

The Removal of Arsenic from Acidic Solution using Jarosite and Sonication

ジャロサイトと超音波照射を用いた酸性溶液からのヒ素の除去

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1. Introduction

The coprecipitation of arsenic with iron hydroxide has been used as one method of removing arsenic from acid mine drainage (AMD).¹⁾ This is the simple and low-cost method that adsorbs arsenic using iron hydroxide generated by addition of neutralizing agent. However, a large quantity of arsenic-containing sludge remains after the treatment. If arsenic could be removed before neutralization, it is possible to utilize iron in AMD as a resource. On the other hand, jarosite ($\text{KFe}_3(\text{SO}_4)_2(\text{OH})_6$) is a mineral that forms under an acidic condition and adsorbs arsenic. However, it has been reported that although pentavalent arsenic (As(V)) is removed using jarosite, trivalent arsenic (As(III)) is not removed.²⁾ Thus, we examined application of oxidation of As(III) to As(V) by sonication to As(III) removal using jarosite.³⁻⁵⁾

In this study, we performed the removal of As(III) in acidic aqueous solution using jarosite and sonication.

2. Experimental Procedure

Jarostie sample was prepared by dissolving 31.275 g of $\text{Fe}_2(\text{SO}_4)_3 \cdot n\text{H}_2\text{O}$ (Fe(III) : 5 g/L) and 2.173 g of K_2SO_4 (K : 0.975 g/L) in 1 L of 0.01 M H_2SO_4 . The solution was stirred using a magnetic stirrer (As One RSH-1DR) at 90°C for 24 h. The precipitate was filtered through a No.3 filter (Advantec), then washed several times with ion-exchanged water and dried at 110°C for 24 h. The synthesized solid was identified using a powder X-ray diffractometer (Rigaku RINT2000, $\text{CuK}\alpha$).

As_2O_3 and $\text{Na}_2\text{HAsO}_4 \cdot 7\text{H}_2\text{O}$ were used to make treated solutions of As(III) and As(V) (10 ppm). pH value of solutions was adjusted to 2.6 with H_2SO_4 . The schematic of the experimental apparatus is shown in Fig. 1. The sonication was performed with an ultrasonic generator (Kaijo TA-4021) and a submersible transducer (Kaijo). The output and frequency of this device was adjusted to 200 W and 200 kHz, respectively. A

submersible transducer was placed at the bottom of a tank filled with water and flat-bottom flask containing the sample solution was placed directly above the transducer. The temperature of the irradiated solution was controlled at about 25°C.

Arsenic removal experiments were conducted as follows. First, 1.0 g of synthetic jarosite was added to 50 ml of As(III) or As(V) solution (10 ppm). The solution was then sonicated for 30 min. To establish the advantage of sonication, we conducted the same experiments using the stirrer at 500 rpm, without ultrasound irradiation. After treatments, jarosite was filtered through a 0.45 μm membrane filter (Advantec) and collected. The residual arsenic concentration was measured using an ICP-OES instrument (Seiko Instruments SPS5510).

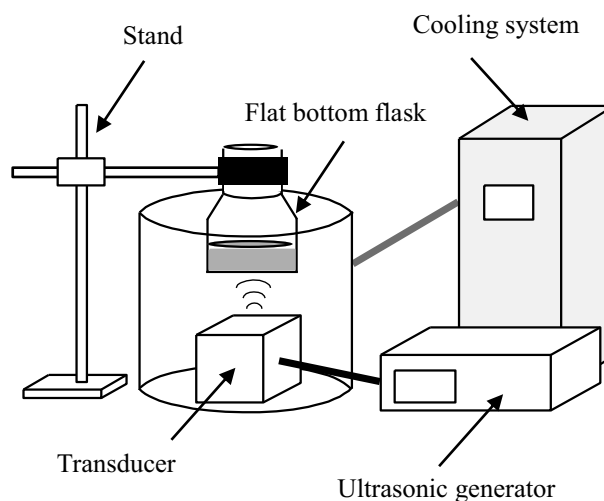


Fig. 1 Schematic of experimental apparatus.

3. Results and Discussion

Figure 2 shows XRD pattern of a synthesized sample. XRD pattern indicates that the sample was jarosite.

Figure 3 shows residual As(V) concentration in the solution treated with jarosite following either

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stirring or sonication. The residual As(V) concentration treated by stirring was 7.1 ppm. On the other hand, the As(V) solution treated by sonication showed 0.4 ppm of residual As(V) concentration. We are considering that the sonication made smaller sized particles of jarosite, and as a result, As(V) was easily adsorbed to jarosite because of its large surface area.

