

Hydrometallurgical Recycling Process for Mobile Phones Printed Circuit Boards Using Ozone

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The metal leaching efficiency was calculated by Eq.1:

$$R = \frac{V_r \cdot C_i}{m_p \cdot \frac{x_i}{100}} \cdot 100\% \quad (1)$$

where R is the metal leaching efficiency, V_r is the leach liquor volume [dm³], C_i is the concentrations of metal in the leach liquor [g/dm³], m_p is the mass of PCB, and x_i is the metal mass fraction [%].

The 5g sample for analysis was prepared as a pressed pellet (5g PCB ground). (The result in the Table 1 is the average of 3 samples). V_r was assumed for the calculations - the volume of the solution measured after 4 h (after the experiment). At the beginning there was 200ml, after 2 hours less solution and after 4 h even less. For example, 150ml left.

The results in the table differ after 2h and 4h. Which affects the final result of the leaching degree.

Table 1. Copper concentration obtained after leaching in HNO₃, HCl and H₂SO₄ with the addition of H₂O₂ or O₃ within 2 and 4 hours.

Leaching agent	Additional oxidiser	Temperature [K]	Concentration % 2h	Concentration % 4h
HCl	H ₂ O ₂	298	20.18	18.24
H ₂ SO ₄	H ₂ O ₂		19.32	13.70
HCl	O ₃		0.88	4.82
H ₂ SO ₄	O ₃		0.77	2.72
HNO ₃		313	100.00	91.30
HCl	H ₂ O ₂		82.28	78.06
H ₂ SO ₄	H ₂ O ₂		26.09	24.83
HCl	O ₃		14.88	26.51
H ₂ SO ₄	O ₃	353	2.89	17.63
HNO ₃			96.92	74.79
HCl	H ₂ O ₂		24.79	28.51
H ₂ SO ₄	H ₂ O ₂		18.10	15.49
HCl	O ₃		40.11	70.17
H ₂ SO ₄	O ₃		3.49	5.21

HNO ₃	100.00	79.96
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Table 2. Tin concentration obtained after leaching in HNO₃, HCl and H₂SO₄ with the addition of H₂O₂ or O₃ within 2 and 4 hours.

Leaching agent	Additional oxidiser	Temperature [K]	Concentration [g/dm ³]	
			2h	4h
HCl	H ₂ O ₂	298	100.00	100.00
H ₂ SO ₄	H ₂ O ₂		4.57	6.21
HCl	O ₃		26.91	24.39
H ₂ SO ₄	O ₃		9.96	8.56
HNO ₃				
HCl	H ₂ O ₂	313	9.56	100.00
H ₂ SO ₄	H ₂ O ₂		1.51	1.35
HCl	O ₃			100.00
H ₂ SO ₄	O ₃		3.87	5.15
HNO ₃				
HCl	H ₂ O ₂	353	47.69	100.00
H ₂ SO ₄	H ₂ O ₂		1.46	1.30
HCl	O ₃		100.00	100.00
H ₂ SO ₄	O ₃		1.40	5.92
HNO ₃				

Table 3. Gold and silver concentration obtained after leaching in HNO₃, HCl and H₂SO₄ with the addition of H₂O₂ or O₃ within 2 and 4 hours.

Leaching agent	Additional oxidiser	Temperature [K]	Concentration Au [g/dm ³]	
			2h	4h
HCl	H ₂ O ₂	298	2.72	2.84
HCl	H ₂ O ₂	353	7.61	12.46
HCl	O ₃	313	0.92	2.95
HCl	O ₃	353	6.89	5.46
Leaching agent	Additional oxidiser	Temperature [K]	Concentration Ag [g/dm ³]	
			2h	4h
H ₂ SO ₄	O ₃	313		1.62
HCl	O ₃	353	1.83	12.94