

RECOVERY OF COPPER FROM PRINTED CIRCUIT AND ELECTRONIC WASTE

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Resumen

La obtención de cobre de recursos primarios mediante extracción con disolventes se ha venido desarrollando de forma continua durante los últimos 25-30 años. En esta investigación se presenta el estudio experimental para la recuperación de cobre a partir de residuos electrónicos. La metodología se basa en la reducción de tamaño y clasificación del material, lixiviación, extracción y regeneración del extractante, así como, la electrodeposición del metal. Los resultados de lixiviación utilizando agentes lixivante y oxidante selectivos, muestran altas concentraciones de cobre para los tamices 6 y 10, que corresponden a 9705 y 12157.5 mg/L, respectivamente a 100 minutos de agitación. Para la separación del metal se emplea ACORGA 5774 como extractante para el metal, obteniéndose rendimientos de extracción del 99%. Finalmente, se regenera el extractante para continuar con la electrodeposición del cobre.

Abstract

The recovery of copper from electrical waste and electronics by solvent extraction has been developed continuously over the past 25-30 years. In this paper, the experimental study for the recovery of copper from electrical waste is presented. The methodology is based on the reduction of size and classification of the material, leaching, extraction and regeneration of the extractant, as well as the electrodeposition of the metal. The leaching results using a selective leach and an oxidant agent show high copper concentrations for sieve size 6 and 10, corresponding to 9705 and 12157.5 mg/L, respectively at 100 minutes of stirring. ACORGA 5774 as extractant is used for the removal of the metal, getting extraction yields of 99%. Finally, the extractant is regenerated to continue the electrodeposition of the copper.

Palabras Clave

Copper; Leaching; Extraction liquid-liquid; Recovery; ACORGA 5774

INTRODUCTION

WEEE is for *waste electrical and electronic equipment*. It is end-of-life electrical and electronic equipment and covers virtually everything with a plug or battery. It is classified as either household or non-household WEEE.

Improvements in the computers processing power have shortened their half-life. Therefore, every year, the amount of waste electronic devices (WEEE) increases three times faster than other forms of municipal waste [1].

The main challenge in this field is that they contain up to 60 different elements which are also closely related to complex sets and subsets [2], such as copper, iron, aluminum, lead and tin, as well as precious metals whose physical and chemical properties are very different.

The number of discarded circuit boards is increasing, and it is imperative to adopt environmentally friendly scientific methods.

On one hand may remission the pollution of the environment, on the other can also be recovery precious metal from waste electrical. Therefore, the develop of cost-effective, environmentally friendly methods of metal recovery has become the focus of the current research [3].

For the recovery of metals, hydrometallurgical and pyrometallurgical processes are both used, but the pyrometallurgical process is more pollutant and costly [4], [5], [6].

The hydrometallurgical process consist of a first stage in which the metals are extracted in the solution of chemical leaching in an acid or alkaline medium, and then a second step which consists in the purification of the solution. Precipitation, cementation, absorption, ion exchange, electrolytic extraction and liquid-liquid extraction are currently used purification methods.

MATERIALS AND METHODS

Preparation of the sample

First, the printed circuit board from computer recycle or waste collection centers were obtained (IMAGE 1) and then we removed the parts by hand, in order to avoid a chemical erosion. Therefore obtained smaller cuts ranging from 2 cm x 3 cm, it was continued with the pulverization in a hammer mill (IMAGE 2).



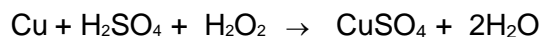
IMAGE 1. Printed circuit board from computer recycle or waste collection centers.



IMAGE 2. Hammer mill, chemical engineering laboratory, University of Guanajuato.

Leaching

For the leaching, based on the bibliographic review, conditions were found to which a higher percentage of dissolution was obtained. The suggested procedure for leaching electronic waste is: 10 g of pre-crushed copper-rich sample, 80 mL of 2 mol/L H₂SO₄ and 10 mL of 30% (P/V) H₂O₂ are added to 250 mL three-necked flask under reflux with cooling water.



The procedure for carrying out the leaching was as follows, in a 500 mL 3-necked flask, at controlled bath temperature and at reflux with cooling water. The leaching was performed at an operating temperature of 70° C and with mechanical agitation of 650 rpm (IMAGE 3). The test was done for 180 min and at 80 min it was added 10mL of H₂O₂; and every 20 min get one solution from 500 mL 3-necked flask (IMAGE 4).



IMAGE 3. System to carry out the leaching in a 500 mL 3-necked flask, at a water bath and at reflux with cooling water.

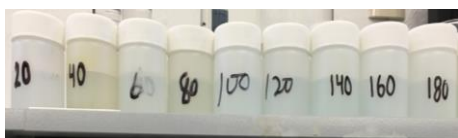


IMAGE 4. Every 20 min get one solution from 500 mL 3-necked flask.

Filter paper for every flask of dregs was used and solution was collected without dregs (IMAGE 5 and 6).



IMAGE 5: Collecting solution from flask of dregs.



IMAGE 6: Leached sieve size 6.10.12.35.

Liquid-Liquid Extraction/Stripping

For the study of copper extraction, the filtered aqueous solution obtained from the leaching stage was used. For the organic phase, a solution of extractant (ACORGA M5774), diluted to a concentration of 30% (v/v) in kerosene was prepared. From bibliographic consultation the recommended extraction pH is 3 in this series of experiments, it is adjusted to that pH value and left in contact for 20 minutes.

