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TWO-PHASE LEACHING FOR METAL RECOVERY FROM WASTE PRINTED CIRCUIT BOARDS: STATISTICAL OPTIMIZATION

Article Highlights

- Two-stage leaching was employed for the efficient recovery of heavy metals from PCBs
- Optimization by RSM results in a leaching efficiency of 97.06% Cu, 94.66% Sn, 96.64% Zn, and 96.89% Pb
- Simultaneous extraction has proved to be successful in separating and recovering heavy metals

Abstract

The rapid growth of technology is inevitable in humankind's life and has a significant stint in electronic waste (e-waste) generation. Electronic waste possesses tremendous environmental and health effects, and one such major contributor to it is printed circuit boards (PCBs). The present work deals with the recovery of heavy metals from PCBs by using aqua regia as a leaching reagent in two stages (first stage HCl and HNO_3 and second stage HCl and H_2SO_4). The response surface methodology was used to determine the optimal recovery conditions for the heavy metal ions: the recovery time of 5 h, the pulp density of 25 g/L, and the temperature of 90.1 °C with desirability 0.761. These optimized values provide a maximum recovery rate of Cu (97.06%), Sn (94.66%), Zn (96.64%), and Pb (96.89%), respectively. EDXs are used to analyze the metal concentrations of the sample before and after treatment.

Keywords: aqua regia, e-Waste, printed circuit board, response surface methodology, two-step leaching.

Electronic waste (e-waste) means electrical or electronic waste. Technological advancement, business expansion, economic growth, and shorter electrical and electronic equipment (EEE) have contributed to a significant rise in e-waste. PCBs are the main components of this e-waste, which typically includes 40% metals, 30% ceramics, and 30% plastics [1,2]. The metallic composition consists primarily of 10-30 % of cu and other metals such as Sn Zn, Pb Ni, Fe, Ag, Cd, Au, etc., in different proportions based on PCB sources [3]. The recovery of metals from PCBs is very difficult due to the heterogeneous distribution of materials in PCBs. An analysis of PCBs by atomic adsorption spectroscopy shows that 2 kg of PCBs contains 5.94% of Sn, 21.3% of Cu, 3.2% of Pb, and 2.24% of Fe [4]. Informal processing of e-waste in developing countries can lead to adverse effects on human health and environmental pollution. In 2016, 44.7 million metric tons of e-waste were produced worldwide [1,2]. An estimated 3.8 tons of e-waste were produced annually in India, of which only 19,000 tons were recycled. India faces a considerable challenge to dispose of an estimated 4.5 tons of e-waste per year produced domestically and imports from abroad [5]. If the e-waste was directly disposed of by filling the soil without removing metal ions from PCBs, the pollution of land and water supplies would result.

E-waste recycling has been accomplished through formal and informal techniques in several countries [6]. While formal recycling techniques ensure protection and efficient separation but are costly to install and

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