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Effects of surface electrical property and solution chemistry on fine wolframite flotation

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ABSTRACT

In this paper, the effects of the surface electrical property and solution chemistry on the fine wolframite flotation were investigated by zeta potential measurement and the modified concentration logarithm diagrams. Based on that results, the flotation effects of different monominerals, including wolframite, scheelite, fluorite, calcite and quartz, were studied using different single collector, including sodium oleate, salicylaldoxime, benzohydroxamic acid and fatty-acid collector GYR. However, the wolframite recovery was low, and thus the mixed collectors were used to improve the recovery using benzohydroxamic acid as main collector and other collector as additional collector, including sodium oleate, salicylaldoxime, benzohydroxamic acid, fatty-acid collector GYR and fatty-acid collector TAB-3. The results show that the maximum recovery of wolframite exceeded 86% using GYB and TAB-3 as mixed collectors, which was up 13% compared with single GYB. These results could be explained in terms of the modified concentration logarithm diagrams in conjunction with the IEP values of different monominerals mentioned in this work. The infrared spectrogram indicated that because of different structures and properties of GYB and TAB-3, GYB could be complementary with TAB-3.

1. Introduction

At present, world's reserves of tungsten are estimated to be 3×10^6 t [1]. China, the most rich country in tungsten resources, has about 40% of the world's reserves of tungsten [2]. Most of tungsten ores, particularly wolframite and scheelite of industrial interest, occur in the deposits with very low content of WO_3 (0.1–2.5%) that is not economically viable to apply directly metallurgical methods to extract tungsten [3]. In general, tungsten ores are beneficiated by crushing-grinding to liberation size followed by flotation concentration. However, tungsten ores are brittle. They are easily over-crushed and over-ground in the crushing and grinding processes. In addition, due to the tiny dissemination particle size, fine-grinding is the key to increasing further tungsten mineral liberation degree. These result in that amounts of fine particles can be found in the crushing and grinding processes. This reason causes loss of one fifth of tungsten ore in the world. Therefore, the efficient recycling of fine particle tungsten ores will be of important significance.

Flotation is widely applied in the mining and metallurgical industry all over the world. It is often employed to separate hydrophobic particles from an aqueous suspension by introducing air bubbles [4,5]. The separation in a flotation machine is achieved through the successful occurrence of three sub-processes. They are, in sequence, the collision between the hydrophobic solid particles and the air bubbles, the attachment between the solid particles and the air bubbles, and the stable aggregate between the solid particles and the air bubbles. The schematic illustration of the flotation sub-process is given in Fig. 1, where the light green circle represents the air bubble, the thick dashed line corresponds to the liquid film encompassing the air bubble, and the small dark circle displays the solid particle [4,6,7]. Derjaguin and Dukhin suggested that the collection efficiency of solid particles is the product of three probability functions quantifying the collision, attachment, and detachment efficiencies [6,8]. Therefore, the attachment between solid particle and air bubbles in aqueous solutions is of academic and practical significance.

A few studies have been conducted for the recycling of tungsten. Some of the studies have focused on the flotation reagents, such as salicyhydroxamic acid, N-(6-(hydroxyamino)-6-oxohexyl) octanamide fatty-acid collector GYR, fatty-acid collector TAB-3, sodium oleate and benzylhydroxamic acid as collectors, sodium carbonated, sodium silicate and lead nitrate as regulators [9–14].

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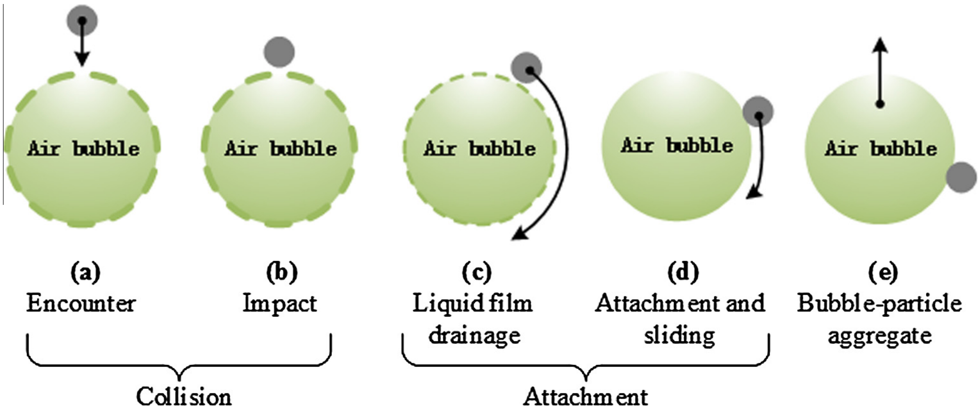

Fig. 1. Schematic representation of the flotation sub-process.

