



Flotation separation of chalcopyrite from galena by sodium humate and ammonium persulfate



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Received 3 March 2015; accepted 15 June 2015

Abstract: The flotabilities of chalcopyrite and galena with sodium humate (HA) and ammonium persulfate (APS) as the depressant were studied by flotation test, adsorption measurement and infrared spectroscopic analysis. Single mineral flotation test shows that the slurry oxidation environment and the proper oxidation of galena surface are prerequisites for the depression of galena by sodium humate. The closed-circuit flotation test of copper/lead bulk concentrate shows that the grade and recovery of Cu reach 30.47% and 89.16% respectively and those of Pb reach 2.06% and 1.58% respectively in copper concentrate, and the grade and recovery of Pb reach 50.34% and 98.42% and those of Cu reach 1.45% and 10.84% respectively in lead concentrate with HA and APS. The selective depression effect of HA and APS is more obvious than that of potassium dichromate. The results of FTIR analysis and adsorption measurements indicate that the adsorption of sodium humate on the fresh surface of galena is negligible, while after oxidation, sodium humate can be chemically adsorbed on the surface of galena. According to the theory of solubility product, the sodium humate can display the oxidation product $PbSO_4$, after then, adsorb on the surface of lead chemically to produce inhibitory effect. Thus, it can be seen that the combination of HA and APS is an efficient non-toxic reagent to achieve cleaning separation copper/lead bulk concentrate by flotation. The combination of HA and APS is an efficient non-toxic reagent to achieve cleaning for copper/lead bulk concentrate by flotation.

Key words: chalcopyrite; galena; sodium humate; sodium persulfate; flotation

1 Introduction

Chalcopyrite always coexists with other sulphide minerals, such as zinc and lead sulphide minerals [1]. Generally, two kinds of basic methods are commonly used for the separation of copper/lead minerals [2,3], such as copper depression with lead flotation and lead depression with copper flotation. Some reagents such as sodium cyanide for the depression of chalcopyrite and sodium dichromate for the depression of galena are employed [4]. Although only small amount of this kind of reagents were used, they caused serious environmental pollution [5]. So, some other environmentally friendly methods of depression are preferred.

According to the recent studies, the organic depressants have attracted a considerable amount of attention. In the laboratory and commercial processes,

dextrin [6], starch [7], CMC [8] and ferrochrome lignosulfonate (FCLS) [9] have been used in the separation of chalcopyrite and galena. These kinds of reagents are nontoxic, biodegradable and relatively inexpensive compared with the widely used inorganic depressants.

Sodium humate is the sodium salt of humic acid and can be extracted from leonardite which is complicated, naturally forming organic compounds with high relative molecular mass. CHEN et al [10] indicate that sodium humate can be used as pyrite depressant in the separation of chalcopyrite and pyrite at lower pH values. The studies on the flotation behavior of pyrite and arsenopyrite in the xanthate and sodium humate systems showed that the sodium humate can depress arsenopyrite well [11,12].

There have been some studies on the separation of actual copper/lead ore with sodium humate as the

depressant of galena [12,13], while the mechanism is still unclear and the depressing effect is uncertain. The aim of this work is to determine the depression mechanism of galena with sodium humate as the inhibitor, and put forward an environmentally friendly way for the separation of copper/lead minerals. The floatabilities of chalcopyrite and galena in the presence and absence of the depressants were studied. The adsorption measurement and infrared spectroscopic analysis were conducted to investigate the interaction between reagents and minerals.

2 Experimental

2.1 Materials and reagents

Galena and chalcopyrite samples were obtained from Bainiuchang Mine in Yunnan Province, China. The samples were purified by hand sorting, and the X-ray powder diffraction data confirmed the high purity of the samples. The chemical analysis revealed that the galena content (mass fraction) of the sample was 96.5% and the chalcopyrite content was 94.9%. The samples were respectively dry-ground in a porcelain ball mill and dry-screened to obtain particles with size range of 38–74 μm for the single mineral flotation and adsorption measurements. The fraction of particles with size larger than 74 μm was reground to the desired size fraction. A small part of particles with size less than 38 μm was further comminuted using agate mortar to 2 μm for infrared spectroscopic analysis, whereas the fraction of particles ranging in 38–74 μm was used. The ground products were stored separately in sealed glass bottles with nitrogen protection against further surface oxidation.

The sample of copper/lead bulk concentrate was obtained from the mineral processing plant of Bainiuchang, and the chemical compositions (mass fraction) are 9.60% Cu and 36.76% Pb.

Industrial grade butyl xanthate (BX, purity>85%) and methyl isobutyl carbinol (MIBC) were respectively used as the collector and frother, which were provided by Zhuzhou Flotation Reagents Factory in Hunan Province, China. Chemical grade sodium humate and sodium persulfate were obtained from Tianjin Guangfu Fine Chemical Research Institute (Tianjin, China). The solutions of all the reagents were prepared using distilled water. The dilute solutions of sodium hydroxide and hydrochloric acid were used as pH modifier.

2.2 Flotation tests

Flotation tests of single minerals were carried out in the micro-flotation cell with an effective volume of about 40 mL and the flowsheet is shown in Fig. 1. A 2.0 g mineral sample (38–74 μm size fraction) was used in

each experiment and was cleaned ultrasonically prior to the tests. After agitation for 1 min, the pH of the pulp was firstly adjusted to a desired value by adding pH modifier. Then, the ammonium persulfate (APS) and/or (HA) sodium humate solution (adjust to neutral pH by H_2SO_4 in order to avoid the pH fluctuation) was added to the cell. Five minutes later, the samples were conditioned with xanthate for 2 min. After that, MIBC was added to the slurry. The flotation time was set to 2 min in all of the single-mineral experiments.

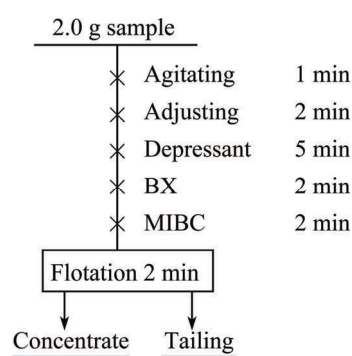


Fig. 1 Flowsheet of flotation tests on single minerals

The closed-circuit flotation test of copper/lead bulk concentrate was achieved in an XFG single-trough flotation machine with effective volumes of 0.25, 0.5, 0.75 and 1.0 L. The flowsheet is shown in Fig. 2.

2.3 Adsorption tests

The adsorption of HA on chalcopyrite and galena both in the absence and presence of different concentrations of APS at pH=6.5 was determined by measuring the residual concentration with total organic carbon analyzer. SHIMADZU total organic carbon analyzer of Japanese (TOC-L) was used in the test.

2.0 g mineral sample of 38–74 μm size fraction was cleaned by ultrasonic and then repulped with 50 mL distilled water at desired pH. After addition of the desired reagents, the solution was agitated with the identical condition as described in flotation test. Then, the pulp was centrifuged by centrifugation at 9000 r/min for 10 min using a high speed refrigerated centrifuge. The supernatants were withdrawn for the analysis of residual HA concentrations. The adsorption amount was calculated from the difference between initial and residual concentrations of the solution.

2.4 FTIR studies

The infrared spectra of galena, HA, the oxidized product of galena by APS, and the interaction products of unoxidized/oxidized galena with HA were obtained using Shimadzu IR Affinity-1 spectrometer.

Samples with size of 2 μm were prepared in the

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