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Short communication

Utilization of benzyl aminopropyl dimethoxymethylsilane as collector for the reverse flotation of silicate minerals from magnetite

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ABSTRACT

In this paper, a collector benzyl aminopropyl dimethoxymethylsilane (BADM) was utilized for the reverse flotation of silicate minerals from magnetite. The micro-flotation results showed that good floatability of quartz, garnet, olivine and magnetite was obtained at pH 8 in the presence of BADM. However, the depressant, soluble starch, showed a selective depression for magnetite. Separation of the three silicate minerals from magnetite was performed by mixed- mineral flotation experiments with the soluble starch as depressant and BADM as collector. In order to probe the validity of these findings, zeta potentials were measured and the results showed that conditioning of the silicates with soluble starch prior to BADM did not prevent the adsorption of BADM while the adsorption on the magnetite surfaces was decreased.

1. Introduction

China is far behind western countries given that only 5% of its iron ores have a grade over 50%, and the average Fe grade is around 33%. These low-grade iron ores need to be enriched before smelting (Liu et al., 2011). Therefore, the processing of poor, fine, and mixed ores has become an important issue that must be solved using technological advancements (Yan et al., 2014). Researchers and engineers must exploit the full value of ore resources, improve the utilization ratio of valuable minerals, increase the production of mine, and alleviate the pressure from importation to ensure steady and healthy development of the steel industry (Wu et al., 2016).

Flotation is one of the most important and versatile mineral-processing techniques. In a direct flotation process, a value-bearing mineral is usually transferred to the froth and gangue minerals are left in the pulp or tailings (Liu et al., 2018a; 2018b; Zhang et al., 2017a; Yu et al., 2016). By contrast, in a reverse flotation process, the gangue minerals are reported into the float fraction while the valuable mineral is collected in the tailings. A long-term experimental study showed that reverse flotation embraces more technical advantages than direct flotation and is crucial to upgrading iron ores (Zhang et al., 2017b). Magnetite usually coexists with more than two types of Si-bearing minerals in its ore deposits. The commonly used amine cationic collector for removing silicate minerals from magnetite is dodecylamine when the mineral dissemination is complex (Mowla et al., 2008). However, it is difficult to separate silicate minerals from magnetite due to the high reactivity and low selectivity of dodecylamine, hence the separation is still an important problem.

Flotation reagents are critical in the flotation separation process. To achieve excellent separation performance for minerals, many investigations indicated that the additional polar groups -O-$(CH_2)_3$ on the amine structure could promote collector adsorption at the liquid-gas interface, thereby decreasing the interface surface tension and increasing the elasticity of the thin films around the bubbles (Liu et al., 2016; Araujo et al., 2005). Recently, the research on novel flotation reagents for reverse flotation desilication (flotation of aluminosilicates and depression of diaspore) has been soaring in China. Guan synthesized a novel cationic surfactant BADM which had little influence on aluminosilicates floatability while inhibited diaspore when using starch as a depressant at around pH 8. Thus, according to this interaction mechanism, the cationic surfactant BADM could also be used as a potential collector for the separation of silicate minerals from magnetite. Three silicate minerals (quartz, olivine and garnet) were selected in this work. Control studies using dodecylamine were also performed to evaluate the superiority of the BADM. This was accomplished by the use of micro-flotation and zeta-potential tests.

