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Chalcopyrite Leaching Kinetics in the Presence of Methanol

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Abstract:

The dissolution of chalcopyrite under near ambient conditions represents one of the main challenges in the copper industry. Thus, various routes have been proposed for chalcopyrite treatment, such as the use of polar organic solvents, and this has shown promising results. In this paper, we present a study of copper leaching from a chalcopyrite concentrate in aqueous acidic medium with methanol and various H₂O₂ concentrations at 15, 30, and 40 °C. The results show that nearly complete copper extraction was attained within 5 h at 40 °C. The extraction percentages were plotted as functions of time at each temperature. The experimental data were modeled using the shrinking core model considering the cylindrical particle shape (shrinking cylinder model) within acceptable confidence levels, yielding an estimated activation energy of 24.3 kJ/mol. Furthermore, the process was dependent on the H₂O₂ concentration, and it acts as a reagent rather than an oxidant in the leaching reaction. It was found that sulfur is the only species present in the solid phase formed during the leaching of chalcopyrite, demonstrating the co-dissolution of both copper and iron.

Keywords: leaching, chalcopyrite, methanol, hydrogen peroxide, shrinking core model

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1 Introduction

In recent years, the amount of ore with high copper content has declined dramatically because of the over-exploitation of natural mineral sources (Feng et al. 2012). Thus, efficient processes must be developed for the treatment of low-grade copper ores to yield metallic copper. Approximately 70 % of the global copper reserves are found as chalcopyrite (CuFeS₂) (Dakubo, Baygents, and Farrell 2012).

Chalcopyrite is one of the most difficult mineral phases to dissolve in any liquid medium. The difficulty in dissolving chalcopyrite arises because of the formation of a passivating layer on the CuFeS₂ surface (Nazari and Asselin 2009). Studies have shown that extreme pressures and temperatures (pressurized leaching) or long treatment times (bioleaching) are necessary to extract copper from ores that contain the CuFeS₂ phase (Nazari, Dixon, and Dreisinger 2011; Majuste et al. 2012; Padilla, Rodriguez, and Ruiz 2003).

Various authors (Gahremaninezhad, Dixon, and Asselin 2012; Nava and González 2006; Nava et al. 2008; Arce and González 2002) have concluded that the solution potential is the most important variable in the dissolution of chalcopyrite. Furthermore, there is a potential zone, below that of passivation, where the copper extraction increases dramatically with the solution potential (Gericke, Govender, and Pinches 2010). This behavior has been attributed to an alternative mechanism that operates below the critical potential (passivation potential) (Cordoba et al. 2008; Kametani and Aoki 1985). However, the known electrochemistry of this system does not explain the chalcopyrite solubility satisfactorily because most studies have focused on the transformation of chalcopyrite in stages to species such as covellite, chalcocite, and bornite.

To achieve the required potentials, various oxidizing agents have been proposed. Aydogan, Ucar, and Canbazoglu (2006) performed chalcopyrite leaching tests using potassium dichromate as an oxidizing agent and obtained copper extraction rates of more than 80 %. The authors analyzed the data using the shrinking core model and concluded that the process is controlled by diffusion, having an activation energy of 24 kJ/mol.

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