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The effect of aluminum ions on the flotation separation of pentlandite from lizardite

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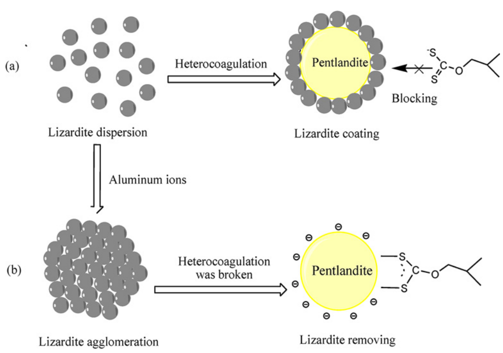
GRAPHICAL ABSTRACT

In Fig.(a), hetero-coagulation occurred between pentlandite and micro-fine lizardite particles, in Fig.(b) the hetero-coagulation can be broken between pentlandite and lizardite when the size of lizardite particle is increased with Al(III) ions, promoting the absorption of SBX collector on pentlandite surface.



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ABSTRACT

The role of aluminum ions on the flotation of pentlandite depressed by lizardite has been studied by flotation tests, adsorption tests, zeta potential measurements, solution chemistry calculation and particle size distribution test. The results show that the finer the lizardite slime is, the lower the pentlandite recovery will be at the routinely performed pH 8.5. The addition of aluminum ions prevents the detrimental effect of lizardite on pentlandite flotation. Good floatability of pentlandite was obtained around pH 8.5. Precipitation of the hydrolyzed species of aluminum ions occurred in this pH region, these species absorb on lizardite surface by special interaction and promote the coagulation of lizardite slimes, and therefore hetero-coagulation between lizardite and pentlandite can be broken.

1. Introduction

Nickel is an important nonferrous metal that is used in the alloys, aviation, as well as other industries, called the “vitamin of industry”, nickel is one of the strategic metals that is identified for stockpiling in many countries [1,2]. sulphide mineral pentlandite is a primary source of nickel and flotation is the commonly used method for the recovery of pentlandite. Lizardite is a stratified magnesium silicate gangue mineral

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common in valuable sulphide ores, such as pentlandite [3–6]. Over the past few decades, many investigations have been indicated that the surface charge of lizardite and pentlandite is opposite under weakly alkaline condition [7–9]. This creates an electrostatic attraction which results in the positively charged lizardite slime coatings attached to the hydrophobic negatively charged sulphide particle surface, reducing collector adsorption and may also depressing the floatability of sulphide minerals [5,6,10].

In order to improve flotation separation performance of sulphide minerals and lizardite, carboxylation chitosan [11], carboxymethyl cellulose [12], and sodium hexametaphosphate [13,14], are used to eliminate the reverse effect by serpentine slime on the sulfide flotation. However, effective concentrations of the above depressants were normally in the range of 1–1.5% [15], and high reagent dosages are needed for the depression of lizardite slime, such low concentrations and high dosage resulting in large solution volume additions. Hence, removing lizardite slime from sulphide minerals surface is still a big problem.

Previous research shows that particle size significantly influences the interaction of heterogeneous particles. As such, clay slime is removed from coated surface when the particle size of clay slime are agglomerated [16]. Thus, the selective agglomeration of lizardite slimes can be used to limit the detrimental effect of slimes on the available mineral flotation. The hydrolysis of aluminum ions can generate aluminum hydroxide colloid which has the flocculation ability [17]. In this work, aluminum ions were used as a potential regulator to remove lizardite slimes from pentlandite surface. “Possibly”, one can prevent lizardite the detrimental effect of lizardite on sulphide minerals flotation using aluminum ions or other metal ions, which have a selective aggregation ability.

2. Experimental

2.1. Samples and reagents

Lizardite and pentlandite samples used for the experiments were obtained from Jinchuan nickel mine of China. The samples were crushed and ground using an agate mortar. The lizardite particle size distribution was determined by a Malvern Instruments Mastersizer with d_{90} of 9.09 μm and an average diameter of 5.38 μm. The -74 + 37 μm pentlandite particles was used for micro-flotation tests and adsorption tests. The BET surface area of the size fraction of −74 + 37 μm pentlandite was 2.28 m^2/g. The −2 μm size fractions were prepared for zeta potential measurements. The X-ray diffraction (XRD) analyses indicated that the purity of both samples were very high (Fig. 1).

