



Effects of galvanic interaction between galena and pyrite on their flotation in the presence of butyl xanthate



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Abstract: The effects of galvanic interaction between galena and pyrite on their flotation and electrochemical characters were studied by electrochemical, adsorption, flotation and FTIR techniques, respectively. Electrochemical tests indicate that galena is electrochemically more active than pyrite and serves as an anode in galvanic combination with pyrite. The galvanic current density from a mixture of galena and pyrite is 4 times as high as the self corrosion current density of galena, which indicates that the corrosion rate of galena is accelerated. Adsorption tests show that the adsorption of butyl xanthate on galena surface is enhanced, and affected by a combination of pyrite–galena mixtures and conditioning time. Compared with individual mineral particles, galvanic interaction reduces the floatability difference between galena and pyrite. The flotation recovery of galena decreases while that of pyrite increases when two minerals are mixed together due to the influence of galvanic interaction on the formation of hydrophilic/hydrophobic product. The FTIR results show that the formation of dixanthogen on pyrite surface is depressed due to the galvanic interaction.

Key words: galvanic interaction; galena; pyrite; butyl xanthate; flotation

1 Introduction

The interaction between collector and sulphide mineral is the dominant factor in the effective flotation separation and it remains partially understood because the process involves many variables such as pH, pulp potential, and species introduced by the addition of regulators or released from minerals [1]. Generally, the electrochemical reactions occurring in the sulphide mineral flotation system include oxidation and reduction processes [2].

Most of the fundamental investigations to understand the mechanism of minerals in aqueous solutions with surfactant were undertaken on isolated sulphide mineral [3]. However, exploitable ores are usually found as an association of different sulphide minerals [4]. It has been known that the flotation behavior of the single mineral is different from that of the mixed mineral, and this may be attributed to galvanic interaction between sulphide minerals. To better understand the flotation system, it is essential to study

collector–mineral interactions in a mixed mineral system. Most of sulfide minerals possess semiconducting properties. The contact between a cathodic material and an anodic one results in the formation of galvanic cell [5]. In a mixture of two sulphides, the mineral with higher rest potential will act as the cathode, while that with the lower rest potential will be the anode. A lot of researches on electrochemical interaction in sulfide mineral extraction were completed including the grinding [6,7], flotation [8,9] and leaching [10–12] systems. In the presence of collector, different kinds of galvanic cells have been present for the prediction of mineral reactivity, while the electrochemical interaction between galena and pyrite has not been studied thoroughly [8,9,13–15]. Meanwhile, most of the quantitative studies of the collector adsorption on mineral used FTIR-ATR spectroscopy with block electrode [1,16], which was different from the actual flotation system. In order to simulate the actual flotation system, a special apparatus was introduced in this work. The aim of this work was to determine the electrochemical interaction between galena and pyrite

under different conditions and its effect on the adsorption of butyl xanthate (BX) by using electro- chemical, flotation, adsorption and FTIR techniques.

2 Experimental

2.1 Materials

The mineral samples, pyrite (FeS_2) and galena (PbS), were purchased from Yunnan Province, China. Detailed description of the mineral samples can be found in Table 1. XRD analysis (Fig. 1) confirms that the main mineral phases are galena and pyrite. The mineral samples were prepared by dry hand-grinding pure crystals in an agate mortar and pestle and by screening out the $-74 - +38 \mu\text{m}$ fraction for micro flotation and adsorption study. The powder of $-38 \mu\text{m}$ was further ground to $-2 \mu\text{m}$ for FTIR experimental study. For electrochemical measurements, the mineral electrode was cut from highly mineralized rock specimens and polished using emery paper. The experimental data

Table 1 Chemical composition of mineral sample

Mineral	Mass fraction/%				
	Pb	Fe	Cu	Zn	S
Galena	83.92	0.26	0.05	0.01	13.55
Pyrite	0.05	44.25	0.11	0.05	53.42

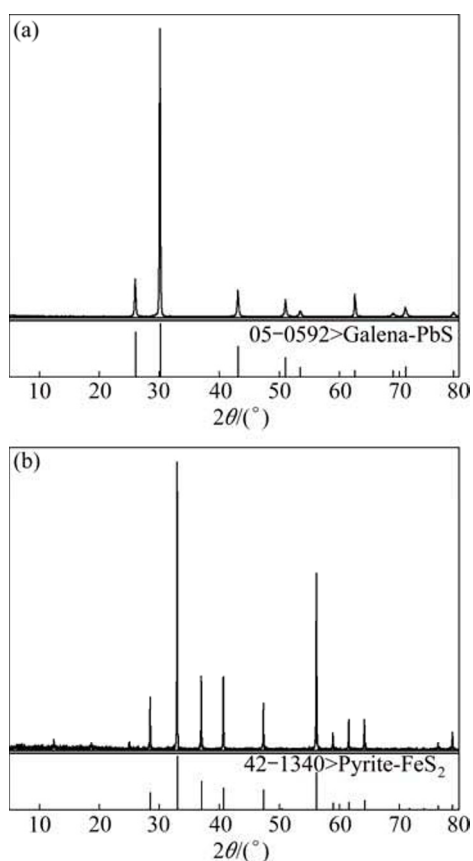


Fig. 1 XRD patterns of galena (a) and pyrite (b)

presented in this work were collected on the same mineral sample for each mineral in order to avoid sample variation. Sodium butyl xanthate ($\text{C}_4\text{H}_9\text{OCS}_2\text{Na}$) used in this study was with purity of above 90%. Buffer solution, prepared with commercial $\text{Na}_2\text{CO}_3/\text{NaHCO}_3$ (pH 10) of analytical grade in twice distilled water was used throughout the experiments. All the other reagents used were of analytical grade.

2.2 Electrochemical equipment and procedures

The electrochemical studies were carried out using an EG & G PAR potentiostat/galvanostat model 283 with power suite software. The traditional three-electrode system consisted of working electrode, counter electrode (graphite rod) and reference electrode (Ag/AgCl electrode) was used. Mineral electrodes were cut from highly mineralized rock specimens as described previously. To simulate the mixed mineral system, the galena and pyrite electrodes were electrically connected to each other through the potentiostat, and the galvanic currents and potentials were measured by the galvanic corrosion/ZRA technique at any desirable time interval. Before the experiment, the solution was bubbled with air for 30 min.

2.3 Flotation test

A 40 mL flotation cell was used for micro flotation tests with a total of 2 g mineral. The samples were conditioned for 3 min in 40 mL specified solution under an open air condition to enhance electrochemical interaction. The pH values were measured with a pH meter (PHS-3C) and adjusted by NaOH and HCl. The recovery of each mineral was calculated after chemical analysis. In addition, pine oil was used as the frother in the flotation tests. The pulp potentials during the conditioning stages were monitored by a Pt electrode with reference to Ag/AgCl electrode (3.0 mol/L KCl) and the values were quoted with respect to a standard hydrogen electrode. The pulp potential values reported in this work corresponded to the potentials at the end of conditioning stage.

2.4 Adsorption tests

The adsorption speed and capacity of collector on the mineral surface are two methodologies to measure the floatability of minerals in froth flotation. A special apparatus as drawn in Fig. 2 was used.

A total of 4 g mineral sample was added into 120 mL solution with 1×10^{-4} mol/L butyl xanthate. The pulp was stirred in a temperature-controlled water bath at 293 K for different conditioning time. To enhance the solution exchange, a syringe was introduced and pushed-and-pulled at a frequency of 10 min^{-1} . At desirable time interval, 1 mL test specimen was collected

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