ELSEVIER Science Press
Available online at www.sciencedirect.com
ScienceDirect
Trans. Nonferrous Met. Soc. China 26(2016) 3253−3257
Transactions of Nonferrous Metals Society of China
www.tnmsc.cn

Effect and mechanism of octanol in cassiterite flotation using benzohydroxamic acid as collector

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Received 31 May 2016; accepted 18 October 2016

Abstract: The effect of octanol in cassiterite flotation using benzohydroxamic acid (BHA) as a collector was investigated. The adsorption mechanism of octanol and BHA on the surface of cassiterite was analyzed by adsorption experiments and infrared spectra analysis. Micro-flotation results indicated that single octanol exhibited almost no collecting power to cassiterite over a wide pH range. However, as an auxiliary collector, octanol could markedly decrease the consumption of collector BHA and keep the recovery of cassiterite in high level. The results of adsorption experiments and infrared spectra demonstrated that single octanol was not adsorbed on the surface of cassiterite. It formed adsorption connected with BHA on the surface of cassiterite, and enhanced the hydrophobicity of cassiterite. Octanol promoted the adsorption amount of BHA on the cassiterite surface, and decreased the consumption of BHA.

Key words: octanol; benzohydroxamic acid; cassiterite; flotation; mechanism

1 Introduction

Cassiterite is the primary mineral from which tin metal is extracted. The estimated resource of tin metal is about 4.9×10^6 t in the world, and 30.5% of it is in China [1]. Because of the characteristics of heavy, hard, and extremely brittle, cassiterite is preferentially concentrated by gravity separators [2−5]. However, the separation efficiency of gravity concentration drops considerably in dealing with the complex polymetallic low-grade cassiterite ore in the form of fine and ultrafine size [6,7].

The development of oxide minerals surfactants makes it possible to recover the fine and ultrafine cassiterite from gravity tailings by flotation [8−14]. SREENIVAS and MANOHAR [15] investigated the flotation and surface chemistry of cassiterite in the presence of octyl hydroxamate. During the pulp pH value from 6.2 to 9.0, octyl hydroxamate showed good flotation ability to cassiterite, and it can be adsorbed on the surface of cassiterite by the combination of physical and specific forces. WU and ZHU [16] investigated selective flotation of cassiterite from synthetic mixtures of cassiterite−quartz and cassiterite−calcite using benzohydroxamic acid (BHA). Laboratory micro-flotation studies showed that BHA floated cassiterite more efficiently than calcite and quartz with the existence of sodium hexametaphosphate. The main interaction between BHA and the surface of cassiterite was chemisorption with the formation of Sn–BHA compounds. SUN et al [17] applied BHA to the flotation of complex polymetallic low-grade cassiterite in Yunnan province of China. The concentrate was upgraded from 0.55% Sn to approximately 40% with the recovery of 65%. Analogously as BHA, salicylhydroxamic acid (SHA) showed good flotation ability to cassiterite, and it can be adsorbed on the surface of cassiterite by a formation of Sn−SHA compounds [18,19].

Although the surfactants mentioned above achieved good results on cassiterite flotation in the laboratory, BHA is most widely used as a collector in the cassiterite flotation industry at present. However, the dosage of BHA is usually more than 1 kg/t ore, which is a quite high cost for production. In this work, the influence of octanol in cassiterite flotation was investigated to reduce

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Foundation item: Project (B14034) supported by the National "111" Project of Ministry of Education of China; Project (2015CX005) supported by the Innovation Driven Plan of Central South University, China; Project supported by the 2014 Sublimation Scholar Program of Central South University, China

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DOI: 10.1016/S1003-6326(16)64458-8

the dosage of BHA. The adsorption mechanism of octanol and BHA on the surface of cassiterite was analyzed by ultraviolet spectroscopy and infrared spectroscopy measurements.

