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Bioleaching of chalcopyrite by moderately thermophilic microorganisms

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HIGHLIGHTS

- Leaching results showed the existence of an optimum pH in leaching of chalcopyrite.
- There was clear benefit in leaching chalcopyrite within the low solution potential.
- Maintenance of an appropriate concentration of total dissolved iron was necessary.
- Chalcopyrite was reduced to a series of intermediate products at the low potential.
- The reduction of chalcopyrite to talnakhite and/or bornite is the rate-limiting step.

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ABSTRACT

The leaching of chalcopyrite by moderately thermophilic microorganisms was investigated by employing cyclic voltammetry (CV), accompanying with the leaching behavior elucidation. Leaching experiment showed that there was clear benefit in leaching chalcopyrite within the low solution potential (below 400 mV vs. SCE), compared to the high potential leach (above 550 mV vs. SCE). Simultaneous maintenance of an appropriate concentration of total dissolved iron was necessary and also beneficial to leach chalcopyrite. The leaching results showed the existence of an optimum pH in the leaching of chalcopyrite by the moderately thermophilic microorganisms. The analysis of CV results revealed that the chalcopyrite was reduced to a series of intermediate products (such as talnakhite, bornite and chalcocite) in the cathodic, and then the intermediate product (chalcocite) was oxidized in the anodic.

1. Introduction

Bioleaching low-grade copper ores with microbes offers attractive alternative methods to conventional leaching methods which has been successfully applied for leaching secondary copper sulfides (such as bornite, chalcocite and covellite) in many countries. However, the chalcopyrite ($CuFeS_2$) is recalcitrant to both chemical and biological leaching, due to the passivation of the mineral surface by sulfur (Hackl et al., 1995; Harmer et al., 2006; Klauber et al., 2001) and/or ferric iron compounds, such as jarosite (He et al., 2009; Kinnunen et al., 2006; Parker et al., 2003; Sandström et al., 2005; Xia et al., 2010; Zhu et al., 2011).

In addition, chalcopyrite leaching may involve the formation of iron deficient secondary minerals and intermediates (Sasaki et al., 2009). It is reported that chalcocite and/or covellite might be formed during the leaching process (He et al., 2009; Hiroyoshi et al., 2001; Sandström et al., 2005; Sasaki et al., 2009; Xia et al., 2010; Zhu et al., 2011).

As many researchers reported, the passivation layer and the intermediate compounds would vary at different conditions (pH, Eh, etc.) (Dutrizac, 2008; Sandström et al., 2005; Todd et al., 2003; Vilcáez et al., 2008; Vilcáez et al., 2009). In order to find out the optimum pH conditions for chalcopyrite bioleaching by moderately thermophilic bacteria *Sulfobacillus thermosulfidooxidans* and archaea *Ferroplasma* sp., taking the minimization of passivation effect as well as maximization of the extraction percentage of chalcopyrite into consideration, the surface speciation of chalcopyrite during the leaching process under different pH conditions along with *S. thermosulfidooxidans* and *Ferroplasma* sp. were investigated in this paper.

2. Methods

2.1. Chalcopyrite and copper-bearing sulfide ore

The high grade chalcopyrite used in the test was obtained from Meizhou, Guangdong Province, China. The chemical analysis of the

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