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Effect of serpentine and sodium hexametaphosphate on ascharite flotation

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Abstract: Sodium hexametaphosphate (SHMP) was used to minimize the adverse effect of serpentine for improving ascharite recovery. The effects of particle size and content of SHMP, and serpentine on ascharite flotation process were investigated through flotation, zeta potential tests, FT-IR analysis, XPS analysis and DLVO theory. Particles interaction and mechanism of SHMP were also discussed. It was found that aggregation between serpentine and ascharite particles easily happened, and the particle size of serpentine had a profound impact on the ascharite recovery. In particular, the fine serpentine with size less than 38 μm had the greatest contribution to the deterioration of ascharite flotation performance. After SHMP treatment, the adverse effect of serpentine was significantly reduced. The mechanism of SHMP showed that it could alter the surface charges of serpentine and ascharite to prevent severe interparticle aggregation, which resulted in a well-dispersed pulp and benefited ascharite flotation process. The adsorption of SHMP on serpentine was due to hydrogen bonding and chemical adsorption, resulting in the formation of complex on serpentine surface to decrease its floatability.

Key words: serpentine; ascharite; sodium hexametaphosphate; flotation; DLVO theory; interaction; adsorption

1 Introduction

The main boron mineral resources in China are ascharite ore and paigeite ore. After decades of exploitation, directly available ascharite resources are nearly exhausted and cannot meet the future needs of boron chemical production [1,2]. Therefore, it is crucial to exploit and utilize the less appealing paigeite resources to maintain a steady supply for the boron industry. Paigeite ore is rich in Dandong region, Liaoning province, China. The main valuable mineral in paigeite is ascharite and the main gangue mineral is serpentine closely associated with ascharite [3]. However, the dissemination sizes of serpentine are very fine and serpentine is prone to form slime during mineral processing, leading to a problem in flotation separation of ascharite from serpentine.

Pervious researches have shown that particle size has a great influence on particles interaction and interferes flotation performance significantly [4,5]. For instance, it is found that fine particle serpentine has adverse effects on flotation of nickel-bearing pyrite and chromite [6,7]. Because of the difference on surface charge, fine serpentine particles can be adsorbed to the nickel-bearing pyrite and chromite easily, which leads to a low recovery of target mineral [8]. Sodium hexametaphosphate (SHMP) is found to be a good inhibitor to antigorite, which is one of important mineral polymorphs of serpentine. Moreover, SHMP can be adsorbed on the surfaces of the antigorite, diminishing the chance of the anionic collector adsorption [9]. Nevertheless, so far few studies have been found on the flotation separation of ascharite from serpentine. The influence of serpentine particles on ascharite flotation and the flotation behavior have not been studied systematically. Besides, the mechanism of SHMP is not fully understood.

In this study, the subjects that previous studies seldom discussed were carefully investigated. The influences of particle size and content of serpentine on ascharite flotation process were studied. The particles interaction between serpentine and ascharite was also systematically discussed. SHMP was used to diminish the detrimental effect of serpentine on ascharite flotation. The mechanism of SHMP was investigated to provide

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insights to the ascharite flotation process. A better understanding of the flotation performance of ascharite in the presence of serpentine is essential for the future exploitation of paigeite resources and the mechanism of SHMP discussed in this research provides a reference for further study.

2 Experimental

2.1 Characterization of ascharite and serpentine samples

The serpentine and ascharite samples used in the experiments were obtained from Xiuyan and Dandong, Liaoning province, China. The ascharite was obtained by handpicking and then sieved to <45 μm. A batch of serpentine rocks were first ground and sieved, then three products with different particle sizes were obtained, i.e., coarse (45−74 μm), medium (38−45 μm) and fine (<38 μm). The particle size distribution is listed in Table 1. The chemical analyses of samples were also performed and shown in Table 2. X-ray diffraction patterns are shown in Fig. 1. The results demonstrated that serpentine and ascharite samples with purities of 95.6% and 94.5% respectively could meet the requirement for following research.

