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EXTRACTION OF COPPER FROM SOLUTION AFTER BIOLEACHING OF PRINTED CIRCUIT BOARDS (PCBs)

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Preliminary Note – Prethodno priopćenje

The solvent extraction of copper and iron from bioleaching solutions of PCBs with LIX 860N-IC and nex t stripping test with H_2SO_4 were investigated. In test the effect of varying sulfuric acid concentration on stripping rate of Cu and Fe and also phase ratio (O : A) were determined. It was found that the stripping rat e of copper increases with the sulfuric acid concentration. The optimal concentration of H_2SO_4 is suggest ed to be about 150 g/L and phase ratio O:A = 1:1.

Key words: copper, solvent extraction, electronic waste, bioleaching, LIX 860N-IC.

INTRODUCTION

Printed circuit boards (PCBs) are the main carrier of valuable metals in the electronic waste. For example, metal content in these elements of mobile phones is about 28 %, including 10 - 20 % of copper , 1 - 5 % of lead, 1 - 3 % of nickel, content of precious metals (Ag, Pt, Au) about 0,3 - 0,4 %, and the rest are plastics (19 %), bromine (4 %), glass and ceramics (49 %) [1]. The quantitative composition of polymetallic electronic elements makes this type of wastes, an attractive material in terms of valuable metals recovery . Printed circuit boards (main component of many portable electronic devices) are an example of a source of valuable metallic constituents.

In addition to traditional methods of electronic scraps processing (pyro- and hydrometallur gical methods), new solutions are searched, which could replace or improve current practice processes. It is important that efficient metal recovery and the principles of environmental protection must be kept. Well known is application of biohydrometallurgical methods in recovery process of metals (such as Cu, Au, Ni, U, Zn, Pb) Over the past few years bioleaching–solvent extraction–electrowinning (BL–SX–EW) process has been conducted in hydrometallur gical production of copper from low grade ores. About 20 – 25 % of the world's total copper production originates from solvent extraction followed by electrowinning processes [2,3].

In recent years, much attention has been paid to the possibility of using microorganisms in the extraction of metals from a variety of waste. A small number of publications is dedicated to the possibility of further recovery of metals from solutions after bioleaching. As a result of bioleaching of electronic waste, a multi-component solution is obtained, containing various metal ions, of which copper is predominant component. Due to the presence of additional metal cations, especially iron cations, direct recovery of copper is much more hindered. In this case, an ef fective method that allows the separation of desired metal (Cu) from their mixture may be solvent extraction [4,5].

Not many studies have been undertaken for the solvent extraction of copper from polymetallic post-bioleaching electronic scrap solutions [6].

Experimental works using bacterial leaching for the extraction of some base metals (Cu, Zn, Pb, Ni, Sn) from electronic waste were carried out with the participation of Acidithiobacillus ferrooxidans and Acidithiobacillus thiooxidans.[7-9]. It was indicated that in the presence of these strain and at the ambient temperature, 99 % of copper can be extracted into solution during bioleaching.

Typical polymetallic solution after bioleaching of PCBs form used mobile phones consists (g/L): 3,228 - 4,525 Cu, 2,084 – 3,437 Fe, 0,061 Sn, 0,0005 Pb, 0,0695 Ni. The solvent extraction allows selectively separate copper from solution and next further recovery of Cu from a loaded or ganic phase requires the stripping operation.

The aim of this study was to determine the preliminary conditions of the copper and iron stripping rate from loaded organic phase, using H_2SO_4 at varying concentrations and varying phase ratio O : A. Achieving this goal required set of operation which consisted of the preparation of test material (PCBs milling), bioleaching of waste and the extraction process in accordance with the methodology presented in this article.

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EXPERIMETAL WORK

Materials. The research was conducted on printed circuit boards (PCBs) derived from spent mobile phones. PCBs were ground with the cutting mill to a particle size < 0,5 mm.

Bioleaching. Bioleaching were carried out in Erlenmeyer flasks by using a rotary shaker (130 rpm) at ambient temperature. In this study Acidithiobacillus ferrooxidans strain was used. The culture was maintained in a standard Silverman/Lundgren (9K) medium. Samples of the waste were 2 g, the volume of solution was 200 mL, whereas the quantities of bacteria culture was 10 % (v/v). Bioleaching was carried out within 40 days. Solutions were filtered, combined and then subjected to solvent extraction. The metal content (Cu and Fe) in the solution after bioleching was determined by atomic adsorption spectrometry (SOLAAR M6-UNICAM Atomic Absorption) and was as follows (g/L): 3,228 Cu; 2,084 Fe.

Extraction. The organic solvent such as LIX 860N-IC obtained from the supplier (BASF , Ireland), was used in studies. It was found (data not illustrated) that the optimal concentration of LIX 860 N-IC is suggested to be about 5 %, phase ratio O:A = 1:1 and pH = 1,9. Therefore extraction experiments were carried out in these conditions by using separatory funnel and manual mixing of organic (O) and aqueous phase (A) for time period of 5 minutes.

Stripping. Stripping test was carried out with H_2SO_4 with the varied concentration from 37,5 g/L to 300 g/L. Experiments were carried out in separatory funnel by manual mixing for 5 min. Dif ferent phase ratios O:A were used from 1:3 to 3:1. Concentration of Cu and Fe in solutions during extraction as well as striping experiments was determined by AAS. Stages of studies are illustrated in Figure 1.

