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Use of polyethylene oxide to improve flotation of fine molybdenite

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ABSTRACT

Flotation tests using different size fractions of molybdenite with 50 ppm of Diesel oil and 25 ppm of MIBC, carried out in 0.01 M NaCl solutions and seawater, showed much lower floatability of the −10 µm size fraction. The flotation of this finest size fraction was very much improved with the use of polyethylene oxide (PEO). The tests revealed that the improvement resulted from aggregation of fine molybdenite particles by Diesel oil-PEO emulsion. The flotation in seawater was good only in the pH range from 7 to 9 and it was strongly depressed around pH 10–11. While addition of PEO could improve flotation in the good flotation range over pH 7–9, it was not efficient in the depression range caused by precipitating magnesium hydroxy-complexes/magnesium hydroxide.

1. Introduction

Much of the losses in mineral processing operations may be attributed to the fine size of mineral particles. A very low efficiency of capturing fine particles by bubbles results from unfavourable hydrodynamic conditions. The best means of extending froth flotation to lower size ranges is by the use of techniques that permit aggregation of fines. However, since these aggregates are to be recovered by flotation they must be – at least to some extent – hydrophobic.

Particle size enlargement is a common process employed in solid/liquid separation unit operations such as settling and filtration. Efficiency of these processes is improved with the use of flocculants, water-soluble polymers. However, the use of flocculants in flotation circuits in most cases is impossible since common flocculants are not selective, are very hydrophilic, and thus the flocs they produce are hydrophilic, too (Laskowski and Lopez-Valdivieso, 2004; Castro and Laskowski, 2015).

The list of commercial flocculants includes many polymers, varying in molecular weight, anionic and cationic, and also non-ionic. The last group also contains polyehylene oxide (PEO), $(-CH_2CH_2O-)_n$. A fundamental study of the adsorption-flocculation reaction of PEO with silicas of different hydrophilic-hydrophobic properties was carried out by Rubio and Kitchener (Rubio and Kitchener, 1976, 1977; Rubio, 1981). They found that strongly hydrophilic minerals, such as malachite, tenorite, cuprite, chrysocolla, rutile, quartz, calcite and dolomite were unaffected, while graphite and talc, and also chalcopyrite and covellite, were strongly flocculated. The hydrophilic minerals could be flocculated by PEO if previously rendered hydrophobic with the use of flotation collectors. These conclusions were further supported by Gochin et al. (1985) who showed that while coal (anthracite) was strongly flocculated by PEO (over the pH range 2–10) the same coal when oxidized was not flocculated under any conditions. Laskowski and Yu (1998) further confirmed that while a common polyacrylamide flocculated all coal suspensions irrespective of coal surface properties, PEO flocculated only hydrophobic coal suspensions and was not efficient in flocculating low rank or oxidized coal samples.

One of the promising techniques to handle beneficiation of very fine particles is so-called floc-flotation (also known as agglomerate flotation). The process involves selective aggregation/flocculation of the flotation feed and the recovery of the flocs by froth flotation. Both sub-processes determine the efficiency of the separation: the flocculation must be selective and the produced flocs, in order to be recoverable by flotation, must be to some extent hydrophobic. Soto and Barbery (1988) showed that flotation of fine talc could be improved with the use of PEO and the floc-flotation process in a column. Peng et al. (2016) showed how to improve flotation of bituminous coal by flocculation of fine coal with the use of PEO and hexametaphosphate to disperse clays.

It is known that molybdenite flotation is depressed by common flocculants (e.g. polyacrylamides) (Castro and Laskowski, 2015). But since molybdenite belongs to the same group of inherently hydrophobic minerals as talc and graphite, we selected PEO to test whether flotation

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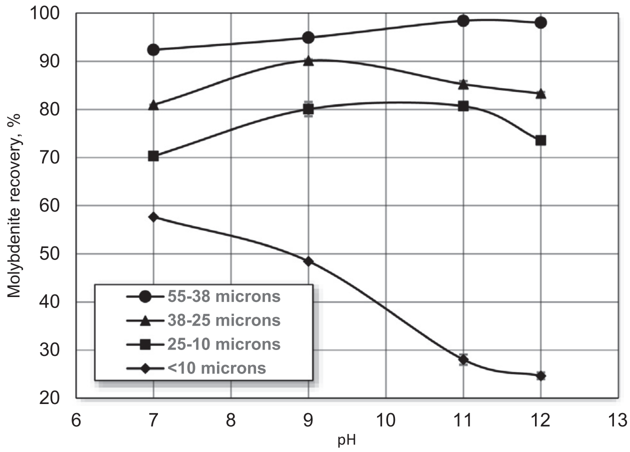

Fig. 1. Effect of pH on flotation of molybdenite particles varying in size. The tests were carried out in 0.01 M NaCl solutions at 50 ppm of Diesel oil and 25 ppm of MIBC.

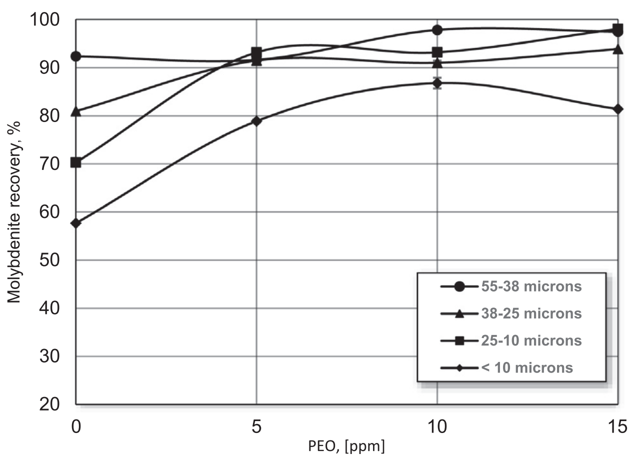

Fig. 2. Effect of PEO on flotation of various size fractions of molybdenite in 0.01 M NaCl solutions at pH of 7. The tests were carried out at 50 ppm of Diesel oil and 25 ppm of MIBC.

