



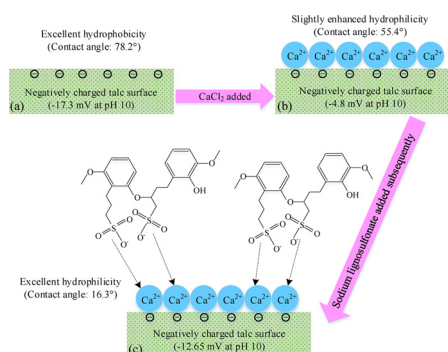
Improved depression of talc in chalcopyrite flotation using a novel depressant combination of calcium ions and sodium lignosulfonate

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GRAPHICAL ABSTRACT



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ABSTRACT

The presence of hydroxylated metallic sites on mineral surfaces promotes the adsorption of polysaccharides on mineral surfaces. In this study, the interaction of calcium chloride and sodium lignosulfonate on talc was investigated through flotation tests and zeta potential, contact angle, adsorption measurements, X-ray photoelectron spectroscopy and infrared spectroscopy studies. Artificial mixed mineral flotation tests indicated that the combined action of calcium chloride and sodium lignosulfonate can reduce the content of talc in the flotation concentrate. Zeta potential and contact angle measurements showed that the combined inhibitory effect of calcium chloride and sodium lignosulfonate on talc is more effective than the individual effects of these reagents. The adsorption densities of calcium chloride and sodium lignosulfonate on talc revealed that the addition of Ca^{2+} contributes to the adsorption of sodium lignosulfonate on the talc surface. X-ray photoelectron spectroscopy and infrared spectroscopy provided evidence in support of a chemical interaction between Ca^{2+} , sodium lignosulfonate and talc. The findings of this study are of great significance for reducing the Mg grade in the flotation concentrate of chalcopyrite.

1. Introduction

Chalcopyrite, a common copper-bearing sulfide ore, is the main raw material for industrial copper smelting [1]. Chalcopyrite ore often

contains layered silicate minerals such as talc. As talc has a strong natural hydrophobicity, it can easily float in the foam product during chalcopyrite flotation, thereby dramatically increasing the Mg content in the flotation concentrate [2,3]. Therefore, the effective inhibition of

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talc during chalcopyrite flotation has become the key to efficient exploitation and utilization of such copper resources.

Talc is a typical layered silicate mineral with a TOT-type structure that consists of two silicon tetrahedral sheets sandwiching one Mg–O (OH) octahedral sheet. Talc, owing to its low hardness, is prone to overgrinding during grinding processes. A considerable amount of talc mud is produced, which makes it difficult to inhibit its floatability [4]. Considerable research efforts have been devoted to overcome this problem. Leung et al. [5] found that copolymers of acrylamide and vinylpyrrolidinone not only possess the strong affinity of vinylpyrrolidinone for talc, but also the strong hydrophilicity of polyacrylamide, which can selectively inhibit the floatability of talc. Surface defects generated by ultrasonic pretreatment can act as active sites for water, thereby significantly increasing the hydrophilicity of talc [6]. Both carboxymethyl cellulose and guar gum are effective inhibitors of talc under weakly alkaline conditions, although the inhibition by guar gum is better than that by carboxymethyl cellulose [7–9]. Zhang et al. [10] suggested that guar gum is chemically adsorbed on the surface of talc, thus inhibiting the floatability of talc during scheelite flotation. Zhang et al. [11] investigated the mechanism by which metal ions influenced the zeta potential of talc, as well as the induction time between talc and bubbles. However, as talc is prone to overgrinding, a large amount of carboxymethyl cellulose or guar gum must be added to inhibit the floatability of fine-grained talc, resulting in decreased recovery of chalcopyrite.

The objective of this study was to explore the selective inhibition of fine-grained talc by calcium chloride (CaCl_2) and sodium lignosulfonate during chalcopyrite flotation. Adsorption tests, zeta potential measurements, and infrared spectroscopy were used to investigate the mechanism by which these reagents decrease the floatability of talc.