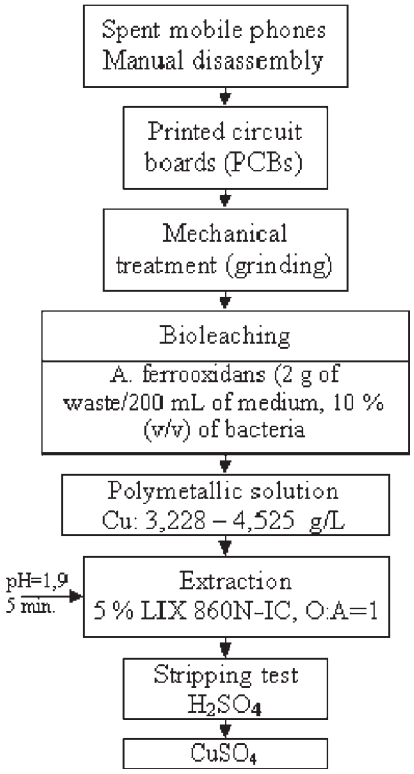

Figure 1 Diagram of research regarding recovery of copper from solution after bioleaching of PCBs

RESULTS AND DISCUSSION

When 5 % LIX 860 N-IC was used, the extraction rate of copper was in the range of 97-98,5 % and iron from 2,5 to 3,8 %. The loaded organic phase came from the solvent extraction was stripped by H_2SO_4 solution. The results of stripping experiment are shown in Figure 2. In test the ef fect of varying H_2SO_4 concentration on stripping rate of copper and iron were investigated. The stripping rate of copper rises with increasing of H_2SO_4 concentration and reached above 92,8 % with respect to sulfuric acid concentration of 150 g/L. Iron stripping rate is constants in all tested range of sulfuric acid concentration and equaled about 24 %.

The influence of phase ratio (O:A) on the copper and iron stripping is shown in Figure 3. With the increase of O:A ratio, copper stripping rate increased. When the O:A rose from 0,33 to 1,0 the copper stripping rate increased from 67,7 % to 92,8 %. In the highest ratio slightly rise to 98,1 % was observed. The iron striping rate was in comparable equilibrium level during all test.

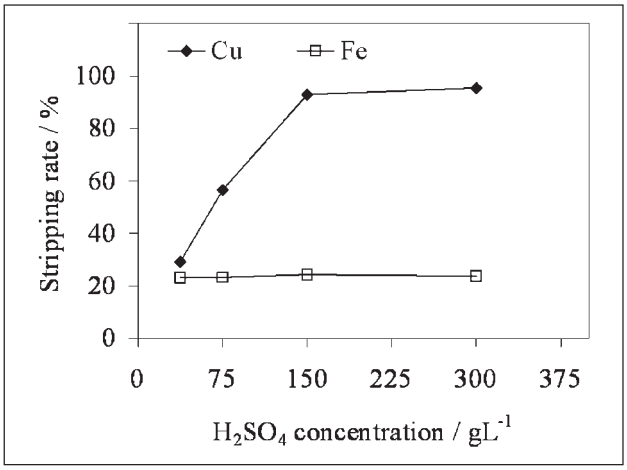

Figure 2 Effect of H_2SO_4 concentration on copper and iron stripping rate, (O:A=1, contact time 5 min.)

SUMMARY

Research on solvent extraction and stripping test of copper and iron from polymetallic solution after bioleaching of e-waste was carried out. It was shown that copper can be separated and recovered by solvent extraction using LIX 860 N-IC. Extraction rate of copper was in the range of 97 – 98,5 % and iron from 2,5 to 3,8 %. It is easy to strip copper from loaded organic phase. About 93 % of Cu was stripped by sulfuric acid with concentration of 150 g/L and phase ratio O:A= 1:1. Iron

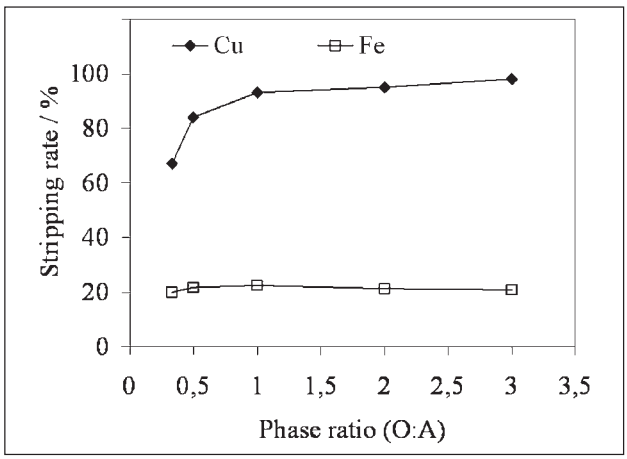

Figure 3 Effect of phase ratio (O:A) on stripping rate of copper and iron (H_2SO_4 concentration 150 g/L, contact time 5 min.)

stripping rate was constants in all experiments and equaled about 24 %.

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Note: Foks P. is responsible for English language, Katowice, Poland