

Recycling of Cu and Al with high purity from end life printed circuit boards

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Introduction



- Printed circuit boards (PCBs) are used in most electric and electronic equipments.



Ten times more Cu than rich-content minerals

Treatment of spent PCBs

Reduction of land filling;

Reutilization of the recovered materials.

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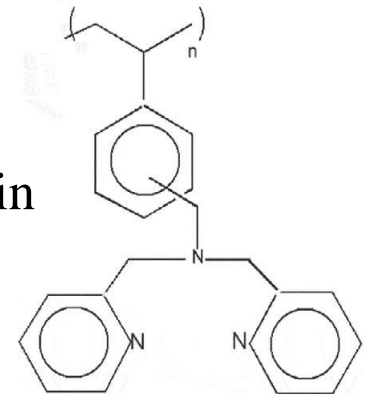


Objectives

To develop a *simple and nearly-closed two-step process* to recover Cu and Al from PCBs residues with high purity.

1° - Leaching Cu from the roasted PCBs residue;

2° - Recovery selectively Cu using a bispicolylamine chelating resin



Structure of bispicolylamine.

Neto IFF, Sousa CA, Brito MSCA Futuro AFM, Soares HMVM, (2016) “A **simple and nearly-closed cycle process for recycling copper with high purity from end life printed circuit boards**”. Separation and Purification Technology, 164: 19-27.

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Metal characterization of the PCBs residue

Metal chemical composition of the milled PCB residue (fraction < 0.250 mm) after roasting (850°C, 3 hours).

Element	Ag	Au	Cu	Fe	Ni	Zn	Al	Sn
Content (wt.%)	0.044	0.051	14.7	3.3	0.50	0.30	5.9	0.77

The main goal was to leach the highest amount of Cu and avoid Au leaching



HNO₃ was selected

Leaching studies

Firstly the effect of HNO_3 concentration and temperature on the leaching of Cu was studied, keeping other parameters constant (L/S = 10; Time = 210'; 150 RPM).

Conc. (mol/L)	T (°C)	Cu (%)
1	25	21.4 ± 0.5
	50	48 ± 2
	80	52 ± 3
2	25	43 ± 2
	50	78 ± 5
3	25	46 ± 6

Other conditions tested:

↑ Time - 210 to 240 min ;

↑ L/S ratio – 20;

↑RPM – 200.



No significantly improvements on Cu leaching were observed

Leaching results

Leached solution at selected conditions: HNO_3 2M; 50°C; 210'; L/S= 10; 150 RPM

Element	Ag	Au	Cu	Fe	Ni	Zn	Al	Sn
Leached (%)	97 ± 4	< 3	78±5	22±2	14 ± 1	37 ± 2	85 ± 4	13 ± 3
Conc. (ppm)	6.1	< 0.18	1151	73.0	8.2	10.3	492	9.3



