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Flotation separation of fluorite from calcite using polyaspartate as depressant

Hailing Zhu[a,b], Wenqing Qin[b,*], Chen Chen[b], Liyuan Chai[a], Fen Jiao[b], Wenhao Jia[b]

[a] School of Metallurgy and Environment, Central South University, Changsha 410083, PR China
[b] School of Mineral Processing and Bioengineering, Central South University, Changsha 410083, PR China

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ABSTRACT

Flotation separation of carbonate fluorite ore is a puzzle in mineral processing. In this study, the flotation separation of fluorite from calcite using polyaspartate (PASP) as depressant and sodium oleate (NaOL) as collector was investigated, and the adsorption mechanism was analyzed by zeta potential measurement and infrared spectrum (IR) analysis. Flotation results show that NaOL exhibits excellent collecting performance to fluorite and calcite. Moreover, PASP addition can selectively inhibit calcite. A concentrate containing 93.56% CaF_2 with a recovery of 57.82% is obtained in the closed-circuit flotation experiment on the real ore. Zeta potential measurement and IR analysis results indicate that both PASP and NaOL can adsorb on fluorite and calcite surface individually. Additionally, the adsorption of PASP can hinder the adsorption of NaOL on calcite surface but exert little influence on the adsorption of NaOL on fluorite surface. Therefore, PASP is an effective depressant for flotation separation of fluorite from calcite.

1. Introduction

Given its considerable fluorine content, fluorite has been widely used in chemical engineering, construction materials, aviation, precise instrument, and other industrial fields (Zheng, 2009). China is abundant in fluorite resource, which includes the low-grade refractory ore, such as carbonate fluorite ore.

Flotation is the most common method for beneficiation of fluorite ore (Aliaga et al., 2006; Ayhan et al., 2006; Kienko et al., 2010; Song et al., 2006; Zhang and Song, 2003). Nevertheless, the flotation separation of fluorite from carbonate gangue minerals (mainly calcite and dolomite) is difficult to realize because of the following three reasons: similar surface properties and chemical reactivity with reagents, highly soluble and complex dissolved components, and surface transformation between these minerals (Gao et al., 2015a; Liu et al., 2016; Pradip et al., 2002). Generally, fluorite is separated from calcite via flotation by using fatty acids (mainly sodium oleate) as collector and water glass (or modified water glass) as depressant in actual production (Peng et al., 2014; Zhou and Lu, 1992; Zhou et al., 2013). Despite its low price and high inhibition, the water glass dosage is high. The strong alkalinity also results in difficulty in subsequent water treatment. Therefore, to satisfy the beneficiation requirements for highly complex ores, the development of environment-friendly efficient depressants with high selectivity is the future development trend in mineral processing. Organic depressants exhibit advantages over inorganic ones with their variety, extensive sources, and good stability. These depressants are also an important research direction with regard to calcite depressants.

Polyaspartate (PASP) is a kind of polycarboxylic acids with excellent performance in dispersion and corrosion inhibition, and it also displays broad application prospects in water treatment field due to its non-toxicity, high water solubility and good biodegradability (Liu et al., 2011, 2012). Hence, in the present study, we study the flotation separation of fluorite from calcite using PASP as the depressant and sodium oleate as the collector through a series of flotation experiments, and analyze the adsorption mechanism by zeta potential measurement and IR analysis.

2. Experimental

2.1. Materials

Pure fluorite and calcite minerals were obtained from Hu'nan province, China. XRD detection (shown in Fig. 1) and chemical analysis results show the high purity of these two samples, and the contents of CaF_2 and $CaCO_3$ are 99.04% and 98.91%. Fractions ranging from −74 μm to 38 μm were used for microflotation tests.

The raw ore of the actual ore is a polymetallic ore, which mainly contains Mo, Bi, W and CaF_2, and the technology for recovering the

* Corresponding author.
E-mail address: qinwenqing369@126.com (W. Qin).

