

Preparation of magnetic polyacrylamide cryogel and its arsenic adsorption behavior

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Abstract

The hybrid monolith adsorbent of magnetite and polyacrylamide cryogel (PAAC-mag) was synthesized under freezing. The hybrid cryogel had many macroporous structures and Magnetite nanoparticles were uniformly dispersed in PAAC-mag from SEM image. The adsorption of As(III) using PAAC-mag reached equilibrium for 8 hours. The adsorption rate of PAAC-mag was the same as that of the magnetite nanoparticles. The total adsorption capacity of As(III) by a column method was the same as the adsorption capacity of As(III) on the magnetite obtained by a batch method. As(III) was desorbed from hybrid cryogel by treatment of the column using 1 M NaOH solution.

Keywords: arsenic adsorption, macroporous cryogel, magnetite, polyacrylamide, monolith,

1. INTRODUCTION

Arsenic is well known as one of toxic elements and arsenic in natural waters causes worldwide problems. The arsenic contamination in groundwater has been reported in many countries such as India (Das *et al.*, 1996) and Bangladesh (Rasul *et al.*, 2002). Long-term uptake of drinking water contaminated with arsenic causes cancers of skin, lung, liver, kidney and bladder (Rasul, 2002). In order to protect public health, Ministry of the Environment, the US Environmental Protection Agency, the World Health Organization and the European Commission have decided to lower the maximum contaminant level of arsenic in drinking water to <10 ppb. In water, arsenic forms principally oxyanions and exists as chemical species, arsenite (H_3AsO_3 , As(III)) and arsenate (H_2AsO_4^- or HAsO_4^{2-} , As(V)) at natural pH (Smith and Martell, 1976). As(V) is easier to remove than As(III) because of the charged characteristics of As(V). In addition, As(III) has higher toxicity than As(V).

Since magnetite (Fe_3O_4) of one of iron oxides exhibits high affinity for arsenite at natural pH (Ohe *et al.*, 2005) and is also not only magnetic material but also eco-friendly

adsorbent. Magnetite nanoparticles aggregate easily because of their magnetic property. We have prepared a hybrid adsorbent of magnetite loaded porous cryogel to suppress flocculation of magnetite. Cryogel is macroporous polymer materials produced at the temperature below the freezing point. The polymerization is initiated at low temperature resulting in macroporous polymer structure with ice as template (Plieva *et al.*, 2005). It is expected that the macroporous structure of cryogel gives useful abilities for water treatment applications.

In this study, the hybrid monolith adsorbent of magnetite and polyacrylamide cryogel was synthesized under freezing, and the arsenic adsorption ability was investigated by the batch and column methods.

2. EXPERIMENTAL

The hybrid cryogel monolith (PAAC-mag) of polyacrylamide (PAAC) and magnetite (mag) was prepared as follows. A solution of monomer acrylamide, cross-linker *N,N*-methylenebis(acrylamide), ammonium persulfate and polymeric initiator *N,N,N',N'*-tetramethylethylenediamine

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was added in glass tube. The solution was reacted at 261 K for 14 hours. Magnetite prepared by co-precipitation method was added in the solution before starting to freeze. Characterization of PAAC-mag was performed by SEM. The time course of As(III) adsorption was carried out using 100 cm³ of 0.4 mM As(III) at pH 7.0 by a batch method. The concentration of As(III) was measured by ICP-AES. Column adsorption experiment of As(III) adsorption was conducted using a column (diameter 1.3 cm, height 5.0 cm) packed with PAAC-mag. A feed solution containing 0.30 mM of As(III) at pH 7.0 was continuously fed to the column. The flow rate was adjusted to 0.52 hour⁻¹ in the space velocity. The adsorbed As(III) was desorbed from the column with 1 M NaOH solution.

3. RESULTS AND DISCUSSION

The pore size of the cryogels (PAAC and PAAC-mag) and the distribution of the added magnetite nanoparticles in the hybrid adsorbent were observed using SEM. The SEM images of the cryogels were shown in Fig.1(a) and 1(b). It can be seen that both the cryogels exhibit a macroporous structure. From Fig.1(b) images it was seen that magnetite nanoparticles were homogeneously distributed in PAAC-mag.

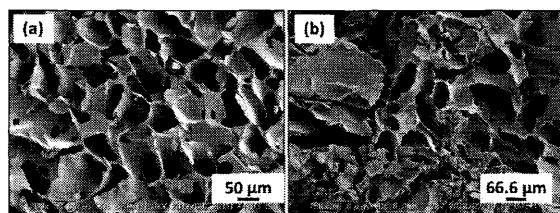


Fig. 1 SEM images of PAAC (a) and PAAC-mag (b).

The effect of contact time on As(III) adsorption on the PAAC-mag was shown in Fig. 2. The adsorption of As(III) using PAAC-mag reached equilibrium for 8 hours. The adsorption rate of PAAC-mag was the same as that of the magnetite.

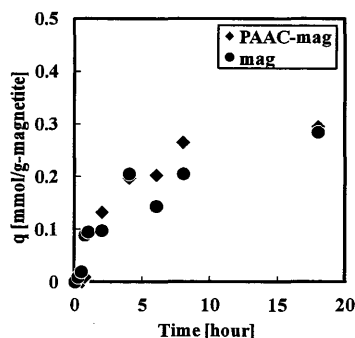


Fig.2 Time course of amount of As(III) adsorption using PAAC-mag and the magnetite (mag) at pH 7.0.

Figure 3 shows the breakthrough curve for As (III) adsorption on PAAC-mag. The breakthrough of As(III) adsorption begins at $V_t/V_{ad}=50$ at the space velocity of 0.52

hour⁻¹. The total adsorption capacity of As(III) was the same as the adsorption capacity of As(III) on the magnetite obtained by the batch method; 0.34 mmol/g. The desorption curve of As(III) from As(III)-loading PAAC-mag is shown in Fig. 4. As(III) desorbed from PAAC-mag using 1 M NaOH was concentrated to 48 times of initial concentration. The PAAC-mag is expected as the adsorbent of As(III) from groundwater.

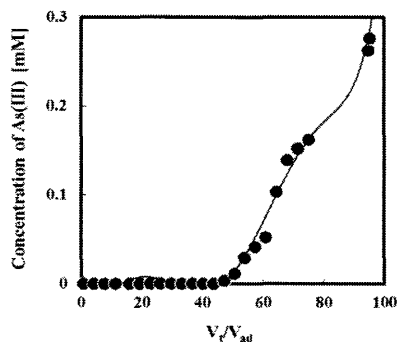


Fig. 3 Breakthrough curve for adsorption of As (III) on PAAC-mag at 0.52 h⁻¹.

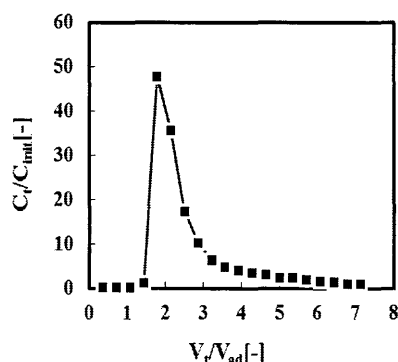


Fig. 4 Desorption curve of As(III) from As(III)-loading PAAC-mag.

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