



# Flotation separation of chalcopyrite using acacia gum as a novel fine quartz depressant

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## ABSTRACT

Recently, global carbon neutrality policies driven by climate change have heightened the demand for environmentally sustainable processes across various industries. This trend extends to the field of mineral processing, where the exploration of eco-friendly reagents, particularly for flotation processes, has emerged as a critical research focus. In this context, the present study aims to investigate, both experimentally and theoretically, the feasibility of using acacia gum (AG) as a depressant during the beneficiation of chalcopyrite from a synthetic siliceous low-grade copper ore. A higher AG adsorption onto chalcopyrite relative to quartz containing Zn (quartz-Zn) was noticed to decrease with increase in pH. Further, theoretical studies performed indicated that the complexation energies for chalcopyrite-AG and quartz-Zn-AG complexes were  $-346$  kJ/mol and  $-272.6$  kJ/mol and this is in tandem with the adsorption results. Additionally, the mineral-AG complexation resulted from partial covalent, conventional hydrogen bonding and other non-covalent interactions. Flotation studies conducted on chalcopyrite-quartz mixture with the weight ratio of 1:24 mimicking Mpanda Mineral Field siliceous ore, at pH 8.5 yielded Cu grade, recovery, separation efficiency and enrichment ratio of 24.7 %, 93.3 %, 92.3 % and 24.0, respectively, in presence of Zn, AG, potassium amyl xanthate, methyl isobutyl carbinol of 80 g/t, 200 g/t, 60 g/t and 25 g/t. The adsorption of AG onto activated quartz attests that the polysaccharide is a potential depressant for quartz in presence of Zn in siliceous ores.

## 1. Introduction

Owing to the increase in the global applications of copper (Elshkaki et al., 2016; Li et al., 2023; Phiri et al., 2022) and the presence of high proportion of lean grade siliceous copper ores globally (Phiri et al., 2022; Northey et al., 2014), research on the enrichment of copper has gained relevance. Flotation, a process that exploits the differences in the surface chemistry of the minerals sometimes promoted by reagents, is the main process used to upgrade minerals (Wang et al., 2024; Feng et al., 2024; Shen et al., 2025; Mweene and Khanal, 2025; Filippov et al., 2019; Park et al., 2015). Prior to flotation, the ore is subjected to comminution. However, the comminution of siliceous copper ores, such as Mpanda Mineral Field ore, results into the liberation of chalcopyrite coupled with the generation of a large proportion of silica fines that pose many challenges in flotation (Mweene and Subramanian, 2019; Mweene et al., 2024; Mweene and Subramanian, 2018; Levie et al., 2023). Fines have been reported to cause a reduction on the grade and recovery of valuable minerals (Liu and Peng, 2022) and a decrease in the collector

adsorption owing to their coverage of the valuable mineral surface (Eskanolou et al., 2022; Jeldres et al., 2019). To mitigate such challenges with a view to utilizing benign reagents, earlier workers proposed the usage of polyethylene oxide as a depressant for silica fines (Mweene et al., 2024). Further, Wang et al. proposed the utilization of Ca ions in the presence of an anionic polymer, sodium alginate, to depress quartz (Wang et al., 2021), while other workers reported on the utilization of starch as a depressant for quartz containing calcite particles (Deng et al., 2019). In addition, Wang et al. conducted tests on the depression of quartz in the presence of Ca ions and citric acid (Wang et al., 2019). Ejtemaei et al., (Ejtemaei et al., 2012) performed tests on the effect of Pb and Zn ions on the depression of quartz in the presence of carboxymethyl cellulose respectively, and indicated that the metal-quartz-polymer interaction was governed by electrostatic forces. Zhao et al., investigated the depression of activated quartz (Zn-quartz) in the presence of sodium polyaspartate (Zhao et al., 2022). Therefore, hitherto, only sodium alginate, carboxymethyl cellulose, starch, and sodium polyaspartate have been reported to be used as depressants for activated

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