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## **Optimization of Copper Extraction from Advanced Milled Chalcopyrite Concentrate with Hydrogen Peroxide Leaching**

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### **Abstract**

Response surface methods (RSM) have some advantages such as easy optimization, to reach results quickly, and availability of evaluation statistically. Because of these reasons, the experiments were designed by using RSM. In this study, copper extraction was investigated from advanced milled chalcopyrite concentrate by using hydrogen peroxide as oxidant and acetic acid as stabilizer. In this context, effects of different parameters were studied such as grinding time, leaching time, peroxide concentration, and leaching temperature. Results showed that nearly 100% of copper was extracted compatible statistically ( $R^2=0.8072$ ) while the most effective parameter was defined the changing of hydrogen peroxide concentration.

**Keywords:** Chalcopyrite, Optimization, Leaching, Peroxide.

## 1. Introduction

Among the copper sulfides used to produce metallic copper, chalcopyrite (CuFeS<sub>2</sub>) is the predominant mineral. The concentrates of chalcopyrite are generally treated by pyrometallurgical methods of smelting and converting processes to win the copper metal. However, this high temperature route has always been plagued with environmental issues concerning pollution not only with SO<sub>2</sub> gas emissions but also with emissions of toxic compounds of arsenic, antimony, and other heavy metals. (Padilla, et al., 2007)

Hydrometallurgical processes offer great potential for treating sulphide concentrates such as chalcopyrite concentrate. On the other hand, leaching of chalcopyrite is difficult and strong oxidant or pressure conditions must be used. These effective conditions are usually provided by using oxygen gas in the autoclave system (Padilla, et al., 2008; McDonald and Muir, 2006a; McDonald and Muir, 2006b), but feeding gas into a pressure autoclave system may be difficult and costly.

The chalcopyrite leaching by hydrogen peroxide can be summarized as (Misra, et al., 2007),



## 2. Results and Discussion

### 2.1. Materials and Methods

Chalcopyrite concentrates namely Ergani concentrate was obtained from Elazig, Turkey. This concentrate was classified by sieving through 200 mesh. The fraction passed (90 % of total mass) through this sieve was used in all experiments. For the chemical analyses of the chalcopyrite concentrate, sample was dissolved by using microwave-assisted acid dissolution technique. After the dissolution, chemical analyses of clear supernatant were carried out by ICP-OES (Perkin-Elmer Optima 2000 DV). Sulphur content of the concentrate was determined gravimetrically. Mineralogical analyses of the concentrate were made by using X-ray diffraction system (Shimadzu XRD-6000) and powder diffraction technique. X-ray diffraction results showed that dominant mineral phases are chalcopyrite (CuFeS<sub>2</sub>) and pyrite (FeS<sub>2</sub>).

Chalcopyrite concentrate sample containing 28.31wt%Cu, 28.52 wt%Fe, 29.36wt%S was used for experiments.

Leaching experiments were performed under atmospheric conditions by using a conventional magnetic multi stirrer (Velp Scientific MultiStirrer 15). At the end of the leaching period, the contents were cooled and filtered. Filtered solutions were analyzed for copper using an AAS (Perkin Elmer-Analyst 400).

Box-Behnken experimental design was used. The experimental variables and their corresponding levels are listed in Table 1.

Table 1. Experimental range and levels of the independent variables.

Experimental parameters	Symbol	Unit	Low Level	High Level
Milling time	A	min	1	39
Leaching time	B	min	5	115
Leaching temperature	C	°C	25	65
H <sub>2</sub> O <sub>2</sub> concentration	D	M	0.1	3.9

## 2.2. Experimental Results

The results of the experiments for each experimental condition are shown in Table 2. As seen in Table 2, the experiments were planned as a total of 29 runs that included 5 center points. The effects of various leaching variables on metal extraction were studied. According to the results, the following variables are of significance as; grinding time, leaching time, peroxide concentration, and leaching temperature. It is clear that high copper extraction can be achieved with long milling time and high leaching temperature. Effect of leaching temperature was examined as seen in Table 2. It is evident that increasing temperature was caused to higher copper dissolution. However, it was observed that the leaching yield decrease at state high concentrations of hydrogen peroxide. Possible reason for this, hydrogen peroxide is an unstable compound, whose decomposition can be catalyzed by certain factors such as the presence of an acid, base, mineral surface or soluble ions. Due to rapid exothermic decomposition of hydrogen peroxide in solution, isothermal leaching conditions may disappear and the active oxygen may not be sufficiently used for oxidation of sulfide minerals in the leaching system. Therefore, to avoid rapid decomposition of hydrogen peroxide, acetic acid was used in the experiments. As a result, it is a group of graphs as follows shows the interaction effect of various parameters on the result (Figure 1).