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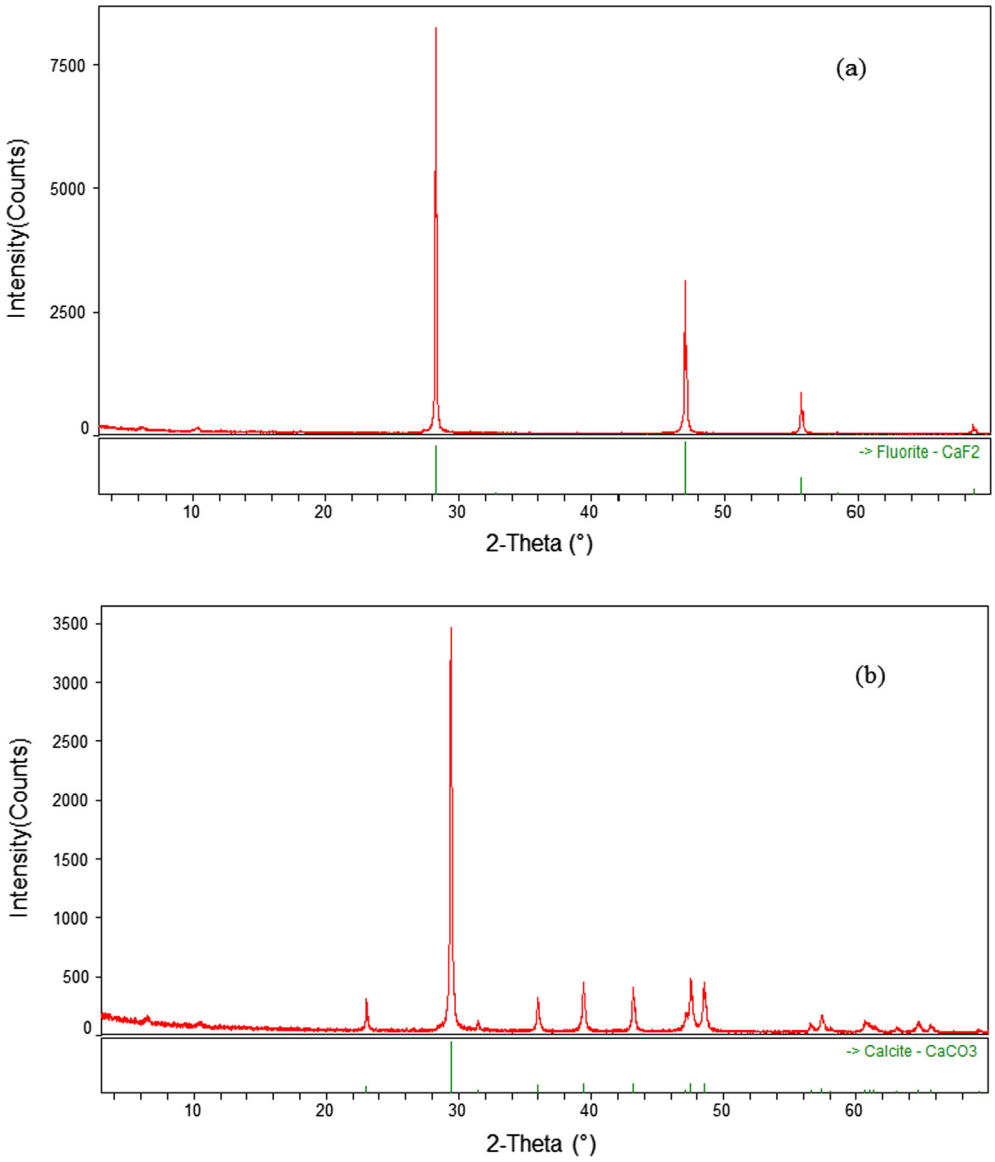

Fig. 1. XRD patterns of fluorite and calcite pure minerals, (a) fluorite, and (b) calcite.

Table 1
Chemical analysis results of the real ore samples/%.

Components	CaF_2	$CaCO_3$	SiO_2	S	TFe	WO_3	Al_2O_3
Content	20.12	6.71	40.69	0.09	4.23	0.10	8.49

valuable contents was determined as flotation of sulphide ores–flotation of tungsten ore–flotation of fluorite. Tailing pulp obtained from roughing and scavenging flotation of tungsten ore is fed for fluorite flotation. Given that this study focused on the beneficiation of fluorite, the feeding properties for fluorite flotation were also investigated. Chemical analysis results in Table 1 shows that it contains 20.12% CaF_2, 6.71% $CaCO_3$ and 40.69% SiO_2, belonging to high calcium carbonate and high silicate fluorite ore. Silicate gangue minerals can be effectively inhibited using the conventional depressant water glass. Therefore, the flotation separation of fluorite from calcite was mainly studied.

The main reagents used in this study were as follows: collector sodium oleate (NaOL), pH regulators HCl and NaOH, and depressant PASP. The chemical structure and IR spectrum of PASP are shown in Fig. 2. PASP exhibits α and β configurations in its structure, and the

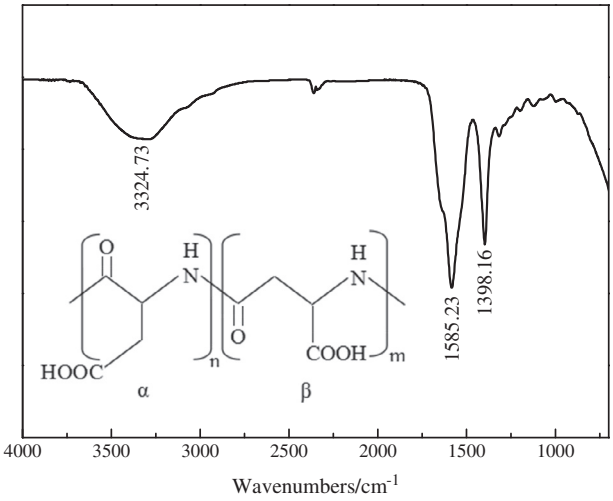

Fig. 2. Chemical structure and IR spectrum of PASP.