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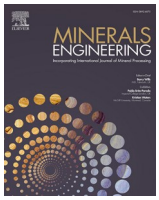

Separation of chalcopyrite from a siliceous copper ore using polyethylene oxide as a depressant: An experimental study complimented by theoretical investigation

Mweene Levie, Hyun-Su Park, Seungmin Kang, Hyunjung Kim *

Department of Earth Resources and Environmental Engineering, Hanyang University, 222 Wangsimni-ro, Seongdong-gu, Seoul 04763, Republic of Korea

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ABSTRACT

The separation of quartz and chalcopyrite during flotation in the presence of polyethylene oxide was investigated experimentally and theoretically. It was observed that the polymer adsorbs onto chalcopyrite more than onto quartz especially in high alkaline environment and this was confirmed theoretically. FTIR results of chalcopyrite-polymer system due to complexation were unveiled theoretically using quantum theory of atoms in molecules to consist of conventional hydrogen bonding with other non-covalent bonds and partially covalent interaction, while quartz-polyethylene complex was revealed to be due to conventional hydrogen bonding only. Therefore, flotation tests were performed on a mimicked siliceous-chalcopyrite synthetic mixture for Mpanda Mineral Field from Tanzania using polyethylene oxide as a chalcopyrite depressant. Flotation tests of quartz and chalcopyrite using 60 g/t of octadecan-1-amine and potassium amyl xanthate, respectively at 100 g/t and 500 g/t of polyethylene oxide at pH 10.5 ± 0.1, yielded Cu grades of 14.7% and 16.7% with recoveries of 70.7% and 75.0%. Therefore, polyethylene oxide could be a potential chalcopyrite depressant.

1. Introduction

With the depletion of high-grade ores coupled with an increase in the global demand of Cu (Northey et al., 2014), researchers have turned their attention to the separation of chalcopyrite, the most abundant copper sulfide mineral, from lean grade ores (Ruth, 1995; Wang, 2005). However, due to the friability of siliceous ores such as Mpanda Mineral Field ore from southwest Tanzania, East Africa, the inevitable comminution of such ores leads to the generation of a large fraction of silica fines (Mweene and Subramanian, 2018, 2019). Apart from promoting the high reagent consumption along with low Cu grades and recoveries (Jena et al., 2019), siliceous concentrates when subjected to leaching lead to the production of colloidal silica that facilitates poor flocculation leading to settling challenges in the thickener. Furthermore, colloidal silica is also known to negatively impact the solvent extraction process by increasing the period for phase disengagement, poor extraction kinetics, unwanted flipping continuity as well as simultaneous increase in crude generation and solvent losses (Boskovic et al., 2018), thereby making Cu cathode production process costly. Therefore, in order to mitigate the aforementioned fine challenge, one of the strategies that some researchers have suggested is to increase the particle size of the particles via the usage of flocculants (Jain et al., 2013; Ng et al., 2015). Different flocculants adsorb on the minerals differently due to the existence of different mineral surface species per mineral promoting different degree of interaction with the flocculant functional groups (Gong et al., 2010; Li et al., 2021; Somasundaran, 1980). For instance, Rubio and Kitchener carried out investigations on the flocculation of hydrophobic, precipitated and heated silica and reported that polyethylene oxide adsorbs more onto hydrophobic silica compared onto the rest (Rubio and Kitchener, 1976b). Further, other authors have reported on the utilization of polyethylene oxide as a hydrophobic mineral depressant (Castro and Laskowski, 2015). Furthermore, Mathur and co-researchers reported that during complexation with the mineral, the ether oxygen for polyethylene oxide is involved in acting as an electron donor (Mathur and Moudgil, 1997) resulting into hydrogen bonding, thereby facilitating flocculation. However, Kim and co-authors (Kim et al., 2022) also reported that ethylene oxide, the polymer monomer, can act both as a hydrogen acceptor and donor. Nonetheless, although the aforementioned researchers reported on the flocculation of silica by polyethylene oxide, literature on the floc-flotation of a siliceous ores such as Mpanda Mineral Field ore is lacking. Furthermore, detailed investigations on the mode of interaction of polyethylene oxide with other

* Corresponding author.
E-mail address: kshjkim@hanyang.ac.kr (H. Kim).

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Highlights

- Adsorption of polyethylene oxide onto chalcopyrite was more than onto quartz.
- Chalcopyrite-polymer bond is non-covalent, partially covalent and hydrogen bonding.
- Quartz-polymer bond is hydrogen bond attesting to lower polymer interaction.
- Polyethylene oxide had a significantly positive influence on the grade and recovery of Cu.
- Polyethylene oxide could be used as a chalcopyrite depressant in siliceous ores.