Table 2. Experimental design with actual factors and observed results

Run	A	B	C	D	Cu %
1	1.00	5.00	45.00	2.00	35.5
2	39.00	5.00	45.00	2.00	68.5
3	1.00	115.00	45.00	2.00	59.8
4	39.00	115.00	45.00	2.00	91
5	20.00	60.00	25.00	0.10	10.56
6	20.00	60.00	65.00	0.10	8.5
7	20.00	60.00	25.00	3.90	21.48
8	20.00	60.00	65.00	3.90	28.58
9	1.00	60.00	45.00	0.10	5.38
10	39.00	60.00	45.00	0.10	9.60
11	1.00	60.00	45.00	3.90	80.93
12	39.00	60.00	45.00	3.90	40.57
13	20.00	5.00	25.00	2.00	54.88
14	20.00	115.00	25.00	2.00	62.25
15	20.00	5.00	65.00	2.00	67.50
16	20.00	115.00	65.00	2.00	100
17	1.00	60.00	25.00	2.00	40.86
18	39.00	60.00	25.00	2.00	68.43
19	1.00	60.00	65.00	2.00	56.25
20	39.00	60.00	65.00	2.00	91.7
21	20.00	5.00	45.00	0.10	9.65
22	20.00	115.00	45.00	0.10	10.40
23	20.00	5.00	45.00	3.90	62.76
24	20.00	115.00	45.00	3.90	32.65
25	20.00	60.00	45.00	2.00	64.59
26	20.00	60.00	45.00	2.00	67.33
27	20.00	60.00	45.00	2.00	65.76
28	20.00	60.00	45.00	2.00	61.30
29	20.00	60.00	45.00	2.00	61.83

