



Flotation behaviors and mechanisms of chalcopyrite and galena after cyanide treatment



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Abstract: Adsorbing tests between CN^- and chalcopyrite or galena were conducted firstly, and then flotation tests of the two cyaniding minerals were investigated in butyl xanthate (BX) system. Results showed that the interaction between CN^- and the two mineral surfaces were both chemical adsorption and can be described by the Langmuir adsorption isotherm model. In the optimum condition of pH 6.5 and 4.0 mg/L BX, the recovery of cyaniding chalcopyrite and galena reached 82.1% and 63.9%, respectively. BX improved the hydrophobicity of the surfaces of the two minerals, although CN^- reduced the contact angle on the surface of minerals. The inhibitory effect of CN^- on chalcopyrite far outweighed galena. Electrostatic adsorption exists in the interaction between BX and the surface of galena after cyanide treatment in the pH range of 4.2–8.4, while the interactions between BX and the surface of chalcopyrite after cyanide treatment is chemical adsorption.

Key words: chalcopyrite; galena; cyanide absorption; flotation; butyl xanthate

1 Introduction

Gold cyanidation tailings are often associated with valuable minerals such as pyrite, chalcopyrite, galena, and sphalerite. The resource wastes and environmental pollution problems caused by the long-term accumulated gold cyanidation tailings, make the effective recycling of valuable minerals in the tailings significant. Due to very fine particle sizes by intense grinding and the existence of CN^- , recovery of useful minerals by flotation from the cyanidation tailings is very difficult [1]. In order to recover the valuable elements, such as Cu, Pb, Zn, S and Fe, many research efforts were made on comprehensive utilization and recovery from gold cyanidation tailings. ZHU et al [2] showed that galena and sphalerite in cyanidation tailings were floated and recovered well by xanthate as a collector, where activated carbon was used to adsorb excess cyanide and residual flotation reagents in the process of gold cyanidation. LV et al [3] proved that sodium hypochlorite oxidized cyanide to cyanate, eliminating the negative effect of residual cyanide to the environment. In the meanwhile, sphalerite and pyrite were depressed by sodium hypochlorite enormously at

pH>10.0, which benefited the recovery of chalcopyrite and galena. GAO et al [4] indicated that one-step chlorinating volatilization technology was suitable for eliminating Cu and As in the cyanidation slags.

Most research efforts were primarily focused on the flotation and recovery of sulfide minerals, and very few studies reported the flotation mechanism of sulfide minerals in the presence of CN^- . PIAO et al [5] found that chalcopyrite was depressed slightly by O,O-bis(2,3-dihydroxypropyl) dithiophosphate (DHDTP) while galena was depressed strongly. Zeta potential experiments indicated that DHDTP absorbed galena more efficiently than chalcopyrite, which was due to the electrostatic attraction between DHDTP and minerals. FU [6] reported that zinc sulphate and sodium sulphite could inhibit the flotation of sulfide minerals by $\text{Zn}(\text{OH})_2$ and $\text{Zn}_4(\text{SO}_3)(\text{OH})_6 \cdot \text{H}_2\text{O}$ generated on the surface of minerals. KOCABAG and GULER [7] found that a critical cyanide concentration and pulp potential existed when cyanide was used as a depressant for chalcopyrite and pyrite, whereas with galena–chromate system no critical potential was observed. PIAO et al [8] indicated that sodium 2,3-dihydroxypropyl dithiocarbonate (SGX), could separate chalcopyrite from galena by depressing

galena. HE et al [9] showed that in the presence of SGX, marmatite could be activated by Cu^{2+} and showed good flotability, while pyrite could not be activated and therefore showed poor flotability. Some researchers [10–14] discussed the mechanism of the interaction between CN^- and sulfide mineral or metal surface from the point of view of molecular structure and quantum mechanics, which were less contacted with flotation and adsorption tests. WOODS [15] and BUSWELL et al [16], based on the electrochemical mechanism of the inhibition of sulfide mineral flotation, found that the oxidation of pyrite surface generated hydrophilic substances such as $\text{Fe}(\text{OH})_3$ and SO_4^{2-} was due to the decrease of surface oxidation potential in strong alkaline environment.

