Minerals Engineering 34 (2012) 11–18

Contents lists available at SciVerse ScienceDirect

Minerals Engineering

journal homepage: www.elsevier.com/locate/mineng

Catalytic effect of pyrite on the leaching of chalcopyrite concentrates in chemical, biological and electrobiochemical systems

Ali Ahmadi [a,d,*], Mohammad Ranjbar [b], Mahin Schaffie [c]

[a] Department of Mining Engineering, Isfahan University of Technology, Isfahan 84156-83111, Iran
[b] Department of Mining Engineering, Shahid Bahonar University of Kerman, Kerman, Iran
[c] Department of Chemical Engineering, Shahid Bahonar University of Kerman, Kerman, Iran
[d] Mineral Bioprocessing Research Group (MBRG), Biotechnology and Bioengineering Research Institute, Isfahan University of Technology, Isfahan 84156-83111, Iran

ARTICLE INFO

Article history:
Received 28 November 2011
Accepted 22 March 2012

Keywords:
Electro-bioleaching
Galvanic interactions
Chalcopyrite
Pyrite
Moderate thermophiles

ABSTRACT

The main objective of this research was to evaluate the potential of electrochemical bioleaching to extract copper from pyritic chalcopyrite concentrates. Bacterial and chemical (uninoculated) shake flask leaching of Sarcheshmeh copper concentrate at 15% (w/v) pulp density, 150 rpm and stirred tank electrochemical bioleaching of the concentrate at ORP (oxidation reduction potential) ranging from 400 to 430 mV (vs. Ag/AgCl), 20% pulp density and 600 rpm were conducted with and without pyrite addition. A mixed culture of moderately thermophilic microorganisms was used in all bioleaching experiments at an initial pH of 1.5, 50 °C, Norris nutrient medium and 0.02% (w/w) yeast extract addition. The results of leaching experiments in shake flasks showed that the addition of pyrite to the concentrate significantly increased the efficiency of copper extraction especially in the presence of microorganisms. In electrochemical bioleaching process, both the rate and extent of copper extraction were selectively (with respect to iron) enhanced in the pyritic copper concentrate in which about 90% copper recovery was achieved from the concentrate after 10 days. Analyses of optical microscopy and SEM/EDS revealed that pyrite remained unaffected in the electro-biochemical system while chalcopyrite was preferentially dissolved. It can also be concluded that at low levels of solution ORP, pyrite remains inert, which acts as a cathode site relative to chalcopyrite and other copper sulfide minerals (galvanic interaction) leading to enhance the anodic dissolution of the copper bearing minerals. Electrochemical system regulates the ratio of ferric to ferrous iron at an optimum level where the dissolution rate of chalcopyrite is maximum. Sulfur oxidizer microorganisms intensify the galvanic interactions and the rate of electron transfer among sulfides by removing the insulating sulfur product.

1. Introduction

Over the last four decades, bioleaching has been considered as one of the most promising alternatives to extract copper from flotation concentrates due to its environmental and technical advantages. It involves the use of iron- and sulfur-oxidizing microorganisms to catalyze the oxidation of metal sulfides in a sulfate medium. Among copper sulfides, chalcopyrite which is the most abundant copper bearing mineral is the most refractory mineral to bioleach.

Pyrite usually is one of the most abundant phases in dirty copper concentrates especially in the concentrates obtained from bulk flotation of porphyry deposits. It has an adverse effect on the efficiency of pyrometallurgical processes, so it must be separated from copper bearing sulfides which is usually performed by flotation method. On the other hand, lots of studies (Berry et al., 1978; Mehta and Murr, 1983; Tshilombo, 2004; Dixon et al., 2007; Majuste et al., 2012) have reported that in leaching processes pyrite has a positive galvanic effect on the dissolution rate of copper sulfides especially chalcopyrite. Galvanic interactions play an important role in the leaching of conducting or semi-conducting minerals by accelerating or retarding the dissolution of the minerals in aqueous solutions. Berry et al. (1978) investigated the galvanic interactions of chalcopyrite and pyrite and found that when pyrite and chalcopyrite were in contact, the resulting galvanic interaction caused the chalcopyrite to be corroded more rapidly than the pyrite, which was effectively protected. Mehta and Murr (1983) also reported that the rate of copper dissolution from chalcopyrite increases with the addition of pyrite especially in the presence of bacteria. They reported that the increase is as a result of galvanic interactions.

A number of recent studies have reported that solution ORP (oxidation reduction potential) is one of the main parameters governing the chemical and biological leaching rate of chalcopy-

* Corresponding author at: Department of Mining Engineering, Isfahan University of Technology, Isfahan 84156-83111, Iran. Tel.: +98 311 3915113; fax: +98 311 3912776.

E-mail address: a.ahmadi@cc.iut.ac.ir (A. Ahmadi).

0892-6875/$ - see front matter
http://dx.doi.org/10.1016/j.mineng.2012.03.022