Minerals Engineering 89 (2016) 163–167

Contents lists available at ScienceDirect

Minerals Engineering

journal homepage: www.elsevier.com/locate/mineng

Effects of lead ions on the flotation of hemimorphite using sodium oleate

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ARTICLE INFO

Article history:
Received 31 October 2015
Revised 5 February 2016
Accepted 6 February 2016
Available online 9 February 2016

Keywords:
Lead ions
Hemimorphite
Flotation
Sodium oleate

ABSTRACT

The effects of Pb(II) ions on the flotation of hemimorphite was investigated by micro-flotation tests, zeta-potential measurements, solution chemistry and Fourier transform infrared spectroscopy. The micro-flotation results indicated that the Pb(II) effectively improved the flotation of hemimorphite minerals. Good floatability of minerals was obtained in the pH region 7 to 9. Adsorption/precipitation of the hydrolyzed species of lead cations occurred in this pH region, these species promote sodium oleate adsorption and from lead oleate on the surface of hemimorphite.

1. Introduction

Zinc is an important base metal that used in the galvanizing, alloys, as well as other industries (Ghosh et al., 2002; Shirin et al., 2006). Hemimorphite is a sorosilicate of formula $Zn_4Si_2O_7(OH)_2 \cdot H_2O$. The termination of the crystal is rather blunt being dominated by a pedion face while the opposite end, is terminated by the point of a pyramid (Anthony et al., 1995). The crystal structure contains tetrahedrons of ZnO_3OH, interlocked with Si_2O_7 groups and water molecules. The zinc is at the center of the tetrahedron while the three oxygens, along with an OH group, are at the four points of the tetrahedron. The mineral is orthorhombic with point group mm^2 (Frost et al., 2007; Nakamura et al., 1977). A molecular model of hemimorphite is shown in Fig. 1.

In industrial flotation, the existence of unavoidable metal ions such as ions of iron, copper and lead, significantly influence the flotation performance of target mineral (Fan and Rowson, 2000; Zhu et al., 2012). They determined that metal ions formed precipitate, the precipitate and the hydroxy complexes could adsorb onto the surfaces of minerals, and increasing their flotation by promoting collector adsorption. (Zhang et al., 2014; Ejtemaei et al., 2012) examined the flotation responses of quartz and feldspar with collectors in the presence of metal ions. They found that quartz floated in the presence of Pb(II), Zn(II) and Fe(II) ions. On the flotation of hemimorphite with collectors in the absence of metal ions was studies by Liu et al. (2015), Salum et al. (1992), however, no one reported use of lead ions as an activator for hemimorphite flotation, lead ions as an activator for the flotation mechanism of hemimorphite is unclear.

Before the study, the hemimorphite activated by lead ions cannot be depressed, whereas Pb(II) ion activation of quartz and calcite as the major gangue mineral found in the zinc oxide ores can be depressed using calcium lignosulfonate as a depressant in the presence of NaOl though single minerals tests. Therefore, achieving a selective separation from the hemimorphite ores is possible in the presence of lead ions. In consequence, the main objective of the present research was to examine the interaction of the hemimorphite surface with lead ions and NaOl. This was accomplished through the use of various techniques, including micro-flotation, zeta-potential analysis, adsorption measurements, lead ions and NaOl species in solution and FT-IR.

2. Materials and methods

2.1. Samples and reagents

The ore samples of hemimorphite minerals were obtained from Changsha of Hunan Province, China. The samples were crushed and ground using an agate mortar. The products were then dry sieved to obtain a particle size of $-74\ \mu m$. The ore was analyzed via a chemical method and phase-examined using powder X-ray diffraction (XRD) showed in Fig. 2. The chemical compositions of the samples are listed in Table 1. According to the result of the XRD analysis, the purities of hemimorphite was very high.

Sodium oleate ($CH_3(CH_2)_7CH{=}CH(CH_2)_7COONa$) (NaOl) was used as the anionic collector for the micro-flotation tests. Lead nitrate ($PbNO_3$) was used as the source of lead ions activator. HCl

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http://dx.doi.org/10.1016/j.mineng.2016.02.002
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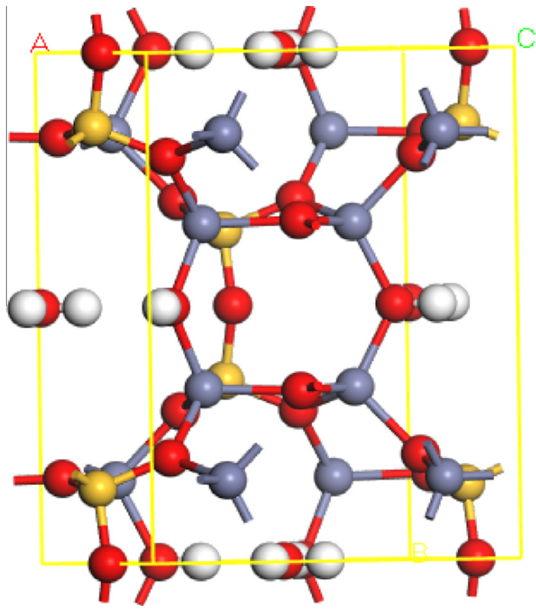

Fig. 1. Model of hemimorphite structure.

