

Mathematical Modelling Of Chalcopyrite Heap Leaching Chemical Kinetics In The Presence Of Ethylene Thiourea

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Extended Abstract

The growing demand for copper has driven advancements in mining and processing, making lower-grade ores viable for heap leaching. While pyrometallurgical methods dominate high-grade sulfide ore processing, challenges such as declining grades and rising costs have increased interest in hydrometallurgical alternatives. Chalcopyrite leaching at ambient conditions is limited by a passivation layer, prompting research into solutions such as using catalysts [1], [2] or additives such as silver, iodine, and activated carbon [3]. Among these, organosulfur compounds have shown promise in enhancing leaching kinetics [4].

This study investigates the impact of ethylene thiourea (ETu) on chalcopyrite leaching in sulfuric acid-ferric sulfate solutions focusing on the kinetics of chalcopyrite leaching relevant to industrial heap leaching. While chalcopyrite leaching and bioleaching have been widely studied, very little work has focused on the use of ETu and the kinetics governing the process. These studies have been mostly focused on kinetics of fine ores [5] and pure or synthetic crystals at laboratory scale. The kinetic data obtained from fine ores cannot be fully trusted for leaching and bioleaching of crushed ores. The overall objective of this project is to develop a kinetic model to predict copper extraction as a function of the leaching and bioleaching process variables for crushed low-grade ores using ETu as a catalyst within a sulfuric acid + ferric sulfate system.

Sample Properties and Experimental Setup

A 0.5 kg chalcopyrite ore sample ($P_{80} = 2.53$ mm, 0.48% Cu) from the Quebrada Blanca mine was loaded into a PVC leaching column (10 cm diameter, 19 cm height). X-ray diffraction (XRD) confirmed that chalcopyrite was the sole copper-bearing phase. The leaching solution was circulated upward through the column with a peristaltic pump. To maintain the ETu concentration, a dosing pump added a stock ETu solution at regular intervals. For chemical leaching, potassium permanganate was used to maintain the oxidation-reduction potential (ORP). In bioleaching tests, bacteria were inoculated into the main lixiviant bucket.

Experimental Design

The chemical kinetics of chalcopyrite leaching was investigated through leaching and bioleaching experiments. The impact of ETu concentration and ferric-to-ferrous ratio (solution potential) and pH was explored using the classic method (one factor at a time). Kinetic modeling was performed to elucidate the effects of each parameter on dissolution rates and mechanisms. Bioleaching tests were conducted under optimized chemical leaching conditions to assess the role of bacteria.

Preliminary results

Leaching with 100 ppm and 200 ppm of ETu achieved 31.13% and 31.04% of copper extraction after 60 days, respectively. From these results, it would appear as if all the liberated copper had been leached and that the copper leaching rate is controlled by factors other than ETu concentration once the concentration exceeds about 100 ppm. The experiment maintained at 20 ppm ETu showed a slower increase in Cu recovery and reached 30.91% Cu extraction after 108 days. The control test only leached 7.73% in 57 days, which shows the beneficial effect of using ETu as a catalyst in chalcopyrite leaching. In bioleaching tests, copper extraction initially lagged behind chemical leaching due to the bacterial lag phase. However, as bacteria adapted and began increasing the ORP, the final copper extraction approached levels similar to those achieved through chemical leaching, demonstrating the potential of bioleaching under optimized conditions.

References

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