**Selective Copper Leaching from End-Of-Life Printed Circuit Boards Using Ammonium Salt Solutions.**

Carolina Silva, Carolina Pinheiro, Maria da Graça Rasteiro, Licínio Gando-Ferreira\*

*CIEPQPF, Department of Chemical Engineering, University of Coimbra, Rua Sílvio Lima, Pólo II, P-3030-790 Coimbra, Portugal*

*\*Corresponding author: lferreira@eq.uc.pt*

**Highlights**

* Copper is the main element in PCB scrap.
* Ammonium salt solutions can selectively recover the copper.
* Influence of reagent concentration and liquid/solid ratio were studied.
* Copper recovery of 100% and a selectivity of 77% were achieved.

**1. Introduction**

End-of-life electrical and electronic equipment such as printed circuit boards (PCB) are becoming a major environmental problem due to their composition, which comprises toxic metals, polymers and ceramics. From an environmental and economic point of view, the amount of metals present, especially copper, makes this residue an interesting secondary source of metals.

The recovery of metals from electronic scrap using hydrometallurgical methods has attracted considerable attention in the literature for being effective and less harmful to the environment [1]. This process uses acid or basic solvents to extract the metals, which are then separated and purified using processes such as precipitation, solvent extraction, adsorption or ion-exchange.

In this context, this work aims at processing the metal containing fraction of PCB using hydrometallurgical processes. A solution of ammonia and hydrogen peroxide was used as oxidizing agent, in order to combine high levels of extraction efficiency as well as a low environmental impact.

**2. Methods**

The analyzed PCB scrap sample was provided by an E-waste Recycling Portuguese company, and was constituted by 4 kg of computer motherboards, RAM memories, mobile phones and processors. First, a mechanical/physical processing was performed, consisting in the dismantling and fragmentation of components using a guillotine and a sheet mill. Afterwards, a blade mill was used to reduce the PCI particle size, which was then separated into two fractions – oversize (>0.0707 mm) and undersize (<0.707 mm).

The chemical characterization was performed by x-ray fluorescence (XRF) model Rigaku Nex CG. Previously, acid digestions were performed in open systems by heating the waste with aqua regia reinforced with hydrogen peroxide. The Cu recovery tests were carried out in a closed cylindrical reactor, with a condenser attached, a termocouple and a mechanical stirrer. Two relevant operation conditions, namely liquid/solid (L/S) ratio and reagent concentration were studied using a 3 level full factorial design of experiments.

**3. Results and discussion**

The chemical characterization of the raw material is shown in Figure 1.


**Figure 1.** Chemical composition of the PCB components analyzed.

The results show that copper is the most abundant metal in PCB and is mostly found in the oversize fraction, with a maximum concentration of about 244 mg/g of waste. Precious metals such as gold are also present in promising quantities, which can also be recovered.

The influence of reagent concentration and L/S ratio on the recovery of Cu is reported in Table 1.

**Table 1.** Leaching yield and selectivity of the Cu recovery.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Run** | **L/S** | **C %** **(vol. %)** | **Yield****(wt. %)** | **Selectivity(wt. %)** |
| **1** | 3 | 23.2 | 64.3 | 75.9 |
| **2** | 5 | 23.2 | 63.9 | 75.5 |
| **3** | 7 | 23.2 | 86.4 | 74.9 |
| **4** | 3 | 42.7 | 68.0 | 86.2 |
| **5** | 5 | 42.7 | 69.3 | 75.9 |
| **6** | 7 | 42.7 | 64.4 | 73.9 |
| **7** | 3 | 72.4 | 74.1 | 76.9 |
| **8** | 5 | 72.4 | 100 | 77.0 |
| **9** | 7 | 72.4 | 78.0 | 72.0 |

A yield of 100% and a selectivity of 77% was obtained for the copper extraction using a reagent concentration of 72.4% and a L/S ratio = 5. It can be concluded that the concentration and L/S ratio have a positive effect on the extraction efficiency. The higher the concentration and the smaller the amount of residue, the easier the dissolution of the metals with the reagents.

**4. Conclusions**

Copper is the main basic metal present in PCB scrap. The best yield for copper extraction was obtained at a maximal reagent concentration (about 72.4%) and a L / S ratio = 5. Recovery of almost 100 % of copper was achieved.

**References**

1. F. Habashi, Hydrometallurgy 79 (2005) 15–22.