Flotation behaviors of minerals and the interaction mechanisms between collector and the surface of cyaniding minerals play a significant role in the comprehensive utilization of gold cyanidation tailings. In this study, chalcopyrite and galena were firstly pretreated by CN^- of which concentration was the same as that in gold cyanidation tailings, and the characteristic of cyanide adsorption was discussed. Secondly, flotation behaviors of chalcopyrite and galena after cyanidation were examined at different pulp pH values with BX as the collector, and the interaction mechanisms between the flotation reagents and the minerals surface were discussed based on the measurements of zeta potential and contact angle.

2 Experimental

2.1 Materials

Chalcopyrite and galena samples were obtained from Zhaoyuan, Shandong Province, China. After crushing and grinding, the size of the mineral samples was less than 0.045 mm, close to the actual size of gold tailings. Chemical compositions of the chalcopyrite sample were: 34.1% Cu, 29.5% Fe, 35.2% S, and 1.2% others. Chemical compositions of galena were 79.1% Pb, 16.5% S, and others 4.4%. Sodium cyanide used in the experiments was obtained from Shenyang Nonferrous Metal Research Institute, China. Industrial grade BX was used as the collector, and terpenic oil was used as frother, which were supplied by Tieling Flotation Reagents Factory, Liaoning, China. Analytical grade NaOH and HCl were employed to adjust the pH of the flotation system.

2.2 Cyanide adsorption process

Predetermined amounts of mineral samples were put into 150 mL NaCN solution (25.0 mg/L). Then, the suspensions were stirred using a magnetic stirrer (FuHua78-1, Made in China) at 2400 r/min for 5 min.

The suspensions were subsequently filtered and dried naturally, to simulate the long-term accumulation of the gold cyanidation tailings.

2.3 Flotation test

The flotation tests were carried out in a micro-flotation cell with a 25 mL effective volume. The amount of cyaniding mineral samples used in each experiment was 2.0 g and the pulp density maintains at 10% with distilled water. The flotation time was 3 min and the stirring speed was 2400 r/min. NaOH and HCl solutions were used to adjust the pH of the flotation system. The floated and non-floated fractions were filtered, dried using a vacuum drying oven (DZF, Made in China) at 40 °C, and weighed for the recovery calculation.

2.4 Contact angle measurement

Contact angles of cyaniding mineral samples were measured using a contact angle instrument (XG-CAMB, Made in China). Cyanide mineral sample (2.0 g) was added to a 50 mL beaker with 20 mL distilled water. After that, the solution was stirred for 5 min with a magnetic stirring apparatus. Following that, the samples were filtered, dried, squashed, and then put onto the platform of the contact angle instrument. A certain dosage of distilled water was dropped one by one. Every sample was measured three times in different positions, and an average value was taken.

2.5 Zeta potential measurement

Zeta potential of cyaniding mineral samples was measured using a zeta apparatus (Nano-ZS90, Made in England) by the measurements of electrophoresis. The samples were ground to smaller than 2 μm in the agate mortar. For each test, 30 mg of cyanidation mineral powder was added to a beaker with 50 mL distilled water. Then, the suspension was stirred for 3 min with a magnetic stirring apparatus. The pH of suspension was regulated with HCl and NaOH solutions to a desired value. After that the suspension was ready for the measurement. Every sample was measured three times, and an average value was taken.

3 Results and discussion

3.1 Cyanide adsorption

The adsorption of CN^- on the surface of chalcopyrite and galena was investigated by the cyanide tests. According to the reaction mechanism of cyanide ions and silver ions in solution, CN^- concentration in the solutions was determined using atomic absorption spectrophotometer with graphite furnace (AA-6300, Made in Japan) by means of silver cyanogen

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