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Leaching effects of metal from electroplating sludge under phosphate participation in hydrochloric acid medium

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Abstract

In recent years, with the rapid development of the electroplating industry, electroplating sludge has reached much attention. Electroplating sludge contains heavy metals such as nickel, copper, cadmium and chromium. To avoid releasing metal into the environment, removal of heavy metals from the electroplating industry is highly desired. In this study, effects of leaching metal from electroplating sludge under phosphate participation in hydrochloric acid medium were measured. The effects of the amount of hydrochloric acid, phosphoric acid concentration, temperature, and liquid to solid ratio along with leaching time were investigated and measured using inductively coupled plasma-atomic emission spectrometry (ICP-AES). Using the optimized conditions of 1.5 mol/L hydrochloric and phosphoric acid concentration, liquid to solid ration 10:1 and temperature 40 ^{o}C, actual electroplating sludge was treated. The leaching rate of copper was measured as high as to 80.6% under optimal conditions.

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Keywords: Electroplating sludge; hydrochloric acid medium; liquid-solid ratio; metal leaching;

1. Introduction

Industry which apply electroplating generate electroplating sludge (EPS) with heavy metals, such as nickel, copper, cadmium, iron and chromium, whose concentration is well above permitted levels and detrimental to the health of living organisms[1]. It was because of the inability of these metals to biodegrade and their tendency to accumulate in the tissues of organisms when exposed in the environment. And there are increasing amounts of EPS produced as

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heavy-metal wastes, for example, China yearly generates more than 100,000 tons which is featured by high enrichment of metals (Ni, Cu, Zn, Fe and Cr etc) as well as organics (surfactants etc) [2,3]. In the meantime, however, if the heavy metals from EPS can be effectively removed, both the filtered sludge and heavy metals have a great possibility of being directly reused. Currently, EPS are disposed mainly by landfilling and brick-making [4,5], both would cause potential pollutions to the ecoenvironment. Hence, removal of heavy metals from EPS prior to its discharge into environment is highly desired [6,7].

Traditionally, conventional treatment techniques, such as electrolysis[8], ion exchange[9, 10], membrane separation [11] and microbiological methods[12-14], have been employed to remove heavy metals from EPS. But the most common method to recover metals from electroplating sludge is the acid-base extraction procedure[3].

In this study, effects of leaching metal from electroplating sludge under phosphate participation in hydrochloric acid medium were measured. The effects of the amount of hydrochloric acid, phosphoric acid concentration, temperature, and liquid to solid ratio along with leaching time were investigated and measured using inductively coupled plasma-atomic emission spectrometry (ICP-AES).

2. Experimental

2.1. Materials

All solvents used such as H_2SO_4、HCL、H_3PO_4 were AR grade and supplied by Sinopharm Chemical Reagent Co., Ltd, Shanghai, China. All aqueous solutions were prepared with distilled water without further purification. Electroplating sludge (EPS) was obtained from a Shanghai electroplating plant. Moisture of EPS were measured in an air-drying oven at 105℃ and found 69.45%.

Heavy metals concentrations of sludge oxidized solution were determined by inductively coupled plasma emission spectrometer (A-6300, Thermo, USA). Water bath shaker (DF-101S water bath), was from KESHENG Instrument Co., Ltd.,Shanghai, China.

2.2. Experiments

The EPS were mixed, dried in a Desktop multi-function lyophilizer, grinded to fine powders before use. Then measurable dried EPS powder were under the conditions that one changed of the variables and others keep still such as liquid-to-solid ratio, temperature and different acid for leaching 4 hours. After that, to measure the concentrations of the heavy metals in the leaching solution, the dried sludge samples were placed into 100 mL beaker. Next, 10 mL sulphuric acid (98%) was added and the sample was digested nearly dry on the electric hot plate at a low temperature. The samples were transferred into 100 mL bottles with deionized water and stored at 4ºC for further analyses of the heavy metals: aluminium (wavelengths 167.0), copper (wavelengths 324.7) and iron (wavelengths 238.2) with the use of an inductively coupled plasma atomic emission spectrometry (ICP-AES) (Prodigy, Leeman, USA). Three different samples of the same sludge were prepared for the analyses.

3. Results and discussion

3.1. Effect of hydrochloric acid on leaching rate

The experiments were under 25ºC and liquid to solid ratio 3:1, at series of HCl solution were 0.25, 0.5, 0.75, 1,1.5, 2 mol/L for investigating the effect of HCl on metal leaching rate from the sludge.

From the results showed in Fig. 1, it can be seen that with the increase of HCl concentration, the metal leaching rate were rapidly go up. When the concentration of HCl was 1.5mol/L, the metal leaching rates were up to highest for all metals measured. After that, when the concentrations of HCl were raise continually, the leaching rate were decrease sharply. On the basis of the mechanism of leaching, the reaction will consume amount theory acid, in order to keep the reaction kinetics of balance at the same time, it should be control excessive acid in the reaction. But the leaching reaction is still under the influence of coexisting ions in the solution of synergy mechanism, such as the addition of excess acid for more than 2mol/L, and did not improve the electroplating sludge increased concentration of heavy