2. Experimental approach

2.1. Materials and reagents

Natural chalcopyrite sample was obtained from Daye City, Hubei Province, China. Natural talc sample was purchased from Baoding City, Hebei Province, China. High-grade raw ore was carefully crushed to -2 mm , from which high-crystallinity ore was manually selected and then ground using a porcelain grinding ball to obtain flotation samples. A $-74 + 45\text{ }\mu\text{m}$ size fraction of chalcopyrite and a $-25\text{ }\mu\text{m}$ size fraction of talc were obtained by elutriation and sieving, respectively. Previous publications [12–14] proved that the physicochemical behavior of minerals particles are mainly governed by the properties of the most commonly exposed surface of the mineral. As shown in Fig. 1, there were few records of impure peaks, indicating that the talc sample were of high purity, and the most commonly exposed surface for talc was

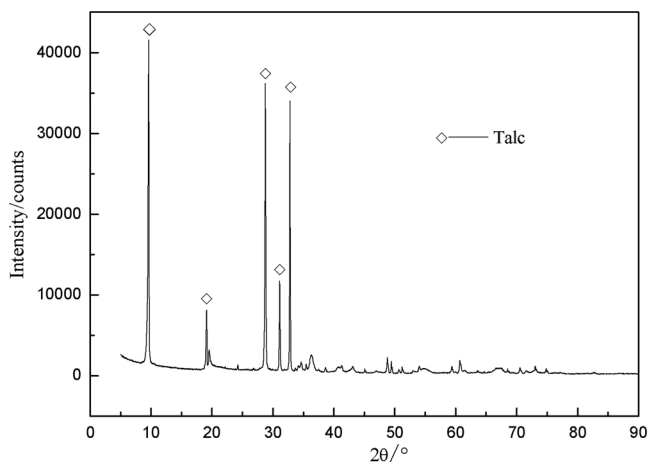


Fig. 1. XRD patterns of talc sample.

Table 1

Multi-element chemical analysis of pure minerals.

Minerals	Content (wt%)					
	Total Fe	Cu	S	MgO	SiO_2	CaO
Chalcopyrite	32.86	32.91	33.32	< 0.05	0.58	< 0.02
Talc	0.12	0.11	< 0.02	31.16	60.58	0.25

{001}. X-ray diffraction and multi-element chemical analysis (Table 1) confirmed that the purities of chalcopyrite and talc were approximately 95.23 wt% and 95.42 wt%, respectively.

Butyl xanthate (collector) was an industrial product, methyl isobutyl carbinol (MIBC, frother) and sodium lignosulfonate were chemically pure, and CaCl_2 was of analytical grade. Analytical-grade hydrochloric acid (HCl) and sodium hydroxide (NaOH) were used as pH regulators. Distilled water was employed in all experiments.

2.2. Artificial mixed ore flotation tests

Artificial mixed ore flotation tests were performed in a flotation apparatus (Fig. 2). The device can dramatically expand the collision probability of valuable minerals and bubbles, and significantly reduce the nonselective entrainment of fine-grained gangue minerals. Hence, the flotation recovery rate of minerals can be more accurately determined.

In a typical flotation test, the mineral pulp was prepared by adding 2 g of artificial mixed ore (1:1 mass ratio of chalcopyrite and talc) to a 50 mL breaker with 50 mL of distilled water and conditioned for 2 min. CaCl_2 , sodium lignosulfonate, butyl xanthate, and MIBC were added to the solution sequentially, then HCl (or NaOH) was added to obtain a pH of approximately 10, and the pulp was stirred for 2 min after each addition. Subsequently, the pulp was transferred to a Hallimond tube and floated for 3 min with a nitrogen flow rate of 0.4 L/min. The froth products (m_1) and tailings were separately collected and dried, and the Cu content (β) in the foam products was determined. The recovery rates of chalcopyrite (γ_1) and talc (γ_2) in the froth products were calculated as follows:

$$\gamma_1 = \frac{m_1 \beta}{0.3291} \times 100\% \quad (1)$$

$$\gamma_2 = (m_1 - \frac{m_1 \beta}{0.3291}) \times 100\% \quad (2)$$

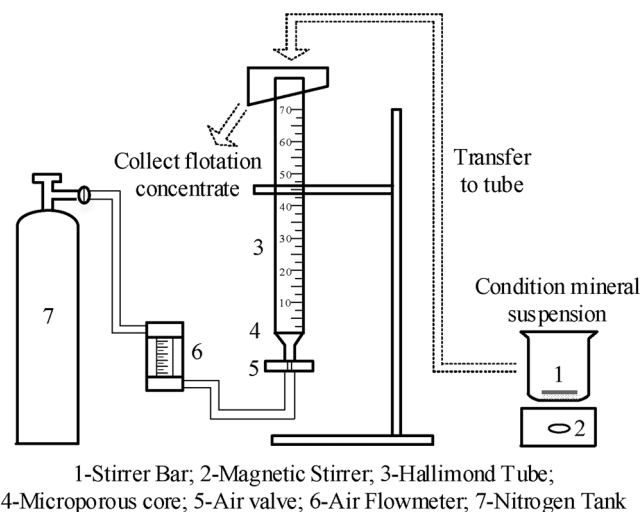


Fig. 2. Schematic diagram of the flotation apparatus (pore diameter of microporous core: 40–50 μm).

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