2 Experimental

2.1 Materials

The high-grade cassiterite samples used in the experiments were collected from Yunnan province, China. After being further purified by gravity concentration, the samples were ground into powders, and then analyzed by X-ray diffraction (Fig. 1) and chemical composition (Table 1). It indicated that most of the samples were pure cassiterite with the purity of SnO_2 over 95%. The samples with the particle size below 74 μm were used in micro-flotation tests and ultraviolet spectroscopy measurements, and the samples with the particle size below 5 μm were used in infrared spectroscopy measurements. The purity of the BHA used in the experiments was over 98%, and octanol was spectral pure. Analytical grade sodium hydroxide and hydrochloric acid were used for mineral pulp pH control. All the reagents were dissolved in deionized water before being used in the experiments each time.

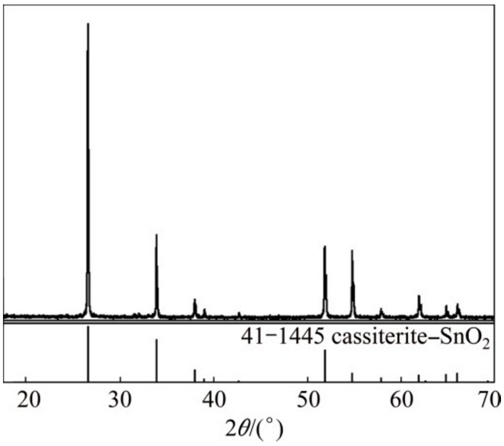

Fig. 1 XRD pattern of cassiterite samples

Table 1 Chemical composition of cassiterite samples (mass fraction, %)

SnO_2	Al_2O_3	MgO	CaO	TFe	Pb	SiO_2	Lost
95.38	0.42	0.23	0.61	0.54	0.11	1.13	1.58

2.2 Micro-flotation tests

Micro-flotation tests were carried out in a 40 mL flotation cell. The impeller speed was fixed at 1650 r/min. In each test, 3.0 g of cassiterite was dispersed in 30 mL deionized water. After adjusting the pulp pH to the desired value with a INESA PHS−3C pH meter, the flotation collector was added into the cell in the desired amount, then the pulp was mixed for 3 min in order to disperse the collector and cassiterite well. The flotation was carried out for 4 min, and the float froth and the pulp fraction were collected and dried separately. Then, each dried solid fraction was weighed and used to calculate the recovery of cassiterite.

2.3 Adsorption

The BHA solution samples at concentrations of 0.1, 0.2, 0.3 and 0.4 mmol/L were prepared for calculating the working curve. In each test, 2.0 g of cassiterite was dispersed in 30 mL BHA and BHA + octanol solution of known concentration at different pH values separately, and mixed for 20 min at 1000 r/min. Then, solid−liquid separation was carried out by centrifuging the suspension in a high speed centrifuge at 5000 r/min for 15 min. The separated liquid was adjusted to pH 7.0, and determined the concentration of BHA by a SHIMADZU UV−2600 ultraviolet-visible spectrophotometer. All experiments were performed in a temperature-controlled water bath at 298 K. The adsorption density of BHA on the surface of cassiterite was calculated by

$$\Gamma = \frac{(C_0 - C)V}{mS} \tag{1}$$

where Γ is the adsorption density of BHA on the surface of cassiterite (mol/m^2), C_0 is the initial concentration of BHA (mol/L), C is the residual concentration of BHA (mol/L), V is the volume of solution (L), m is the mass of cassiterite (g), and S is the specific surface area of cassiterite (m^2/g).

2.4 Infrared spectroscopy

The infrared spectra of samples including BHA, octanol, cassiterite, and their interaction products (cassiterite+BHA, cassiterite+octanol, and cassiterite+BHA+octanol) were tested on a SHIMADZU IRAffinity-1S Fourier transform infrared spectrometer in this experiment to characterize the nature of the interactions between the collectors and cassiterite. The interaction products were firstly prepared by contacting cassiterite samples (<5 μm) with BHA and octanol solution at pH 7.0, then washed with distilled water three times and dried at the temperature of 298 K. Infrared spectra were carried out with a KBr disk that contained 0.5% of the required sample to scan in the wave number range of 4000 to 500 cm^{-1} at a resolution of 4 cm^{-1}.

3 Results and discussion

3.1 Micro-flotation tests of cassiterite

BHA and octanol were used as collectors separately in the micro-flotation tests of cassiterite. The