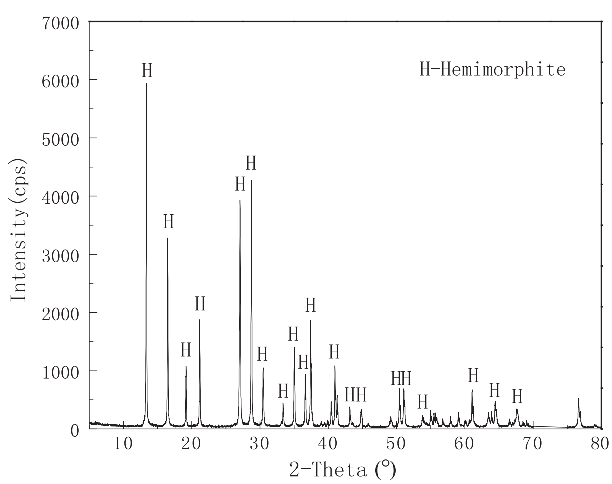

Fig. 2. XRD of the hemimorphite sample.

Table 1
Chemical composition of hemimorphite ore.

ZnO	SiO_2	Al_2O_3	Fe	Pb	Cu	Other
66.75	24.34	0.086	0.141	0.032	0.018	8.633

and NaOH were used for the pH adjustment in the experiments. All the reagents were of analytical grade, and the water used in all the experiments was distilled water.

2.2. Micro-flotation tests

The micro-flotation were carried out in a mechanical agitation flotation machine. The mineral suspension was prepared by adding 2.0 g of mineral to 35 ml of solution. The pulp was continuously stirred for 1 min using a pH regulator, 3 min with the activator, and 3 min with the collector. The pH of the solution was measured before the flotation, and the flotation was conducted for 4 min. The floated and tailing fractions were collected separately and dried and weighed for calculations.

2.3. Zeta potential tests

Zeta measurements were performed in 1×10^{-3} mol/L KNO_3 background electrolyte solution using Coulter Delsa440sx Zeta analyzer instrument. The suspensions (0.01% mass fraction) with small amount of the minerals were dispersed in a beaker magnetically stirred for 15 min in the presence of different concentration of reagents at various pH values. After 20 min of settling, the pH value of the suspension was measured and the supernatant was obtained for zeta-potential measurements. The zeta-potential of each sample was measured three times in this paper, and the average was reported as the final value.

2.4. FT-IR spectroscopy measurements

The FT-IR spectra were obtained using a Spectrum One FT-IR (Japan) spectrometer to characterize the nature of the interaction between the collector and minerals. Approximately 1% (mass fraction) of the solid sample was mixed with spectroscopic grade KBr. The wave number range of the spectra was 400–4000 cm^{-1}. Each spectra was recorded with 30 scans measured at 2 cm^{-1} resolution.

To prepare the samples for FT-IR analysis, pure mineral particles were ground to -5 μm using an agate mortar. A suspension was prepared by adding 2.0 g of the pure mineral particles to 35 mL of deionized water in a Plexiglas cell (40 mL). The suspension was conditioned for 5 min using HCl and NaOH as the pH regulators. Then, the suspension was conditioned for 5 min with lead ions. Afterward, the suspension was conditioned for 3 min with NaOl. Finally, the solid samples were washed three times using distilled water with the same pH and allowed to dry prior to FT-IR analyses.

3. Results and discussion

3.1. Micro-flotation

The objective of this study was to investigate the effects of lead ions on the flotation of hemimorphite in the presence of NaOl. Fig. 3 shows the flotation recovery of hemimorphite as a function of pH with and without lead ions, and with 2×10^{-4} mol/L NaOl. The flotation recovery of hemimorphite showed a better floatability throughout the pH range of 4.0–9.0 in the absence of lead ions which is attributed to increases in the concentrations of oleate

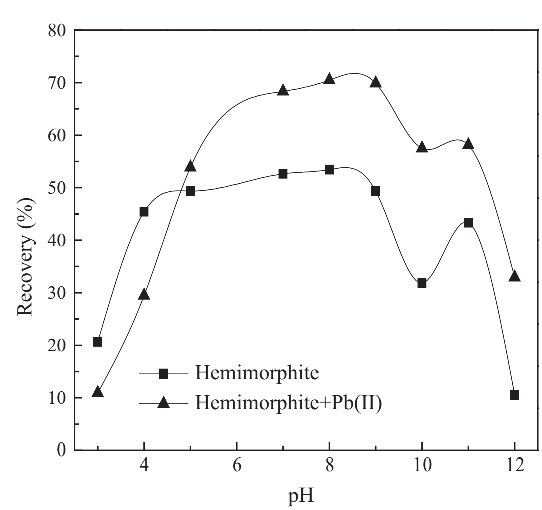

Fig. 3. Flotation recovery of hemimorphite as a function of pH with 4×10^{-4} M Pb (II) and 2×10^{-4} M NaOl.