Minerals Engineering 122 (2018) 79–83

Contents lists available at ScienceDirect

Minerals Engineering

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

Use of locust bean gum in flotation separation of chalcopyrite and talc

Bo Feng[a,*], Jinxiu Peng[a], Wenpu Zhang[a], Xianghan Ning[a], Yutao Guo[a], Wencai Zhang[b]

[a] Jiangxi Key Laboratory of Mining Engineering, Jiangxi University of Science and Technology, Ganzhou, China
[b] Department of Mining Engineering, University of Kentucky, Lexington, KY 40506, USA

ARTICLE INFO

Keywords:
Talc
Chalcopyrite
Flotation separation
Locust bean gum
Selectivity

ABSTRACT

In the flotation separation of chalcopyrite and talc, depressants are usually added to selectively prevent talc from floating. Commonly used depressants lack selectivity, resulting in the depression of both talc and sulfide minerals. To solve this problem, the role of locust bean gum in the flotation separation of chalcopyrite and talc was studied and its mechanism of talc depression discussed. Single mineral flotation test results showed that both chalcopyrite and talc were floatable in the tested pH range of 3–11 and that locust bean gum depressed the flotation of both minerals; however, locust bean gum showed a strong depressing effect on talc in the pH range of 5–9 at a dosage of 2000 g/t. The results of flotation tests performed on mixed minerals indicated that the use of locust bean gum as a depressant can achieve flotation separation of chalcopyrite from talc. A concentrate of 30.1% Cu was achieved at 88.1% recovery from a feed material containing 15.2% Cu. This was attributed to greater adsorption of locust bean gum on the surface of talc compared with that on the chalcopyrite. Zeta potential and X-ray photoelectron spectroscopy measurements showed that the locust bean gum adsorbed on talc mainly through physical interactions; hydrophobic interactions were considered the main driving force and hydrogen bonds also played a role.

1. Introduction

The separation of sulfides and talc by froth flotation is difficult because talc is naturally hydrophobic and easily reports to flotation concentrates, thus reducing concentrate grade (Beattie et al., 2006a,b; Shortridge et al., 2000; Steenberg and Harris, 1984). Talc depression in sulfide flotation can be achieved using polymeric reagents, such as carboxymethyl cellulose, guar gum, and starch (Jenkins and Ralston, 1998; Khraisheh et al., 2005; Morris et al., 2002; Wang et al., 2005). Separation of talc from sulfides can be easily achieved if the polymeric reagents adsorb solely on the talc surfaces; however, these depressants also adsorb on sulfide minerals to some extent and impair flotation performance (Beattie et al., 2006a; Mierczynska-Vasilev and Beattie, 2010). Therefore, an efficient depressant for the selective flotation separation of chalcopyrite and talc is necessary.

Locust bean gum is a vegetable gum extracted from the seeds of the carob tree. It consists chiefly of high-molecular-mass hydrocolloidal polysaccharides, composed of galactose and mannose units combined through glycosidic linkages (Fig. 1), which may be described chemically as galactomannan. The use of locust bean gum as a commercial depressant for the flotation separation of sulfide minerals from talc has not been reported.

The aim of this study was to investigate if locust bean gum possesses unique selectivity for single mineral flotation of chalcopyrite and talc, and whether it can separate these two minerals in a mixture. X-ray photoelectron spectroscopy (XPS) and zeta potential measurements were conducted to define the mechanism of depression of talc by locust bean gum and to provide a reference for reagent selection for flotation separation of chalcopyrite and talc.

2. Experimental

2.1. Samples and reagents

The chalcopyrite was obtained from Saishitang, Qinghai Province, China, and the talc was obtained from Haicheng, Liaoning Province, China. According to X-ray diffraction (XRD) and elemental analyses (Table 1), their purities were 96.4%and 95%, respectively. The samples were dry ground and screened to −150 + 37 μm for flotation and adsorption tests. Their specific surface areas were 0.28 and 8.65 m^2/g, respectively, as analyzed using a specific surface area analyzer (3H-2000BET-A, BEST, China).

The locust bean gum (molecular mass: 250000–300 000) was obtained from Aladdin Chemical Technology Co., Ltd., China. Hydrochloric acid (HCl) and sodium hydroxide (NaOH) were used as pH regulators. Deionized water was used for all tests.

* Corresponding author.
E-mail address: fengbo319@163.com (B. Feng).

https://doi.org/10.1016/j.mineng.2018.03.044
Received 16 March 2018; Accepted 28 March 2018

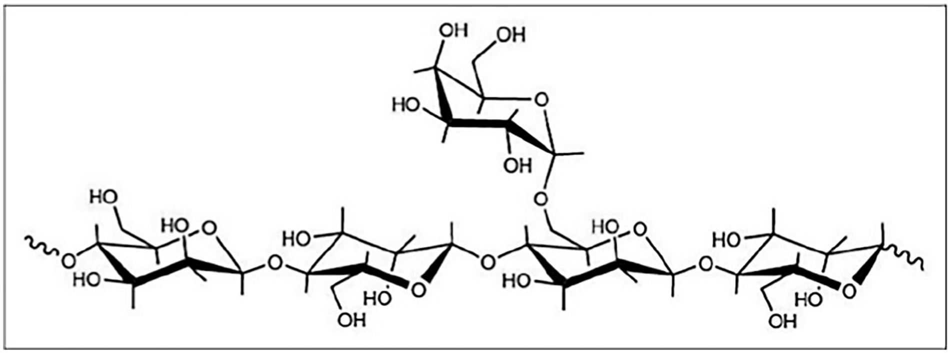

Fig. 1. Structure of locust bean gum (Dionísio and Grenha, 2012).

