Recovery of Copper and Zinc from Brass Wastes via Ionic Liquid Leach

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Abstract

Brass production by smelting copper scrap alloys and zinc ingots in electric furnaces is a common pyrometallurgical process. Copper scrap is melted at about 1050 °C and zinc is added in the liquid pool. Wastes like ash and dust occur during that smelting step containing a considerable amount of metallic values. The recovery of these metals via conventional acid or alkali leaching techniques may not be environmentally friendly due to large acid/alkali consumption and high waste water generation. Therefore, in order to decrease those adverse effects alternative extractants should be developed. In recent years ionic liquids are found to be most promising leaching agents candidate because of their high leaching efficiency, low toxicity and little environmental impact. The aim of this study is to investigate the possibilities of leaching brass wastes using a selected ionic liquid after extensive literature search. Brass ash from Turkey, Ozer Metal, containing 3.4 % Al, 5.81 % Ca, 22 % Cu, 12.17 % Si and 53.92 % Zn mostly copper presents as metallic and remaining part as oxide have been leached using ionic liquid 1-butyl-3-methyl-imidazolium hydrogen sulphate ([bmim]HSO_4) solution at ambient pressure. Results have showed that [bmim]HSO_4 is efficient ionic liquid for the leaching of brass ash providing 99 % Zn and 24.82 % Cu dissolution efficiency at the 50 % (v/v) ionic liquid concentration in solution.

The full paper will be published soon after the conference in a scientific journal.

1 Introduction

High consumption of copper and copper alloys has resulted in significant amount of waste releasing to the environment during production of copper and its alloys. Therefore, the extraction and recovery of copper and zinc from industrial wastes has inevitably become crucial both from the aspect of economics and environmental protection [1-4]. Brass smelting wastes are simply classified as brass

ash and flue dust. While brass flue dust consists of high level of zinc, brass ash contains both remarkable amount of zinc and copper. The origin of this ash is slag which is generated during melting of brass alloys. After a certain treatment steps of slag metallic and non-metallic parts are separated and metallic part is melted again into the furnaces. Remaining non-metallic part called "brass ash" is stored for the recovery of copper and zinc via metallurgical processes [5, 6].

Room temperature ionic liquids are new generation molten salts, generally composed of organic cations with organic or inorganic anions. The most attractive feature of these molten salts is task specific design ability with different anions and cations combinations in order to obtain desired physico-chemical properties. Also, their unique properties such as low vapor pressure, non-flammability, low toxicity, negligible volatility and thermal stability make them useful for a variety of applications including, separation techniques, biochemistry, catalytic reactions and electrochemical applications [7-11]. Water soluble properties and acidic character of ionic liquids allow their use in dissolution of metals [12, 13]. Whitehead et al. have studied leaching of sulphidic copper, gold and silver ores in [bmim]HSO_4 ionic liquid and reported promising results for the extraction of these metals [14-15]. Leaching of chalcopyrite with same ionic liquid has also been investigated [16] and found that pure ionic liquid and its aqueous solutions are more effective than conventional acid solutions for the leaching of chalcopyrite. In this study it has been investigated recovery of copper and zinc from industrial brass ash using ionic liquid 1-butyl-3-methyl-imidazolium hydrogen sulphate ([bmim]HSO_4).

2 Experimental Procedure

The brass ash used in this study was provided by a brass manufacturing plant in Turkey. Concentration of metals in brass ash given in Table 1 was determined by inductively coupled plasma optical emission spectrometry (ICP-OES) and its phase analyses were done by X-ray diffraction (XRD).

Table 1: Chemical composition of brass ash (%)

Zn	Cu	Ca	Al	Mg	Na	K	S	Cl	Si
53.92	22.00	5.81	3.4	0.31	0.30	0.35	0.32	0.35	12.17

The brass ash mostly is in the form of metal oxide compounds except copper. Significant amount of copper also found as metallic phase.

Ionic liquid 1-butyl-3-methyl-imidazolium hydrogen sulphate ([bmim]HSO_4) was of analytical grade. All aqueous ionic liquid leach solutions were prepared with deionized water. The vessel used in leaching tests was a closed glass beaker, placed in a temperature controlled water bath. The leaching tests were carried out at pulp densities of 100 g/L using 100 mL constant volume of leach solution at temperature 70 °C. The solutions were stirred magnetically at 400 rpm during leaching time. The ionic liquid concentration in aqueous solution was 10 %, 30 % and 50 % (v/v). Before sampling, magnetic stirrer was turned off in order to settle the solids in suspension. Samples were

taken using pipette dipped into the top part of the solution. After that samples were filtered using filter paper and metal concentrations in liquors were analysed by ICP-OES.

