XPS spectrum after Argon ion etching of FeOOH particles as a reference, fresh cryogel and As(V)-loaded cryogel (118mg/g-FeOOH) are shown in Figure 4. Three peaks of C1s, N1s and O1s can be detected on both fresh and As(V) loaded PAA adsorbents. Detailed analysis of XPS spectrum will be shown in the presentation.

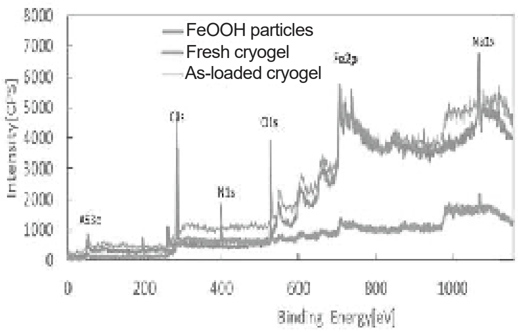

Fig. 4 XPS wide-scan spectra of FeOOH particles and the adsorbents before and after As(V) adsorption.

4. REFERENCES

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