Figure 4 shows residual As(III) concentration in the solution treated with jarosite following either stirring or sonication. In case of the treatment of As(III) solution by stirrer, the residual As(III) concentration did not decrease. We confirmed that As(III) was more difficult to remove compared to As(V) using jarosite. On the other hand, the treatment of the As(III) solution by sonication showed 4.6 ppm of residual As(III) concentration. This is because As(III) was oxidized to As(V) by the OH radical generated during sonication, and the As(V) was adsorbed from the solution into jarosite. However, it is assumed that As(III) was not completely oxidized to As(V) because the residual As(III) concentration is higher than the residual As(V) concentration on the treatment of As(III) and As(V) solution by sonication.

In the future, we will examine the increase of As(III) removal efficiency by changing the atmosphere during sonication.⁴⁾

4. Conclusions

The treatment of As(V) solution with jarosite and sonication caused substantial decrease in the residual As(V) concentration compared to treatment by stirrer. It is believed that particle size of jarosite was small by sonication, and As(V) was easily removed from the solution. In addition, the residual As(III) concentration was also decreased by the use of sonication, because As(III) was oxidized to As(V) by sonication, and As(V) was adsorbed from the solution into jarosite.

References

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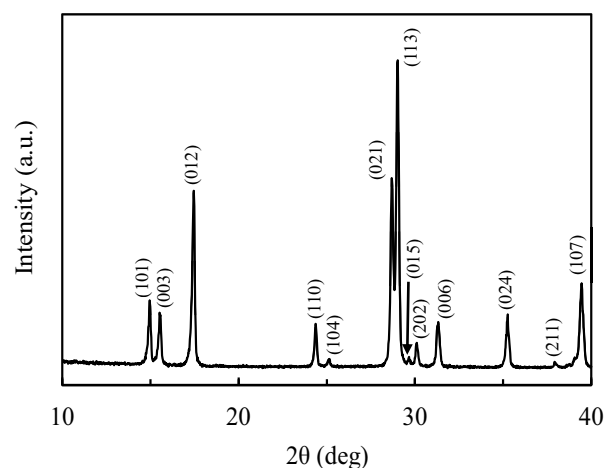


Fig. 2 XRD pattern of synthetic jarosite.

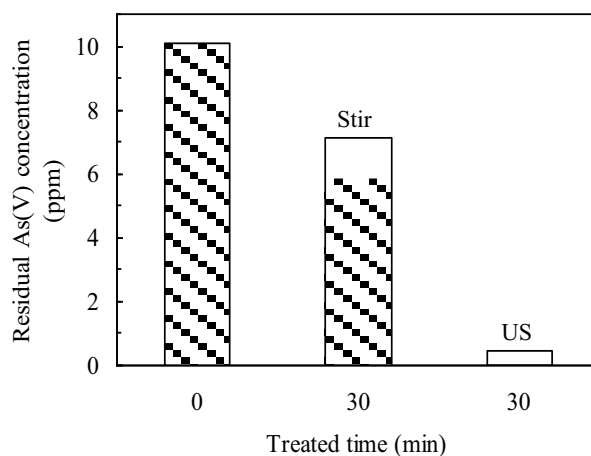


Fig. 3 Effect of sonication on As(V) removal using jarosite.

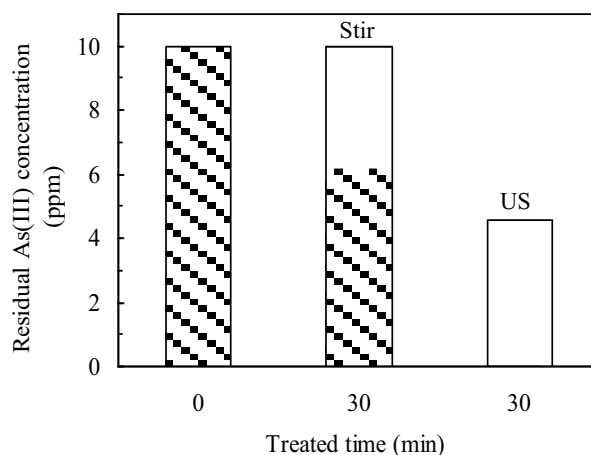


Fig. 4 Effect of sonication on As(III) removal using jarosite.