Biooxidation of Copper Sulfide Minerals

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Abstract. The effects of temperature and the presence of NaCl on bioleaching of chalcopyrite, enargite, and tennantite were studied. Rate of copper extraction from all minerals depended on temperature and was the highest at 45–50 °C. NaCl addition increased rate of copper extraction from chalcopyrite but led to the decrease in copper extraction from enargite and tennantite.

Keywords: Bioleaching · Chalcopyrite · Enargite · Tennantite · Acidophilic microorganisms

1 Introduction

Copper and zinc are mainly extracted from sulfide ores using pyrometallurgical techniques. Pyrometallurgical processing of arsenic containing ores is a problem due to the emission of toxic gases (Filippou et al. 2007). Biohydrometallurgy is widely used to process gold bearing concentrates, and may also be used to extract non-ferrous metals arsenic-containing concentrates (Neale et al. 2017). The goal of the present work was to study copper bioleaching from arsenic-containing minerals and chalcopyrite at different temperatures and in NaCl presence.

2 Methods and Approaches

Chalcopyrite ($CuFeS_2$), enargite (Cu_3AsS_4), and tennantite ($Cu_{12}As_4S_{13}$) as well as mixed culture of acidophilic microorganisms oxidizing ferrous iron and sulfur compounds were subjects of the study. The experiments were carried out in flasks with 100 ml of nutrient medium supplemented and 2 g of milled minerals (P_{100} 75 μM) on a rotary shaker at temperatures from 40 °C to 60 °C for 30 days. In one variant of the experiment, nutrient medium was supplemented with100 mm NaCl.

3 Results and Discussion

The results of the experiments (rates of copper extraction) are shown in Table 1.

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Table 1. Rate of copper extraction from the minerals for 30 days (%)

Variant of the experiment	Chalcopyrite ($CuFeS_2$)	Enargite (Cu_3AsS_4)	Tennantite ($Cu_{12}As_4S_{13}$)
40 °C	14.33 ± 0.08	8.18 ± 0.65	15.33 ± 0.24
45 °C	17.84 ± 1.69	12.89 ± 1.79	26.16 ± 1.33
50 °C	25.29 ± 4.15	14.04 ± 0.95	18.43 ± 0.84
50 °C, 100 NaCl	33.25 ± 0.12	5.91 ± 1.09	13.04 ± 0.03
55 °C	26.75 ± 1.57	14.39 ± 0.01	14.84 ± 0.01
60 °C	17.32 ± 1.01	5.86 ± 2.18	12.83 ± 0.17

We showed that the rate of copper extraction from all minerals depended on temperature and was low at 40 °C. Extraction rate at 60 °C was also low as this temperature might inhibit microbial activity. Addition of NaCl increased rate of copper extraction from chalcopyrite that was a well known phenomenon. At the same time, NaCl addition led to the decrease in copper extraction rate.

4 Conclusions

The results obtained suggest that the efficiency of copper sulfide minerals depended on temperature, while NaCl addition did not allowed increasing the rate of copper bioleaching from arsenic-containing minerals in contrast to chalcopyrite. This fact should be taken into consideration when planning laboratory scale trials on bioleaching of copper sulfide concentrates.

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References

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