ARSENIC REMOVAL BY SULFIDATION SEDIMENTATION IN MAGNETIC FIELD①

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ABSTRACT Sulfidation in cooperation with magnetic field was used to remove arsenic from simulative waste water. The processes were studied by chemical analysis, conductivity gauge, potentials difference, X-ray diffraction and scanning electron microscopy. The results showed that the sedimentation rate of As_2S_3 and the utilization ratio of sulfide agent is increased in the magnetic field, the flocculation and filtration rate are improved also. There are some changes in the structure of the water and the energy state of the particles in the water in magnetic field.

Key words arsenic treatment of waste water sulfide magnetic field

1 INTRODUCTION

As the water source crisis is becoming more and more severe and the environment protection requirements are becoming more and more rigorous, it is necessary to remove arsenic from As-containing waste water. Much attention has been paid to the methods for removing arsenic from waste water and a number of methods have been studied theoretically and verified experimentally (e. g., ion exchange, extraction, bio-adsorption and electrolytic processes). The methods of S^{2-} ion precipitation or arsenic precipitation have been used commercially in the form of arsenious sulfide, in which high containing As(Ⅲ) in the aqueous solution is precipitated in the form of arsenic trisulfide (As_2S_3, orpiment) by adding Na_2S or H_2S into the solution. However, there were still something unsatisfactory such as the low rate of sedimentation and the high moisture content of dregs[1]. Recently, the research of cooperation with physical and chemical methods for the waste water has attracted more attention. Magnetic treatment of water to prevent scale has found wide uses. Several explanations for the magnetic effects have been proposed: change of water structure, magnetic particles in the water, cavitation, inhibition by dissolved constituents of the magnet, etc[2]. This work presents the results of experimental studies of magnetic field effects (MFE) on the processes of sulfide sedimentation.

2 EXPERIMENTAL

The simulative water contains 8 g/L As(Ⅲ), 30 g/L SO_4^{2-}. The sulfide agent is $Na_2S\cdot 9H_2O$ (AR degree).

The main instruments include: UJ-25 model potentiometer, magnetizing equipment (Nd-Fe-B), 78-1 model magnetic stirrer, DDS-11A model conductometer, RAX-10 model X-ray diffraction model, TSM-2 model scanning electron microscope.

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The experiment processes include:

(1) Working process of magnetic field: Let the solution pass through the magnetic field (0.4 T) at the speed of 2.0 mL/s and determine the change of the potential and conductance.

(2) Effects of magnetic field on the consumption of sulfide agent during the sulfide sedimentation: Add Na_2S into the water by electron feeding pump at the speed of 2.0 mL/s and determine the potential change by the potentiometer. At the same time take samples to analyze the content of As(III) in the solution.

(3) Effects of magnetic field on the flocculation and sedimentation: Take identical arsenic waste water to flocculate and sedimentate with or without magnetic field respectively and pay attention to the differences. After filtration and drying, determine the water content of the dregs and test them with SEM for the mechanism.

3 RESULTS

3.1 Effects of magnetic field on consumption of sulfide agent

Fig. 1 shows the relationship between the consumption of sulfide agent and the content of As in the solution during the sedimentation. When the adding velocity of sulfide agent was 1.5 g/(g·h), the utilization ratio of sulfide agent was high[3].

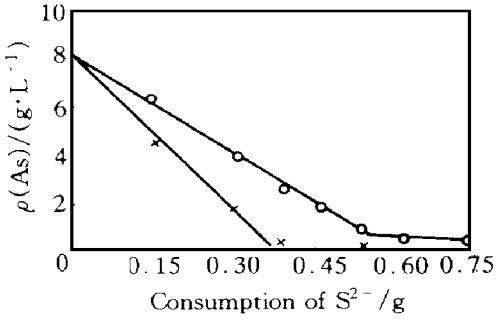

Fig. 1 Relationship of As concentration to consumption of S^{2-}
× —With MFE; ○—Without MFE

3.2 Effects of magnetic field on producing rate of arsenic trisulfide

The change of arsenic concentration was in direct proportion to time during the sulfide sedimentation, namely, $\Delta\rho = (\rho_0 - \rho_t) = kt$, where k is the reaction rate constant at a certain temperature. Fig. 2 shows the changes of arsenic concentration vs time on the different conditions. The calculations showed that k was increased from 2.5×10^{-3} g/(L·s) to 3.33×10^{-3} g/(L·s), when treated with the cooperation of magnetic field.

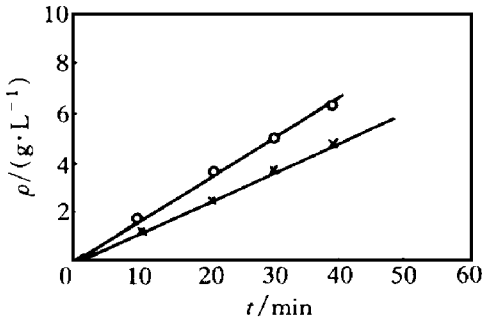

Fig. 2 Changes of As concentration vs time
○—With MFE; × —Without MFE

3.3 Sedimentation rate in MFE and property of solution

The well-stirred arsenic trisulfide dregs obtained with or without MFE were put into a 100 mL measuring tube to test the sedimentation rate. The results are shown in Fig. 3. The changes of potential and conductivity with MFE are showed in Table 1.