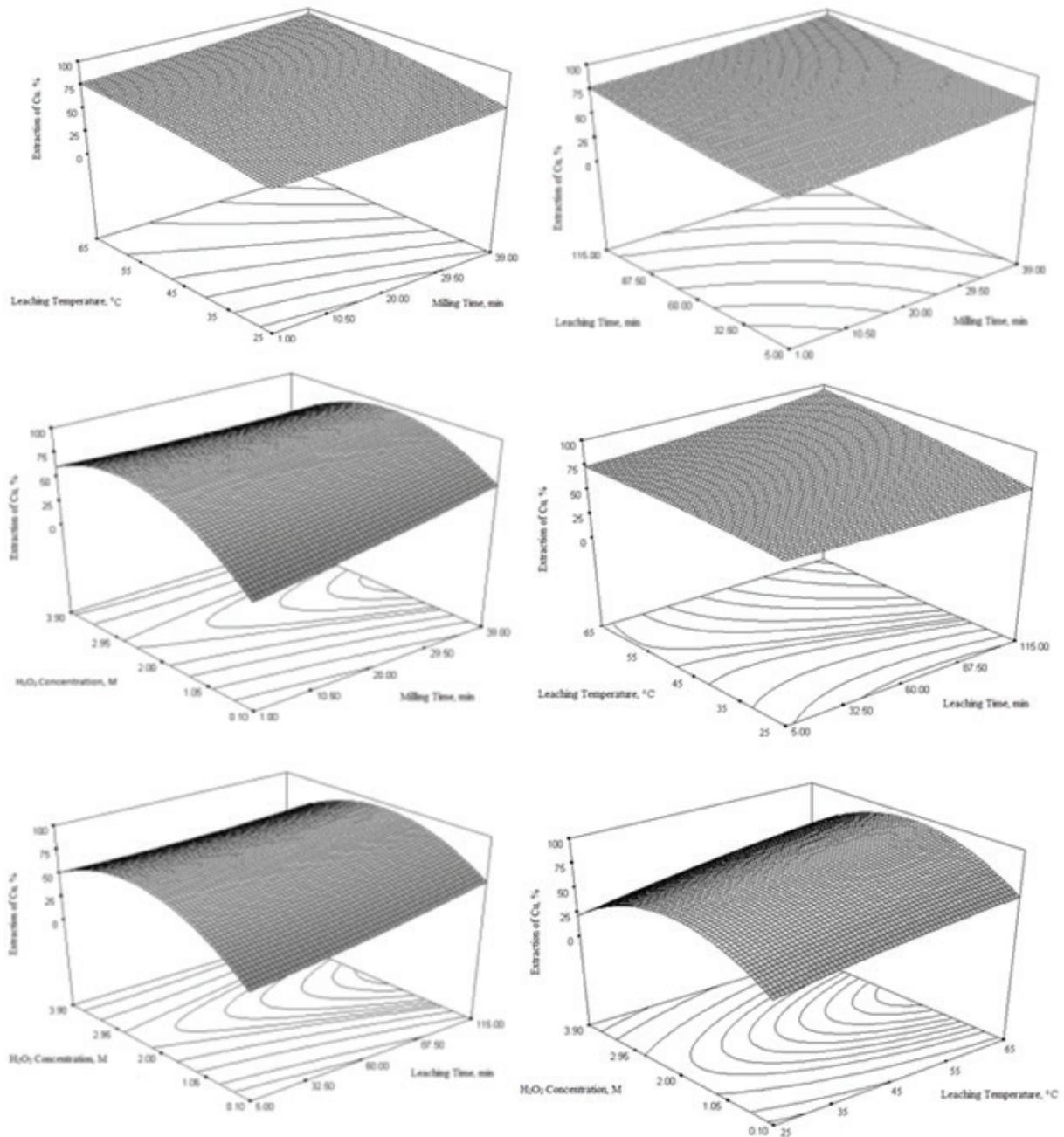


Figure 1. The interaction of various parameters on the copper extraction.

According to ANOVA results, it can be said that most effective parameter on the copper extraction is  $D^2$  namely hydrogen peroxide concentration, so that when the peroxide concentration changes it is having exponential effect on the results.

The experimental results were evaluated and approximating functions of extraction percent of copper is obtained as shown in Eqs. (1).

$$\%Cu = -33.08 + 0.61288*A - 0.1*B + 0.45*C + 60.62*D + 4.83 \times 10^{-3}*A^2 + 8.96 \times 10^{-4}*B^2 - 7.01 \times 10^{-3}*C^2 - 10.85*D^2 - 4.31 \times 10^{-4}*A*B + 5.28 \times 10^{-3}*A*C - 0.31*A*D + 5.41 \times 10^{-3}*B*C - 0.07*C*D + 0.06*C*D \quad (1)$$

## References

Mahajan, V., Misra, M., Zhong, K., Fuerstenau, M C. 2007. Enhanced leaching of copper from chalcopyrite in hydrogen peroxide–glycol system. *Hydrometallurgy*, 20, 670-674.

McDonald, R G., Muir, D M. 2007a. Pressure oxidation leaching of chalcopyrite. Part I: Comparison of high and low temperature reaction kinetics and products. *Hydrometallurgy*, 86, 191–205.

McDonald, R G., Muir, D M. 2007b. Pressure oxidation leaching of chalcopyrite. Part II: Comparison of medium temperature kinetics and products and effect of chloride ion. *Hydrometallurgy*, 86, 206-220.

Padilla, R., Pavez, P., Ruiz, M C. 2008. Kinetics of copper dissolution from sulfidized chalcopyrite at high pressure in H<sub>2</sub>SO<sub>4</sub>-O<sub>2</sub>. *Hydrometallurgy*, 91, 113–120.

Padilla, R., Vega, D., Ruiz, M C. 2007. Pressure leaching of sulfidized chalcopyrite in sulfuric acid–oxygen media. *Hydrometallurgy*, 86, 80–88.