Recover Cu with high purity



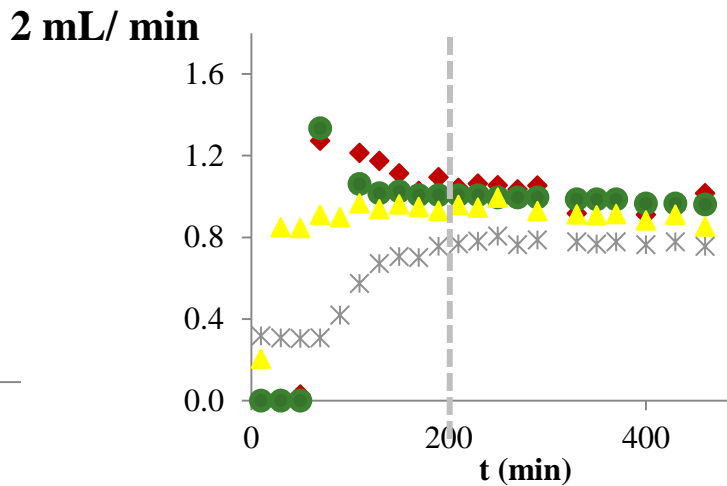
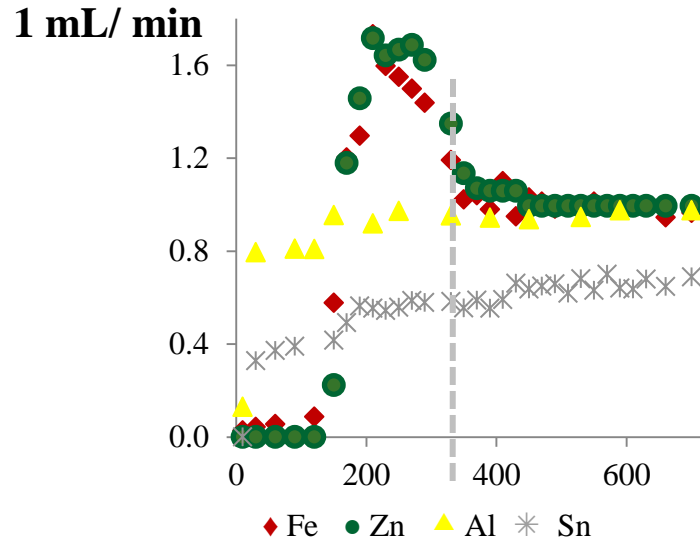
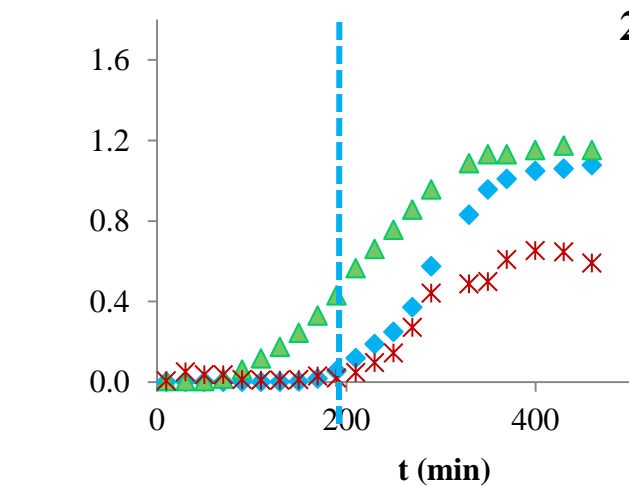
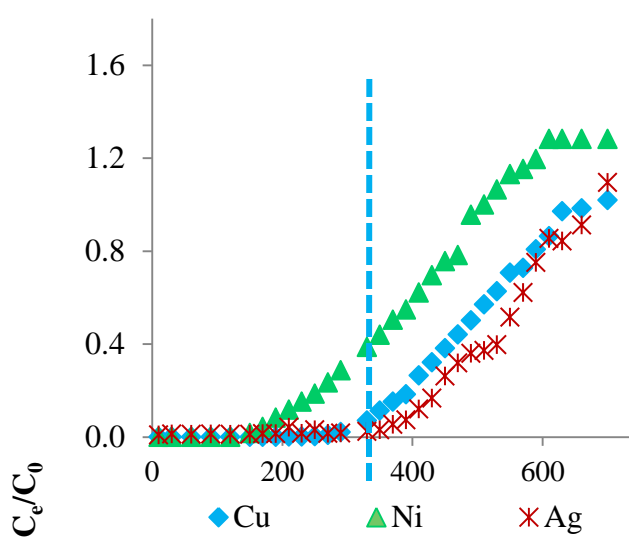
A bispicolylamine resin was selected

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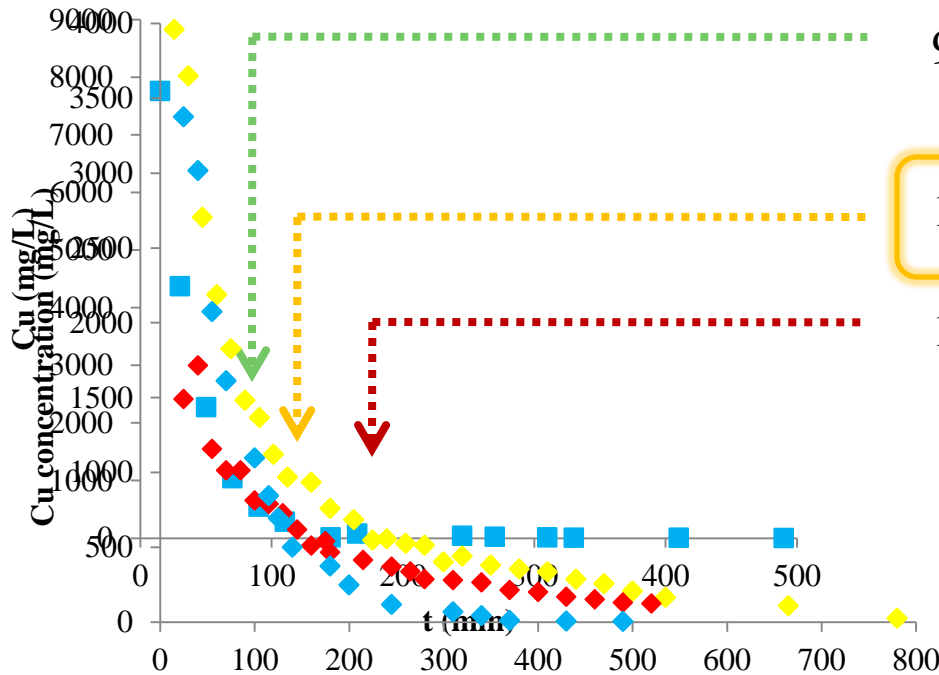
Column adsorption studies with the leached solution



Selected flow rate:
2 mL/min

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Elution of copper with H₂SO₄



90 min → 93% of Cu eluted

Elution conditions:
 120 min → 96% of Cu eluted:
 H₂SO₄ 4 M, 2 mL/min

180 min → 99% of Cu eluted

Faster elution and high concentrated Cu solution

Element	Ag ^t (min)	Cu	Fe	Ni	Zn	Al	Sn
2M_1mL/min	2M_2mL/min	4M_2mL/min					
Initial solution (%)	0.3	66	4	0.5	0.6	28	0.6
Treated solution (%)	0.03	99.1	0.27	0.55	0.01	0.02	0.02