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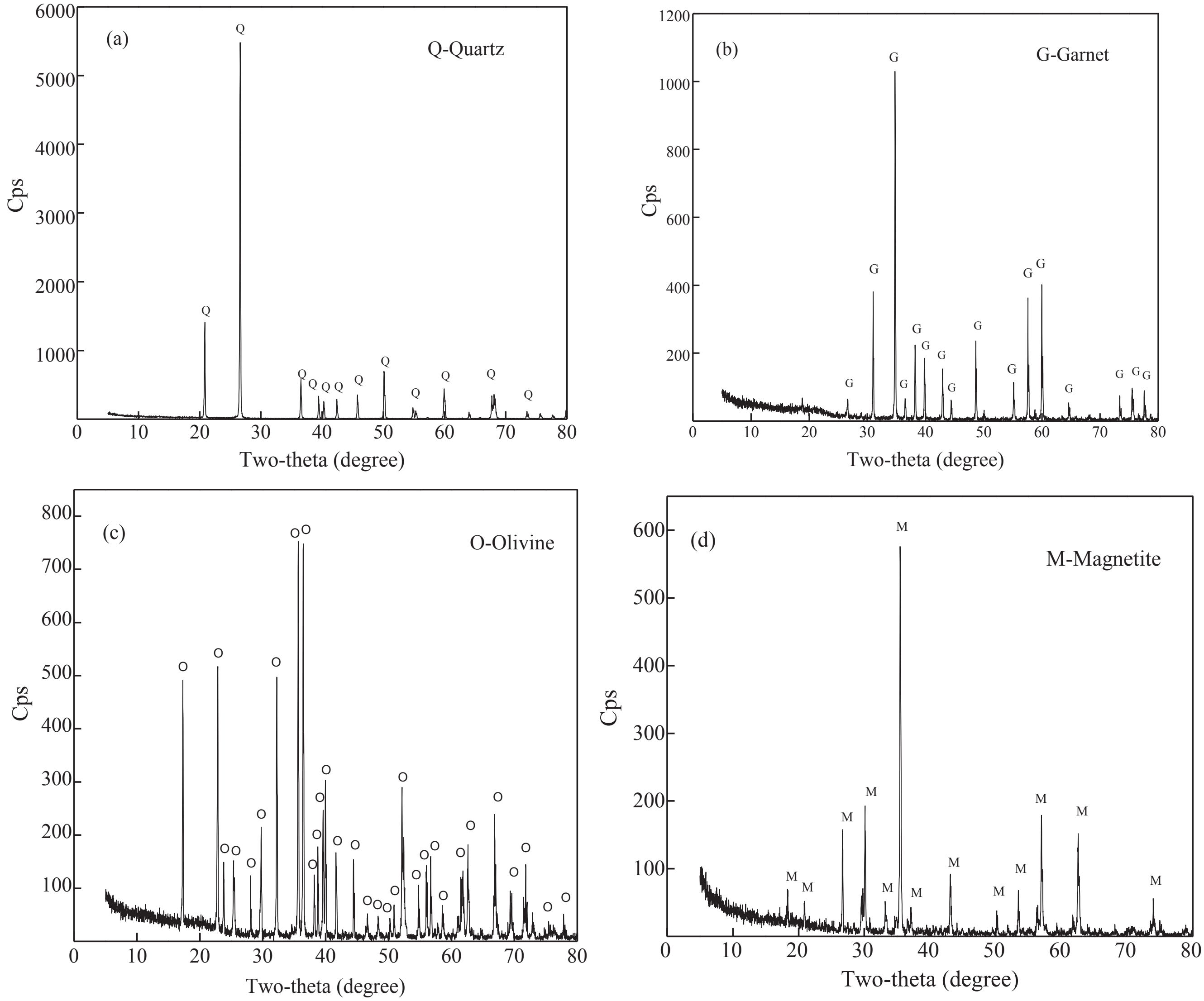
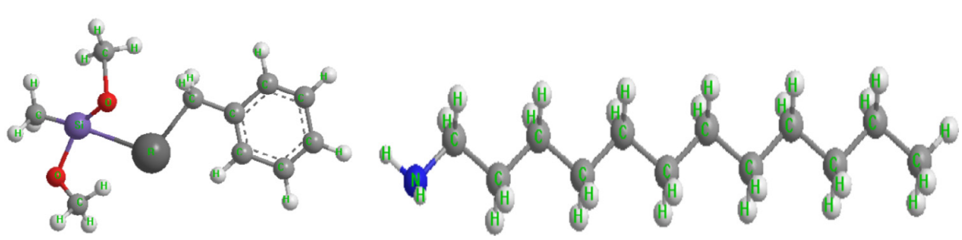


Fig. 1. X-ray diffraction pattern of the four mineral samples.



(a) BADM (b) Dodecylamine

Fig. 2. Molecular structure of BADM and dodecylamine.

2. Experimental

2.1. Materials and reagents

The magnetite and quartz samples were obtained from Zhenzhou, Henan province, China. Olivine and garnet were acquired from Donghai, Jiangsu province, China. The crystals of sample were crushed manually and handpicked and then dry ground and screened. The −74 + 37 μm fraction was used for flotation, the −37 μm fraction was further ground to −5 μm for zeta potential tests. The purity of the talc was confirmed by X-ray diffraction (XRD) analysis and the results are presented in Fig. 1. It can be observed from Fig. 1 that these four samples purity are over 95%, hence, the mineral samples were used for the experiments.

Benzyl aminopropyl dimethoxymethylsilane (BADM) with 90% purity was used as the collector, which was synthesized at the School of Chemical Engineering, Central South University. Anhydrous ethanol was used as solvent and nitrogen as protective gas. Benzyl chloride and aminoethyl aminopropyl dimethoxymethylsilane were used as raw materials (molar ratio of 1.25: 1). Benzyl chloride was gradually drop wise added at under 40 °C atmosphere and the reaction was performed at 90 °C for 8 h. Anhydrous ethanol was removed by rotary evaporation