Table 1
Chemical compositions of chalcopyrite and talc.

Elements	Cu	TFe	S	MgO	SiO_2	Al_2O_3	CaO
Chalcopyrite	33.2	27.2	35.9				
Talc	/	0.6	/	28.9	53.1	/	/

2.2. Experimental

2.2.1. Flotation tests

The flotation tests were carried out in a mechanically agitated flotation machine (FGC5-35, Yunhao Mining and Metallurgical Equipment Co., Ltd., China). Both single and mixed mineral tests (chalcopyrite and talc at a mass ratio of 1:1) employed a sample mass of 2 g. The mineral samples were mixed with 40-mL deionized water and conditioned for 2 min while the desired pH value was adjusted using HCl or NaOH. Locust bean gum and potassium butyl xanthate (PBX) (376 g/t) solutions were added sequentially, with 5 min stirring after each addition. Methyl isobutyl carbinol (MIBC), utilized as the frother, was then added at 204 g/t, followed by 1 min of conditioning, and then flotation was carried out for a total time period of 5 min.

For single mineral flotation, both the floated and unfloated particles were collected, filtered, and dried. The flotation recovery was calculated based on solid mass distributions between the two products. For mixed mineral flotation, the copper grades of the concentrates and tailings were analyzed using the volumetric titration method described by Wang (2005). Recovery was calculated based on the copper grades of the feed, product, and tailings.

2.2.2. Adsorption studies

For the adsorption tests, 1 g of mineral powder was mixed with locust bean gum solution in a 250 mL Erlenmeyer flask. The total volume of the slurry was 100 mL. The suspensions were placed on a rotator and mixed for 1 h to ensure that the adsorption process had reached equilibrium. The slurry was then centrifuged and the concentration of locust bean gum remaining in the supernatant was measured by determining the total organic carbon (TOC) using a TOC analyzer (Vario TOC, Elementar, Germany) and compared with the value of a known calibration standard.

2.2.3. Zeta potential measurements

Zeta potential measurements on talc and chalcopyrite were carried out using a Zeta Plus zeta potential meter (Colloidal Dynamics, USA). One gram of −10-μm mineral was added to 50 mL of 10^{-3} mol/L potassium nitrate solution and magnetically stirred for 10 min and the pH was adjusted to within the range of 3–11 using HCl or NaOH. The zeta potential was then measured alone or in the presence of locust bean gum.

2.2.4. X-ray photoelectron spectroscopy measurements

For the XPS tests, 1-g talc was added into 100-mL distilled water and then locust bean gum added to a concentration of 1000 g/t. After adjusting to pH 7, the suspension was conditioned for 30 min at 25 °C. The minerals were then filtered, washed with 100-mL distilled water, and dried in a vacuum desiccator. XPS measurements were conducted using a K-Alpha 1063 X-ray spectrometer (Thermo Fisher, UK). The vacuum in the analyzer chamber was maintained at $\sim 10^{-10}$ Torr. The binding energy scale of the instrument was calibrated using the Au (4f)7/2 (84.0 eV) line of metallic gold. Samples were in the form of dry powder mounted on conductive carbon tape. No negative effects resulting from charging or X-ray damage were observed.

3. Results and discussion

3.1. Locust bean gum as a depressant for talc and chalcopyrite

The flotation behaviors of chalcopyrite and talc in the absence and presence of depressant are shown in Fig. 2. Chalcopyrite and talc were floatable in the tested pH range of 3–11. These single mineral flotation tests results indicated that separation between chalcopyrite and talc was hardly achieved in the absence of depressant because both minerals reported to the concentrates. This was in good agreement with findings of earlier studies (Beattie et al., 2014; Mierczynska-Vasilev and Beattie, 2010).

When 2000-g/t locust bean gum was added, differences in the flotation recoveries at the same pH values were observed. For chalcopyrite, the depression effect of locust bean gum was minor in the pH range of 3–9. With an increase in pH from 9 to 11, chalcopyrite recovery dropped from 77% to 2.5%. Many studies have confirmed that

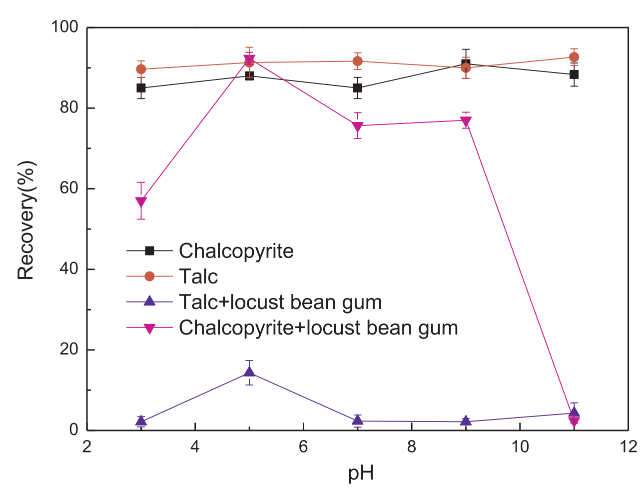

Fig. 2. Effect of pH on the flotation behavior of minerals. c(PBX) = 376 g/t; c(MIBC) = 204 g/t; c(locust bean gum) = 2000 g/t.