Sodium butyl xanthate(SBX) with 88% purity obtained from Zhuzhou Flotation Reagent Company was used as the collector. Analytical-grade aluminum sulfate was used as the source of aluminum ions. Analytical-grade NaOH and HCl were utilized as the pH modifiers in the experiments, and distilled water with a resistivity of 18.2 Ω cm was used for all the tests.

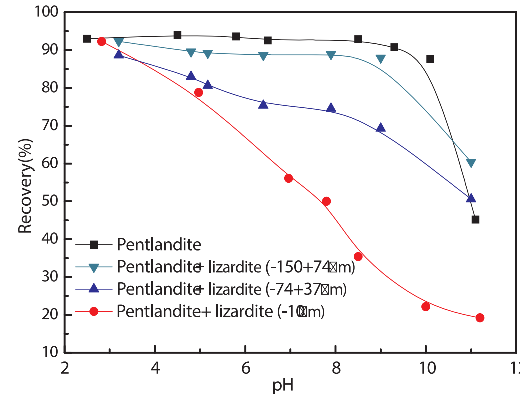

Fig. 2. Effect of pH value on the flotation recovery of pentlandite with and without lizardite (Pentlandite = 50 g/L, Lizardite = 5 g/L, SBX = 1×10^{-4} M and MIBC = 1×10^{-4} M).

2.2. Micro-flotation tests

The flotation tests were carried out in a mechanical agitation flotation machine. Pure mineral particles (2 g) and deionized water (40 ml) were mixed in the plexiglass cell. When needed, lizardite was added prior to the conditioning of pentlandite. pH modifiers (NaOH and/or HCl), aluminum sulfate, and the collector were added in sequence into the suspension, and the suspension was conditioned for 3 min after each addition. The pH value at the beginning of the flotation was recorded, and the flotation was conducted for a period of 4 min. After that, both the floated and unfloated products were collected, then filtered and dried. The recovery was calculated using dry weights of the concentrates and tailings.

2.3. Adsorption tests

Adsorption measurements were carried out using UV spectrophotometry. For the tests, 1 g pentlandite was added to a desired SBX concentration in the absence and presence of lizardite, when required, aluminum ions were added into the mixed lizardite and pentlandite pulp. The total volume was 40 mL and the pH value was adjusted to a desired pH. The suspension was conditioned for 20 min, ensuring that the adsorption equilibrium was achieved. The equilibrium concentration of SBX in the solution was measured by UV spectrophotometry and the value was calculated from the standard curve of SBX which was

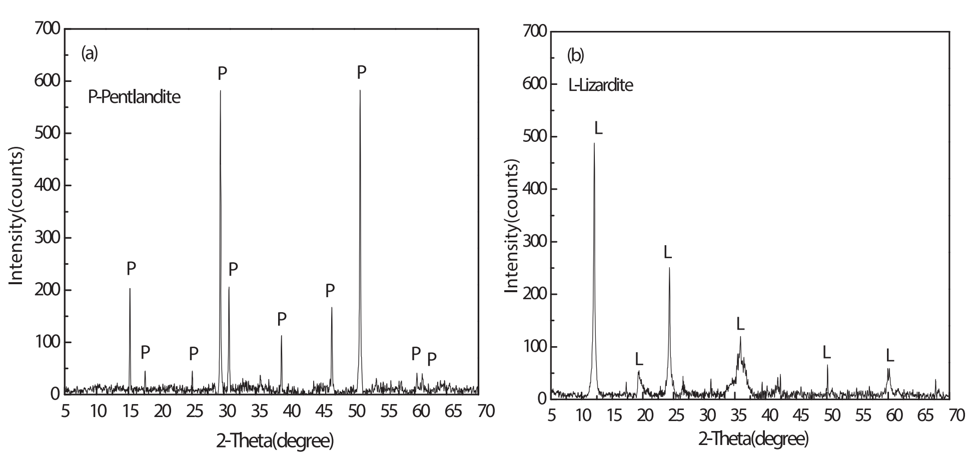

Fig. 1. XRD patterns of experimental samples(a)pentlandite,(b)lizardite.