Solder mask removal and copper recovery from electronic components free waste printed circuit boards

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Introduction

The production of electric and electronic equipment (EEE) is one of the fastest growing and the most dynamic fields. This development has resulted inevitably in continues accumulation of waste EEE (WEEE). As a result, the amount of waste printed circuit boards (WPCBs), which are an integral part of EEE, also have increased [1-3]. The composition of WPCBs is complex, containing polymers, ceramics and metals. The quantity of metals, especially copper, gold and silver, turns this waste into an interesting raw material from an economic point of view [4]. The content of metals in WPCBs is more than 10 times higher than that of rich-content minerals, so WPCBs are considered as "urban mineral resources" [5, 6]. The aim of the current study was to present a novel recovery process of copper from electronic component (EC) free WPCBs.

Materials @ Methods

The two major steps of the process consist in removing the solder mask from the surface of the WPCBs by chemical treatment in concentrated H_2SO_4 followed by the direct anodic dissolution of metals with simultaneous electrodeposition of a high copper content alloy. Figure 1 presents more detailed descriptions of the main steps involved in the recovery process.

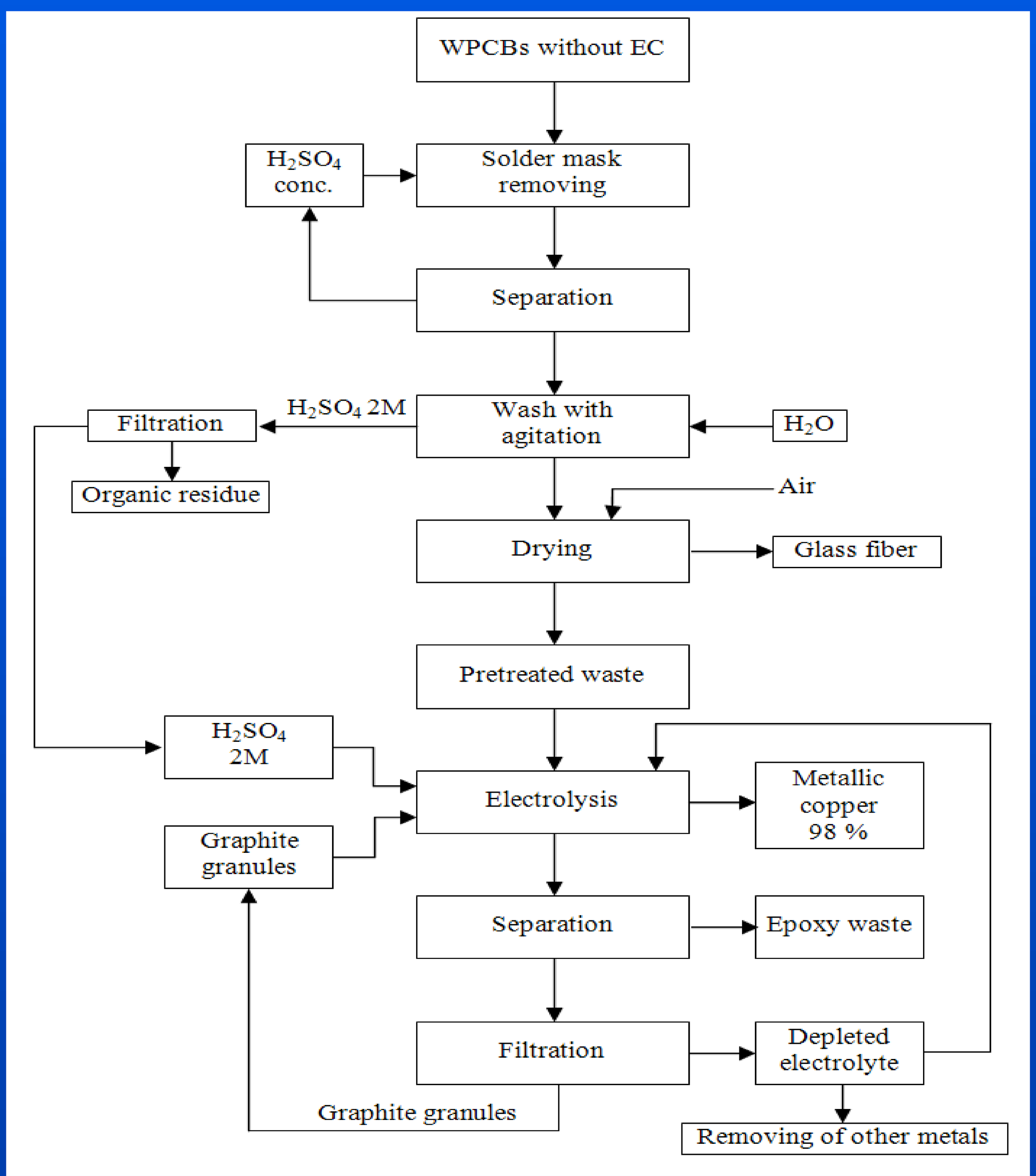

Fig.1. Process flow diagram for solder mask removal and copper recovery process from EC free WPCBs.