3 Results and Discussion

Since 1-butyl-3-methyl-imidazolium hydrogen sulphate [bmim]HSO_4 is water soluble, relatively cheap, environmentally friendly and common ionic liquid was selected for the leaching reagent in this study. It is also known that [bmim]HSO_4 acts as acid in aqueous solutions [14-15]. Figure 1 shows the effect of the selected ionic liquid concentrations on the extraction ratio of copper with leaching time. It can be seen from the figure that no remarkable copper dissolution was reached at concentrations 10 % and 30 % during five hours. When [bmim]HSO_4 concentration is raised to 50 %, copper started to dissolve slowly and its dissolution ratio increased to 25 % after five hours. However, this extraction ratio is still not sufficient according to the aimed dissolution ratio of copper. The main reason for limited solubility of copper in the aqueous ionic liquid may be metallic copper which found more than oxidic copper in brass ash.

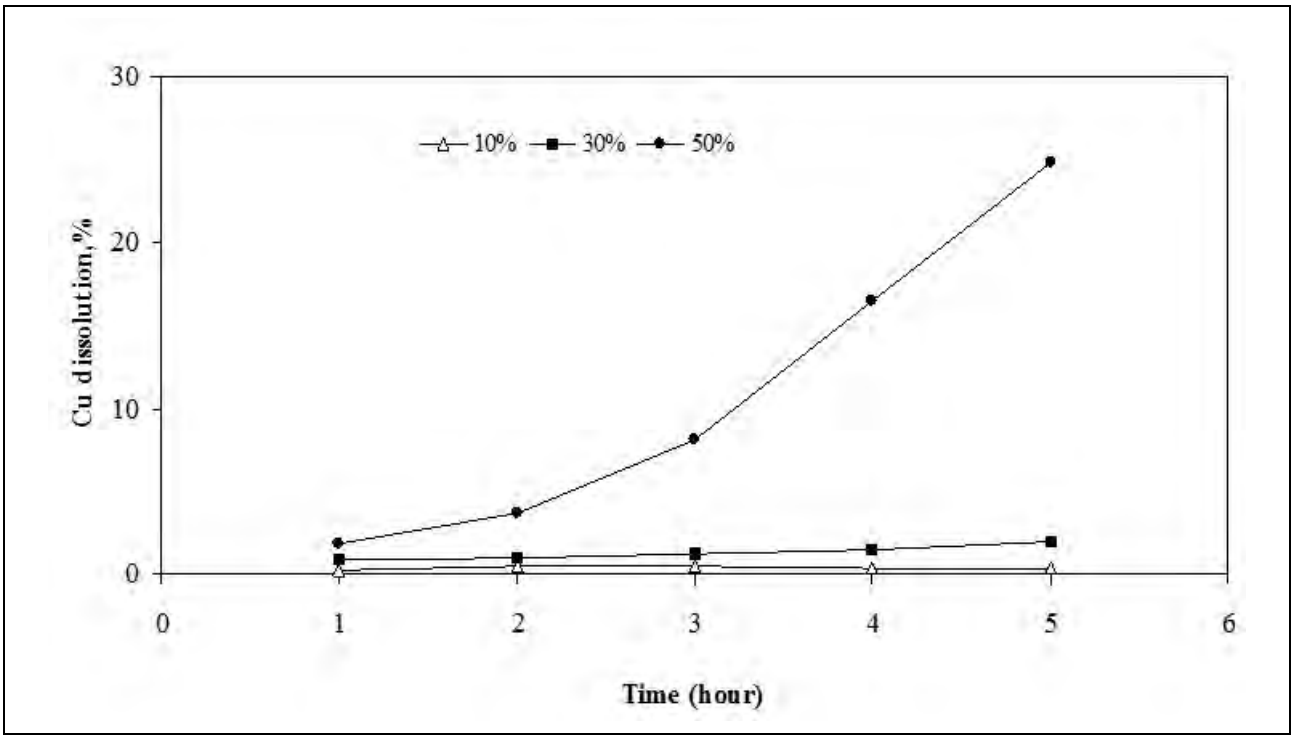

Figure 1: Effect of the bmimHSO_4 concentration on the copper dissolution

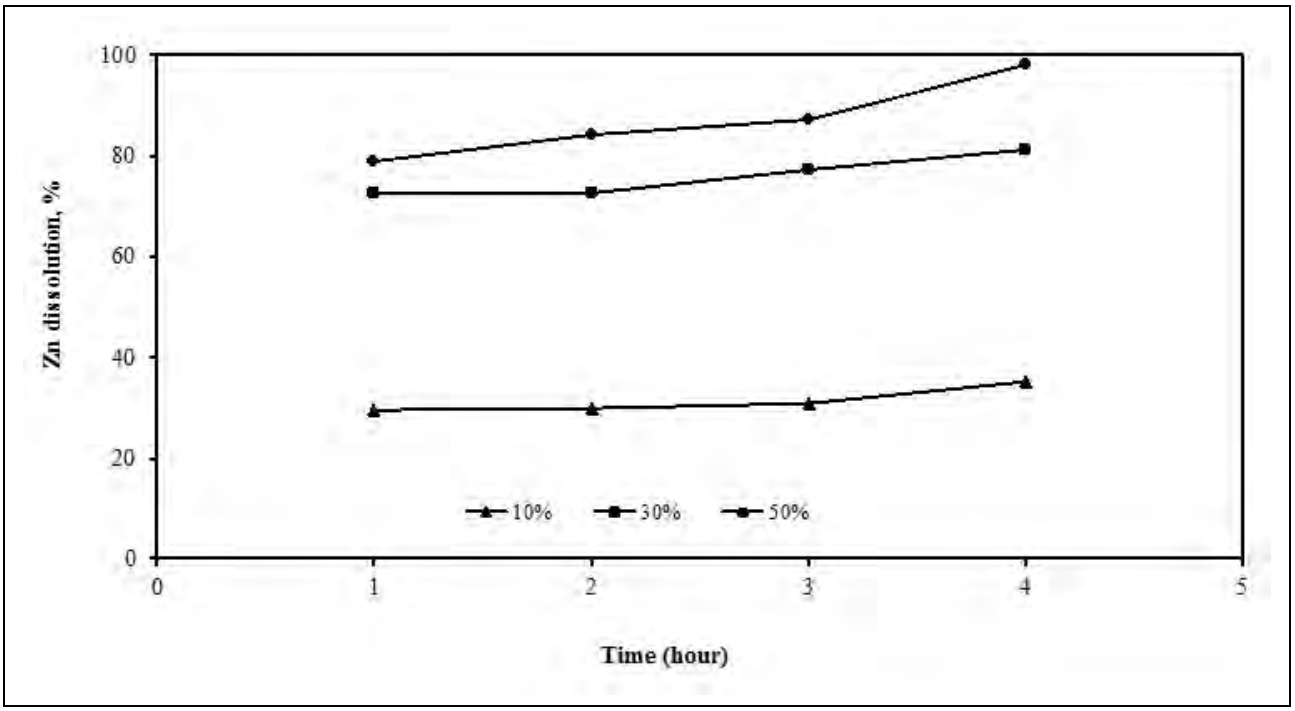

Figure 2: Effect of the bmimHSO_4 concentration on the zinc dissolution

Figure 2 shows the extraction ratio of zinc in various ionic liquid concentrations in water. Zinc extraction percentage increased significantly as the ionic liquid concentration raised from 10 % to 30 %. There was no significant effect of leaching time on dissolution ratio of zinc for both [bmim]HSO_4 concentrations ratio. But, the increment in the extraction was not negligible when the acid concentration raised from 30 % to 50 % at time of four hours. 99 % zinc dissolution ratio was achieved in 50 % ionic liquid concentration at the end of four hours leaching process.

4 Summary

This study shown some promising results for recovery of copper and zinc from industrial brass ash via ionic liquid leach. Ionic liquid [bmim]HSO_4 can be used an efficient leaching agent acting as an acid for leaching of brass ash. All zinc was dissolved successfully at the concentration of 50 % [bmim]HSO_4 in aqueous solution. Though it is known that oxygen in [bmim]HSO_4 plays role as an oxidant in leach solution, metallic copper extraction from brass ash was not satisfied in the absence of additional oxidant. These results in fully version shall be published in scientific journal.

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