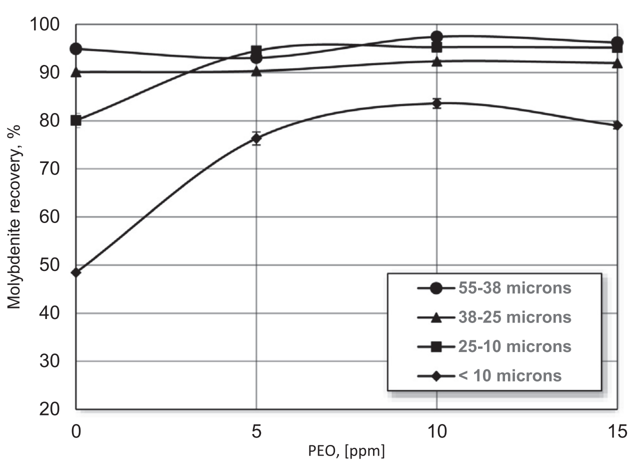

Fig. 3. Effect of PEO on flotation of various size fractions of molybdenite in 0.01 M NaCl solutions at pH of 9. The tests were carried out at 50 ppm of Diesel oil and 25 ppm of MIBC.

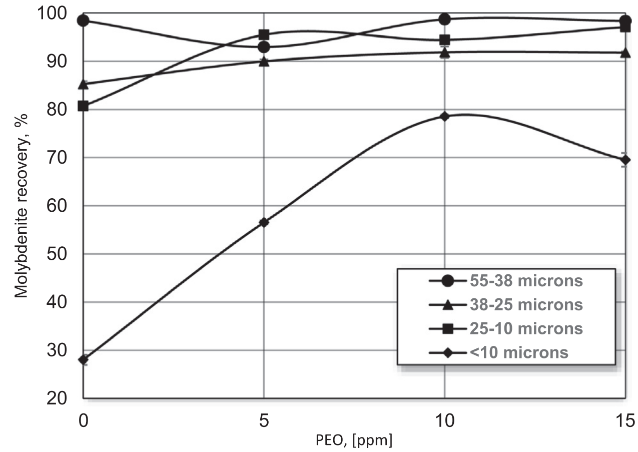

Fig. 4. Effect of PEO on flotation of various size fractions of molybdenite in 0.01 M NaCl solutions at pH of 11. The tests were carried out at 50 ppm of Diesel oil and 25 ppm pf MIBC.

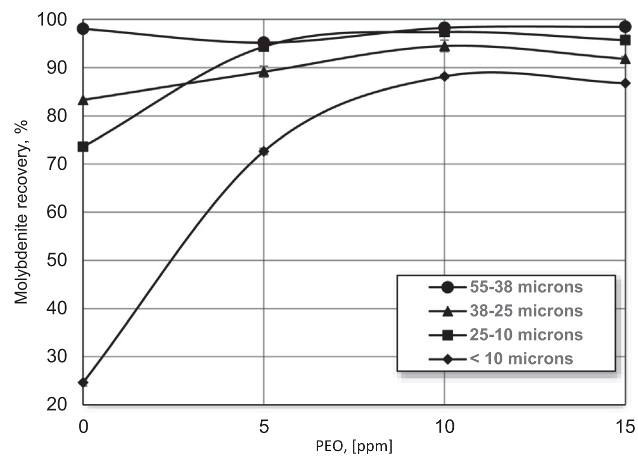

Fig. 5. Effect of PEO on flotation of various size fractions of molybdenite in 0.01 M NaCl solutions at pH of 12. The tests were carried out at 50 ppm of Diesel oil and 25 ppm of MIBC.

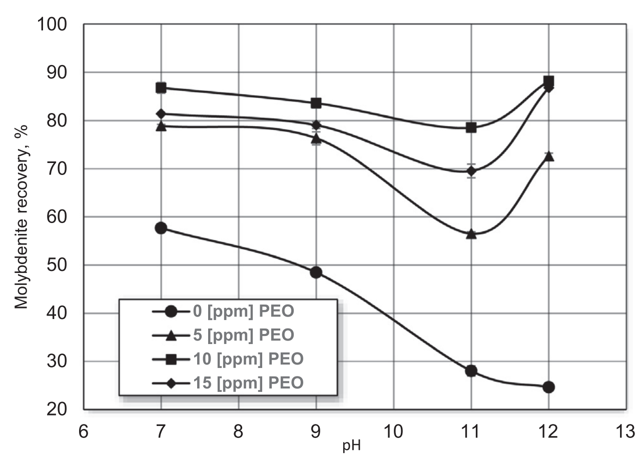

Fig. 6. Effect of pH on flotation of $-10\,\mu m$ size fraction of molybdenite in 0.01 M NaCl solutions at various concentrations of PEO. The tests were carried out at 50 ppm of Diesel oil and 25 ppm of MIBC.

of fine molybdenite could be improved with this agent. It is to be pointed out that Song et al. (2012) reported that the flotation of fine molybdenite could be substantially improved by aggregation of such particles with emulsified kerosene.

2. Materials and methods

Micro-flotation tests were carried out in a 225 cm^3 Patridge and Smith glass cell using nitrogen at a flowrate of 80 cm^3/min. The