Hydrometallurgical processing of waste gas purification dust

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Waste gas purification dust (WGPD) from waste incineration plants contains harmful substances, which prevents its use as a secondary raw material. In this work, dissolution of metals in various organic and inorganic solutions was investigated.

Introduction

Most of the municipal waste and some of other waste is nowadays used as fuel at waste incineration plants. This creates a need for improving the circularity of the incineration products and side streams.

In order to recycle WGPD, harmful and valuable metals should be removed and recovered. In this work, dissolution of Cu, Fe, Ni, Pb, and Zn in different organic and inorganic acids and ethaline was investigated.

The main objective was to decrease the total metal concentration in WGPD below 1000 ppm. Another interest was the selectivity of metal dissolution towards iron (Fe), with the goal of finding a solvent that would extract the metals of interest, but leave iron in the WGPD.

Materials and Methods

WGPD shown in Figure 1 was provided by Ekokem Oyj. The concentrations of metals in the WGPD are shown in Table 1.

Figure 1. Waste gas purification dust

Table 1. Metal concentrations in WGPD

METAL	FRACTION (ppm)
As	2700
Cr	300
Cu	1100
Fe	14100
Ni	300
Pb	6800
Sb	400
Zn	10500

In order to find the most effective solvent, acetic acic, citric acid, ethaline, hydrochloric acid, oxalic acid, and sulphuric acid were tested by leaching the WGPD sample for 24 h on a heated magnetic stirrer. The metals of interest were Cu, Fe, Ni, Pb, and Zn. Redox-potential, pH as well as the final yield of metals into the solution were measured. In total 41 experiments were conducted, 30 solutions at 33 °C and eleven experiments at 50 °C. The used concentrations are shown in Table 2. Ethaline was used as a 2:1 ethtylen glycol : choline chloride solution.

Table 2. Concentrations (M) of acids used in 24 hour leaching tests. The volumes of all liquids were 100 ml.

$[C_2H_2O_4]$ M	$[C_2H_4O_2]$ M	$[C_6H_8O_7]$ M	[HCl] M	$[H_2SO_4]$ M	[HCl] + $[H_2SO_4]$ M
0.5	0.5	0.5	0.2	0.2	0.2
1	1	1	0.5	0.5	
	2	2	1	1	
	3	3	2	2	
	5	4	3	3	
	7		5	5	
			7	7	

The best organic and inorganic solution was tested in bigger scale by batch leaching, schematics of reactor presented in Figure 3. The leaching time was 4 h, and samples and ph and redox were taken at 0.5, 1, 2, and 4 h. The tests were made as a factor test series, factors and their values are shown in Table 2. Therefore, nine experiments were performed for each solvent.

Table 3. The factors and their values used in batch leaching experiments.

TEMPERATURE (°C)	CONCENTRATION (M)
HCl	
30	0.15
60	0.3
90	0.6
$C_6H_8O_7$	
30	0.15
50	0.3
70	0.6

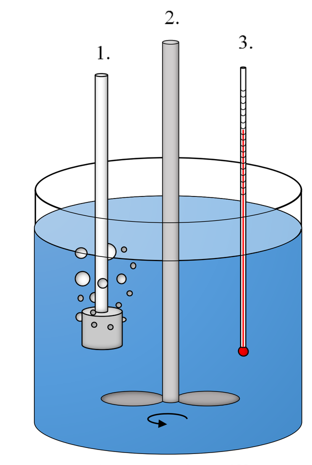

Figure 2. A schematic illustration of the batch leaching reactor, in which 1. presents an aeration sparge sinter, 2. a propeller for mixing the solution, and 3. a thermometer. ©Rasmus Björkvall, 2016.

Results

Citric acid and hydrochloric acid gave the highest metal dissolution in 24 hour leaching tests, considering the industrial scale and availability. Metal extractions to organic and inorganic solvents are shown in Figures 3 and 4, respectively.