Table 1 Particle size distribution of samples

Mineral	Grade	D_{10}/μm	D_{50}/μm	D_{90}/μm	Volume average diameter/μm
Serpentine	45−74 μm (coarse)	33.8	69.9	128.3	75.9
	38−45 μm (medium)	17.7	42.2	77.8	45.1
	<38 μm (fine)	2.1	11.0	42.3	12.8
Ascharite		1.9	20.1	49.9	27.8

Table 2 Compositions of serpentine and ascharite (mass fraction, %)

Mineral	MgO	SiO_2	CaO	B_2O_3	Al_2O_3
Serpentine	42.09	43.68	0.90	−	0.88
Ascharite	46.21	0.74	0.25	39.16	−

2.2 Chemical reagents

Analytical grade reagents dodecylamine and SHMP were used as a collector for ascharite and an inhibitor for serpentine, respectively. Dilute solution of hydrochloric acid (HCl) and sodium hydroxide (NaOH) were employed as pH adjustment agents. Analytical grade reagent potassium nitrate was used to maintain the ionic strength in zeta potential measurement. The distilled water produced by automatic adsorption-type ultrapure water systems was used.

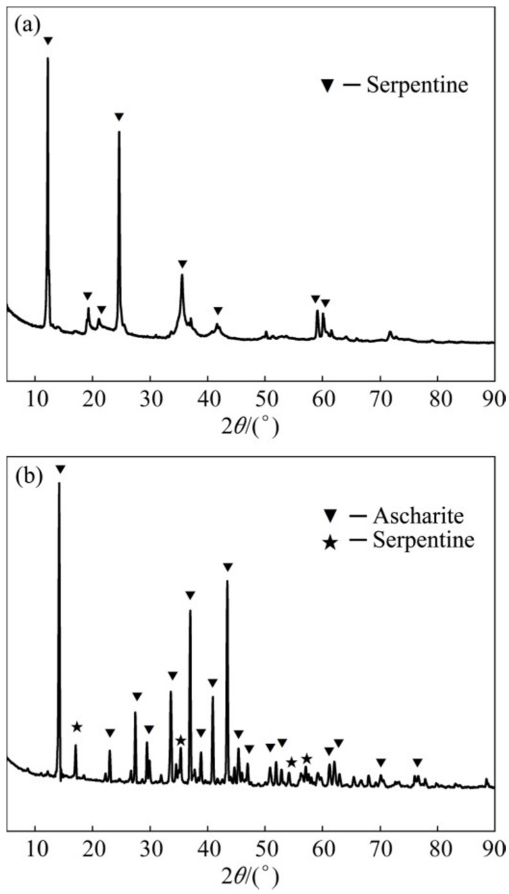

Fig. 1 XRD patterns of samples: (a) Serpentine; (b) Ascharite

2.3 Methods

2.3.1 Flotation tests

Flotation tests were carried out on an XFG flotation machine (30-mL cell and the impeller speed of 1920 r/min). Single mineral experiments were first performed to evaluate flotation performance of serpentine and ascharite, individually. Then, experiments of mixed minerals were carried out. A typical flotation test included the following steps: 1) weigh 2.0 g ascharite or serpentine in single mineral experiments; weigh a mixture of serpentine and ascharite at different mixing ratios (0.1:1, 0.3:1, 0.5:1, 0.8:1, 1:1, mass ratio of serpentine to ascharite) in mixed minerals experiments and keep the mass of ascharite constant (1.0 g); 2) place the mineral samples into the flotation cell, add with 30 mL deionized water, stir for 3 min and maintain the pulp at 20 °C; 3) add HCl and NaOH to achieve required pH value (pH=9.0); 4) add a predetermined dose of SHMP (0.65×10^{-4} mol/L) to the pulp and agitate for 3 min; 5) add a predetermined dose of the collector (3.2×10^{-4} mol/L), agitate for 3 min and collect the flotation froth for another 3 min. The froth products and tailings were dried, weighed and analyzed to calculate flotation recovery.

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