



Research Article

Mitigation strategies of salicylhydroxamic acid collector with oxalic acid in goethite flotation

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ABSTRACT

Flotation of goethite, a representative mineral of laterite ore, which is essential source of nickel used in secondary batteries, was conducted using salicylhydroxamic acid as the collector. The presence of ferric ions derived from goethite in the pulp resulted in an increased consumption of the collector during flotation. Following three washing stages, the maximum recovery of 98.5 wt% was achieved with a collector dosage of only 60 % in the absence of a washing stage. The oxalic acid is employed to eliminate ferric ions via precipitation without the requirement for supplementary water, energy, and time-consuming washing stages. The utilization of 40 g·t⁻¹ of oxalic acid yielded comparable recovery outcomes to those observed in the three washing stages. Furthermore, theoretical investigations were conducted to determine the collector species influencing goethite flotation with density functional theory. It was observed that compared with that of goethite with non-ionized salicylhydroxamic acid complex, the complexation energy for goethite with ionized salicylhydroxamic acid was lower by 113.9 kJ·mol⁻¹, indicating that the optimum adsorption onto the mineral surface strongly depends on ionized salicylhydroxamic acid species. This study presents a potential method for reduction of reagent consumption in the flotation of future complex laterite ore, an acidic soil in which metal ions might be present. Additionally, the theoretical framework elucidates the complexation of collectors to minerals that are challenging to quantify experimentally.

1. Introduction

Widespread and ubiquitous, goethite (α -FeOOH) (GT) is a secondary mineral that derives from the primary iron-minerals (e.g. magnetite, hematite, and pyrite) under oxidizing conditions. Most GT is dominant in the limonite zone of laterite soil, which were formed by weathering in wet tropical regions [1]. GT is an iron ore bearing 1–1.6 wt% nickel. As the demand for stainless steel and lithium-ion batteries increases [2], the demand for the key element nickel is also growing. Therefore, it is necessary to develop not only nickel sulfide minerals but also laterite, a nickel oxide mineral. Nickel from limonitic ores is commonly recovered through hydrometallurgical process such as high pressure acid leaching (HPAL) [3,4] or often processed through a pyrometallurgical process to produce pig iron [5,6]. However, both processes are not environmentally friendly and are energy intensive, and to overcome negative aspects, some researchers have attempted to enrichment of nickel through beneficiation (e.g. flotation, magnetic separation, and gravity separation) [7].

In particular, the enrichment of nickel using flotation is a challenging study due to the complex mineralogy and the presence of nickel as fine particles. In flotation using an amine collector, the nickel content increased from only 1 wt% to 1.4 wt% [8]. Another flotation study using commercial collector, Aero 6493 (cytec), no or minor upgrading of nickel content was observed in limonite samples [9]. There is still a need to study limonitic laterite by flotation. Therefore, basic research on single minerals such as GT, which is the dominant Ni-bearing mineral in limonite, is required.

Oxidized minerals may contain other metal ions in addition to the target mineral [10]. Laterite soil is acidic soil that is low in potassium, lime, phosphorus, and nitrogen, with a pH 4–5 and a low base-exchange capacity [11]. Acidic ground water can dissolve soluble minerals to form solutions containing ions such as iron, nickel, and magnesium [12]. Furthermore, laterite soils with a high moisture content (ca. 20–30 wt%) [13,14] may contain a variety of ions in dissolved form. The presence of ions in solution can affect the results of flotation by adsorption on the surface of minerals or interaction with reagents such as collector.

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Highlights

- The Recovery of goethite is 98.7% at pH 8.3 with salicylhydroxamic acid as a collector.
- The removal of metal ions in the pulp reduce collector consumption.
- Oxalic acid is a potential ferric species cleaner in the pulp.
- Ionized salicylhydroxamic acid is the principal driver of goethite flotation.



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