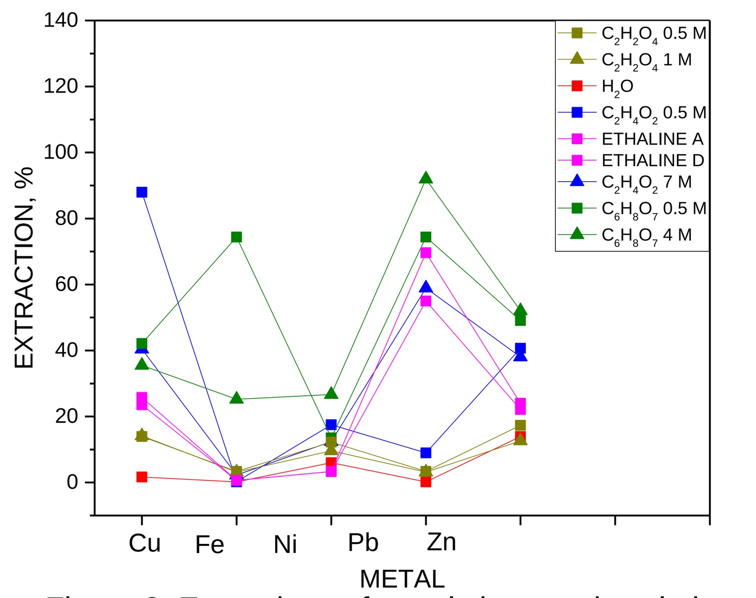

Figure 3. Extractions of metals in organic solutions and water.

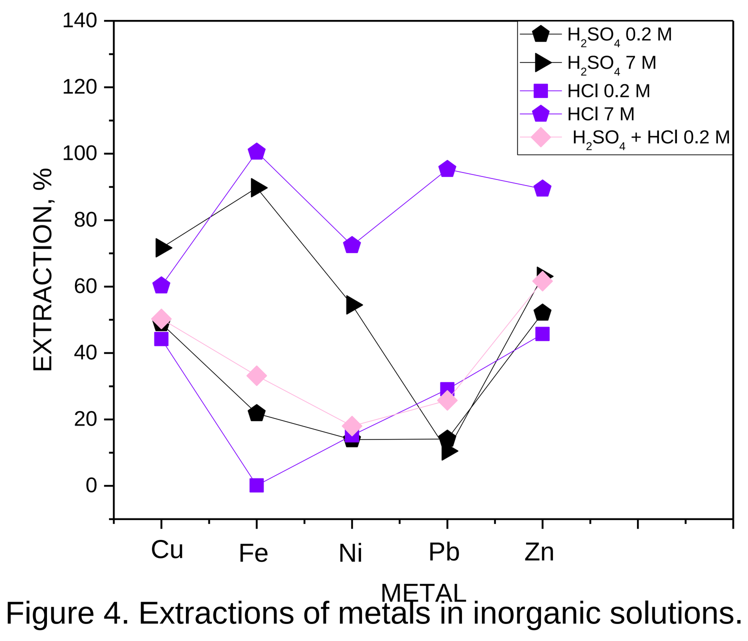

Figure 4. Extractions of metals in inorganic solutions.

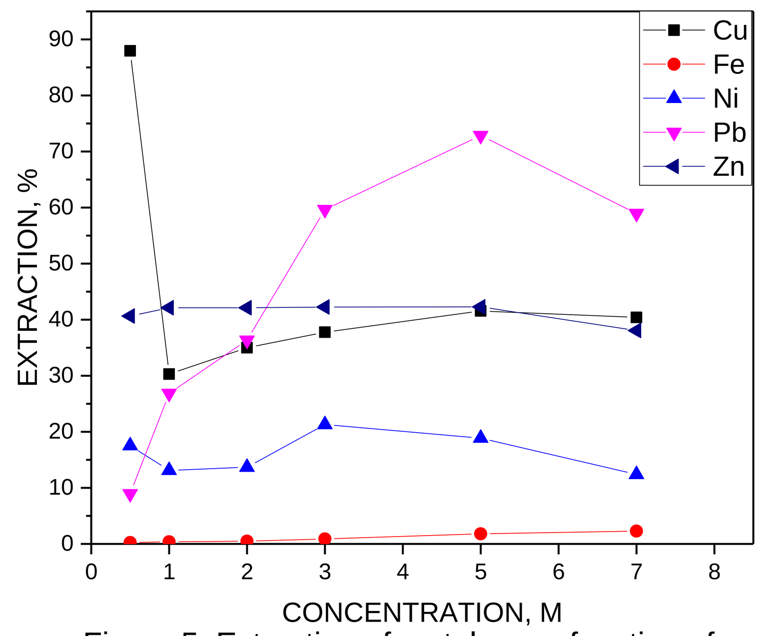

Figure 5. Extraction of metals as a function of concentration in acetic acid.

Figure 5 shows that Pb leaching in acetic acid was quite selective towards Fe (>70% Pb leaching with <2% Fe leaching in 5M acetic acid solution). This phenomenon was valid for Pb specifically at higher concentrations.

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