Tungsten ore with a WO_3 grade of 0.48% was floated using benzylhydroxamic acid and fatty-acid collector GYR as collectors, and scheelite concentrate with a WO_3 grade of 72.21% and wolframite concentrate with a WO_3 grade of 47.92% were obtained. The total recovery of tungsten exceeded 79.56% [15]. Zhou et al. found that a copper tailing with a WO_3 grade of 0.23% was floated using fatty-acid collector TAB-3 as collector, and tungsten concentrate with a WO_3 grade of 52.17% and a recovery of 74.25% were obtained [16]. Zhou et al. found that wolframite slime with a WO_3 grade of 0.26% was floated using salicyhydroxamic acid and the tungsten concentrate with a WO_3 grade of 38.01% and a recovery of 64.27% were obtained [17]. Lu et al. found that fine wolframite was floated using polyacrylic acid as flocculant and sodium oleate as collector and tungsten concentrate with a WO_3 grade of 68.48% was obtained. The recovery exceed 80% [18].

The present work aims to build a foundation for the efficient recovery of fine wolframite by analyzing the flotation behaviors of different monominerals. Wolframite and scheelite are the main valuable minerals, calcite, fluorite and quartz are the main gangue minerals in the tungsten ores. Zeta potential measurement infrared spectrogram and the modified concentration logarithm diagrams were used to analyze the flotation behaviors.

2. Experimental

2.1. Materials and reagents

Tungsten concentrate were obtained from Zhangyuan Tungsten Company of Jiangxi province in China. It was processed according to the flowsheet shown in Fig. 2. The monomineralic wolframite (<0.038 mm) with 97.09% purity were obtained. The chemical analysis and X-ray diffraction analysis are shown in Table 1 and Fig. 3, respectively.

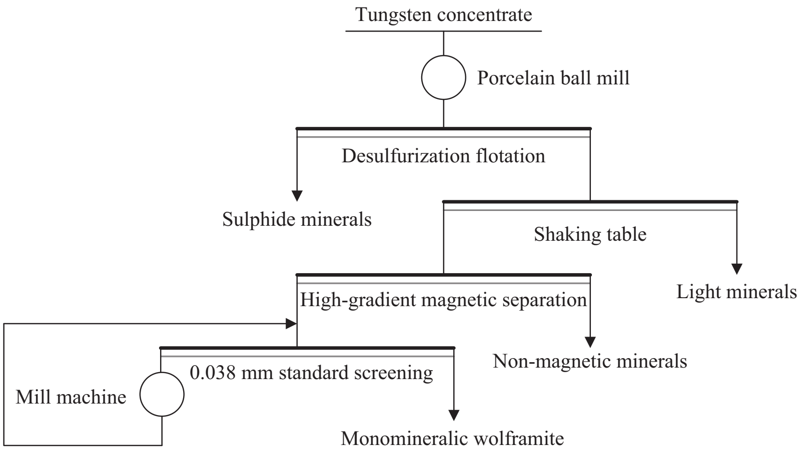

Fig. 2. The flowsheet of monomineralic wolframite preparation.

Table 1
Chemical analysis of the monomineralic wolframite, scheelite, fluorite, calcite and quartz.

Monomineralic wolframite	Composition	WO_3	Mn	Fe	SnO_2	Al_2O_3	SiO_2
	Mass, %	74.28	7.26	10.37	0.56	1.12	1.50
Monomineralic scheelite	Composition	WO_3	CaO	SiO_2	Al_2O_3		
	Mass, %	74.79	17.06	4.17	1.25		
Monomineralic fluorite	Composition	CaF_2	$CaCO_3$	SiO_2	Al_2O_3		
	Mass, %	95.68	0.58	2.02	0.23		
Monomineralic calcite	Composition	$CaCO_3$	MgO	Al_2O_3	SiO_2		
	Mass, %	99.06	0.14	0.08	0.11		
Monomineralic quartz	Composition	SiO_2	CaO	MgO	Al_2O_3		
	Mass, %	99.15	0.13	0.03	0.062		