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Al precipitation

Element	Ag	Cu	Fe	Ni	Zn	Al	Sn
Raffinate (%)	0.1	0.8	13	0.3	1.9	84	0.1
Recovered solid (%)	0.0	0.7	13	0.1	0.9	86	0.1
Filtrate (mg/L)	0.1	0.6	0.6	0.4	4.3	0.0	0.1

↑ pH to 8.5 was possible recover Al as a solid \Rightarrow $\text{Al}(\text{OH})_3$

Correction of the pH \Rightarrow

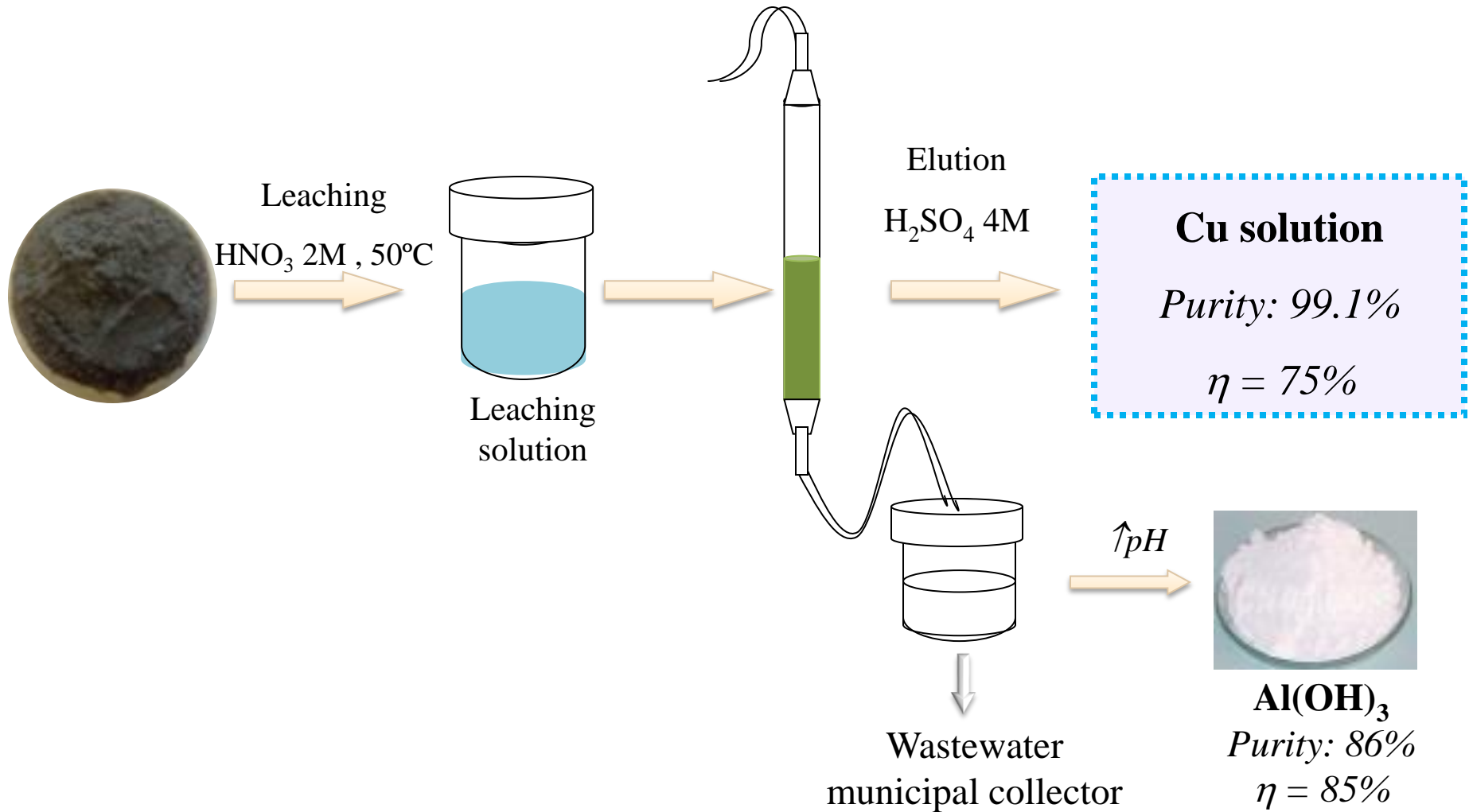
Discharged to the municipal wastewater collector

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Nearly closed overall process



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Conclusions

- The selected leaching conditions allowed extracting a high amount of Cu, together with other metals, mainly Al. No Au was leached.
- The bispicolylamine resin allowed separating Cu efficiently from other metals and a final solution of Cu with a grade of purity of 99.1% was achieved.
- Al present in the raffinate, at high concentration was recovered by precipitation, giving a solid of aluminum hydroxide.

A simple (two-steps) and nearly-closed cycle process was developed to recover Cu and Al from end life PCBs with high yield and purity

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Acknowledgments

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