For regeneration of the extractant, 10 mL of sample (aqueous phase obtained during extraction) were taken and contacted with 10 mL of 2 mol/L H₂SO₄, by stirring for 20 min (IMAGE 7).



IMAGE 7. Add NaOH in flask with mechanical agitation of 600 rpm. In order to pH 3.

Organic phase with sulfuric acid were combined with mechanical agitation and then turn on (IMAGE 8).

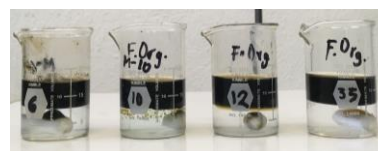


IMAGE 8: In the beginning organic phase combine with sulfuric acid.

After 20 min the solution is different from the one at the beginning (IMAGE 9).



IMAGE 9: In the flask separate phases at particle different sizes.

Electroposition

The purpose of conducting electrodeposition is to demonstrate that copper can be recovered from the solution that comes from the desextraction. In this way conditions that allow the electrodeposition of the metal are used, but they are not the best conditions. A study could be carried out in the future for this final stage of the process and then find out the optimal electrodeposition conditions.

For the electrodeposition of copper the appropriate electrodes were used; as the cathode a steel plate and as the anode one of commercial lead, as well as a regulated power source DC Power Supply model PRL-25 and the aqueous charged phase of copper coming from the desextraction step (IMAGE 10).



IMAGE 10: Electrodeposition of Copper with ammeter, Voltmeter.

RESULTS AND DISCUSSION

Preparation of the sample

A total of 135.53 g (free sample of capacitors, resistors, plastics) was obtained from the collected material of electronic waste, which was then sieved. The results are shown in TABLE 1.

TABLE 1: Results of the granulometric analysis.

Sieve sizes	Diameter (mm)	Weight Retained (g)	% Retained	% Pass
6	3.35	26.24	19.36	80.63
10	2	10.3	7.59	73.04
12	1	27.76	20.48	52.56
35	0.5	15.81	11.66	40.89
Gravel	>3.35	55.42	40.89	

Leaching

For this test, sulfuric acid was used as leaching agent and hydrogen peroxide as oxidizing agent, because copper is in metallic form and is therefore more stable in acid solution (IMAGE 11).

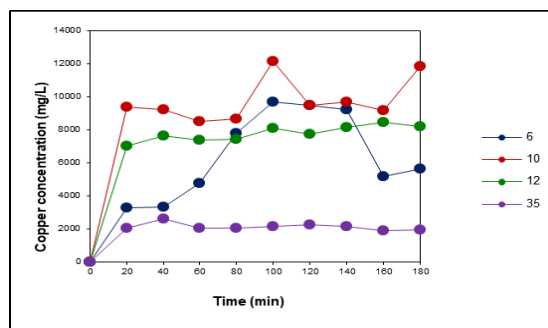


IMAGE 11: Copper leaching with particle sizes in different time.

In this graph it can be seen that using the sieve size 6 and 10, the highest concentration of copper in sulfuric acid solution, corresponding to 9705 and 12157.5 mg/L, respectively, is obtained during a contact time of 100 min.

Extraction liquid-liquid/Desextraction

In this section, the extraction efficiency is determined by the equation:

$$\%Extracción = \left(1 - \frac{M_f}{M_o}\right) * 100$$

M_f and M_o , correspond to the final and initial concentrations of copper in aqueous phase, respectively. The results obtained for this calculation are presented below (IMAGE 12).

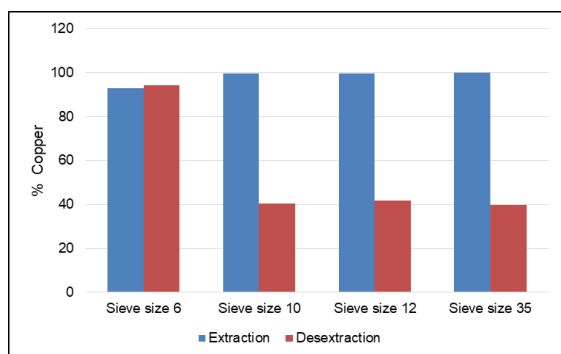


IMAGE 12: Extraction / desextraction yield of copper as a function of particle size.

As it can be seen in this graphic, using the sieve size 35 it is obtained the highest percentage of extraction, and the percentage of extraction for metal oscillates between 93 and 99%. For the regeneration of the extractant, the percentage of yield is obtained for the sieve size 6.

Electroposition

The copper electrodeposition of the extraction solution was carried out under the conditions: 3 V, 1 A, and 1 hour at temperature of 55 ° C.



IMAGE 13: Equipment used for electroposition of copper.

It can be seen this photo (IMAGE 13) that this step indicates a good selectivity of the process for recovering the copper from the solution, and shows the metal deposit.

CONCLUSIONS

This process shows that is possible the recovery of copper from these electronic waste. The number of discarded circuit boards is increasing, and it is imperative to adopt environmentally friendly scientific methods. On one hand may remission the pollution of the environment, on the other can also be recovery precious metal from waste electrical.

Therefore, the developpe of cost-effective, environmentally friendly methods of metal recovery has become the focus of current research.

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