The metal composition of WPCBs without electronic components, obtained by atomic absorption spectroscopy (AAS) measurements, after mineralization with aqua regia, are presented in Table 1.

Table 1. Metal composition of WPCBs sample without electronic components.

WPCBs	Metal composition, (wt. %)						
	Cu	Zn	Ni	Sn	Fe	Ag	Au	Pb
Type 1*	23.60	0.020	0.150	2.10	1.200	0.040	0.0100	1.45
Type 2**	30.50	0.042	0.003	1.34	0.004	0.005	0.0054	0.76

Note: mass of WPCBs sample was 100 g

*network interface card

**data acquisition extension board

The electrochemical reactor contains a perforated Pb cage where the cut pieces of WPCBs were mixed with graphite granules (current collector) as anode and an stainless steel plate as cathode, all immersed in 2M aqueous solution of H_2SO_4 used as electrolyte. The anodic dissolution and cathodic deposition of metals is based on the following reversible redox reaction:

$$M^{n+} + ne^- \leftrightarrow M$$

where M = Cu, Au, Ag, Fe, Sn, Zn, Pb, Ni.

Results @ Discussions

The performance of the process was evaluated by means of current efficiency, Cu electroextraction degree and specific global energy consumption (W_S).

The electrowinning degree of the metals obtained by anodic dissolution and electrodeposition are presented in Table 2 and the composition of the deposit is presented in Table 3.

The evolution in time of the copper conversion (X_{Cu}) and total current efficiency (r_F) are presented in Fig. 2.

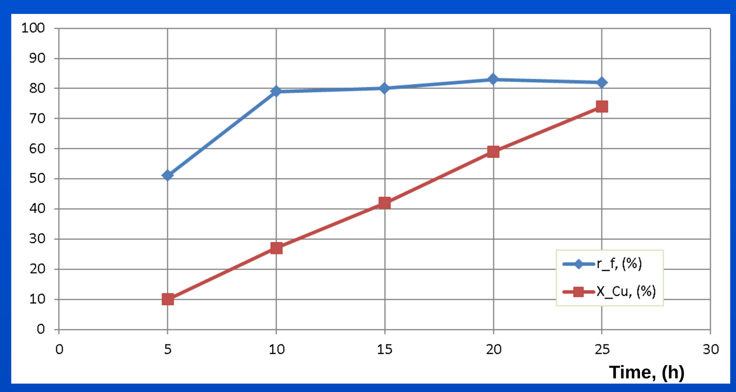

Fig. 2. The current efficiency and copper conversion vs. time.

Table 2. The extraction degree of the metals from WPCBs sample, without EC, after anodic dissolution and electrodeposition (determined by AAS measurements).

Metal	Cu	Zn	Ni	Sn	Fe	Ag	Au	Pb
Deposit, (wt. %)	77	3	2	15	1	73	1	23
Electrolyte, (wt. %)	23	97	98	85	99	27	99	77

Table 3. The metal composition of the copper deposit.

Metal	Cu	Zn	Ni	Sn	Fe	Ag	Au	Pb
(wt.%)	98.03	0.01	0.03	1.78	0.12	0.01	0.0002	0.02

a b c d

Fig.3. The WPCBs samples, without EC, in different phases of the copper recovery process:
a - Initial; b - After surface treatment with H_2SO_4;
c - After partial anodic dissolution; d - After total anodic dissolution.

Conclusions

- The results prove the high efficiency (100 %) of direct electrochemical dissolution of metals from WPCBs using a Pb cage with graphite granules as anode current collector.
- The specific energy consumption for the cathodic deposit were W_S = 1.06 kWh/kg with a 98 % copper content.
- The obtained Cu deposits can be utilized in the production of anodes used in the further electrorefining of copper.

Acknowledgements

This work was supported by a grant of the Ministry of Research, Innovation and Digitization of the Romanian Government, CNCS - UEFISCDI, project number PN-IV-P2-2.1-TE-2023-1152, within PNCDI IV.

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