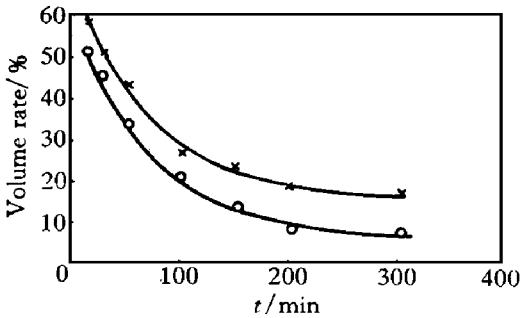

Fig. 3 Effects of magnetic field on sedimentation rate
○—With MFE; × —Without MFE

3.4 Property of filtration dreg

Under the same conditions, the filtration rate with MFE is twice faster than that without

MFE. After filtration and dewatering 1 h, the water content of dreg with MFE is 42. 2%, while that without MFE is 54. 5%. The structures were found unformed through the XRD after vacuum drying. The particle size and appearance tested by the SEM are shown in Fig. 4. From the figures it can be seen that the shapes are both irregular flakiness but there are some globe coagulation in the dregs with MFE.

Table 1 Changes of potential and conductivity

Items	Without MFE	With MFE
Conductivity/ ($\mu s \cdot m^{-1}$)	0. 22	0. 27
Potential/ V	420	400

4 DISCUSSION

From the results, evidently, magnetic field has marked effects on the rate of sedimentation and flocculation. Above mentioned results show that the magnetic cooperation had brought about both chemical and physical changes to the solution. The increase of the conductivity and the decrease of the potential showed in Table 1 indicate the changes of the ions intensity.

The Lorentz force on charged particle has been considered[4-6], it is given by the vector product:

$$\boldsymbol{F} = q\boldsymbol{v} \times \boldsymbol{B} \quad (1)$$

where $\boldsymbol{F}$ is the force, q is the charge, $\boldsymbol{v}$ is the velocity, $\boldsymbol{B}$ is the magnetic induction. Lorentz effect is the interaction of the induced magnetic field with the charged species of the fluid flowing at a certain speed, it could together produce energy though the amount of energy produced in the process is small[6]. This energy might be important to alter the equilibrium between the ions and particles of the precipitated compounds. Fig. 1 and Fig. 2 indicate that the reaction rate was increased in the magnetic field. It is demonstrated that the Lorentz force promotes the protonation of HS^- and AsO_2^-, the magnetic field changes some reaction process such as the hydration ions or other molecules, and increases the probability of the reaction between As^{3+} and S^{2-}, so the production of As_2S_3 was promoted. Abbona pointed out that the magnetic field could decrease the bond between ions[7], thus distinctly improve the denaturing of dregs.

5 CONCLUSIONS

(1) Sulfidation in cooperation with magnetic field is beneficial to the purification of the containing arsenic waste water and the recovery of arsenic. The utilization ratio of the sulfide agent is also increased.

(2) Magnetic cooperation is beneficial to the reactions of the sulfur and the arsenic ion.

(3) The flocculation, sedimentation and filtration are promoted and water content of the

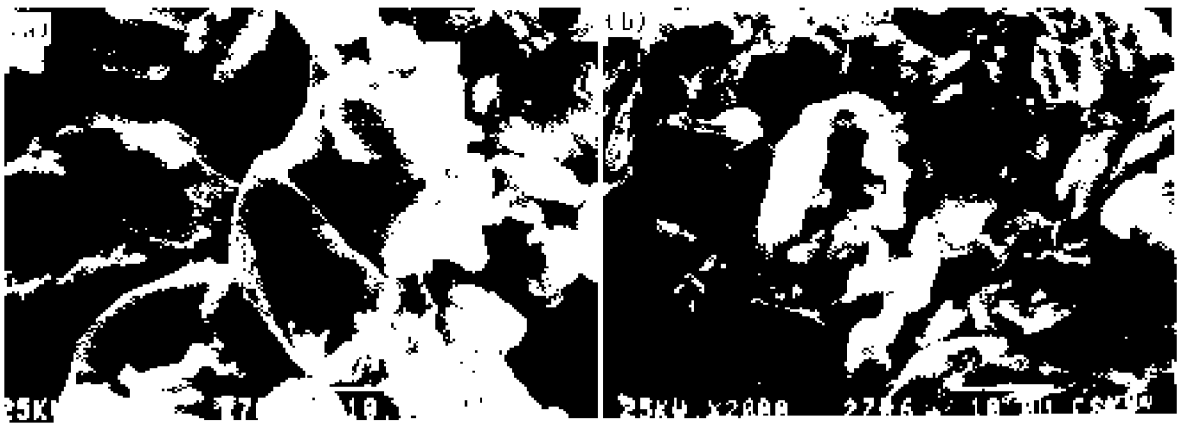

Fig. 4 SEM photographs of As_2S_3 dregs(× 2 000)
(a) —With MFE; (b) —Without MFE

dregs is decreased in cooperation with magnetic field, although there are no evident effects on the shape of the sulfide dregs.

(4) The mechanism analysis indicate that the magnetic field has both chemical and physical influences on the process. The particles might have obtained enough energy from the magnetic field for overcoming the bondage of a certain position to complete the processes.

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