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Enhancing the adsorption of chromium(VI) from the acidic chloride media using solvent impregnated resin (SIR)

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HIGHLIGHTS

- ▶ Both polymeric support and extractant of SIR enhanced its adsorption capacity for chromium(VI).
- ▶ Adsorption of chromium on SIR followed Freundlich isotherm and Thomas model.
- ▶ Chromium from chromium-loaded SIR was eluted effectively by 0.1 M NaOH solution.
- ▶ The SIR can be used for adsorption of chromium at least in three cycles.

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ABSTRACT

In this study, the solvent impregnated resin (SIR) based on impregnation of Cyanex 923 in Amberlite XAD-7HP resin was used to remove hazardous chromium(VI) from the acidic chloride media. The results showed that SIR adsorbed chromium effectively when the solution pH was low (acidity of solution; 0.3–2.0 M). The adsorption mechanism of the SIR for chromium(VI) could be explained taking into account the interaction between the protonated oxygen atoms of polyacrylate (ester group) in the resin and the solvation of Cyanex 923 with trioxochloromate (CrO_3Cl^-) complexes. The involvement of both the polymeric support and extractant for chromium adsorption enhanced uptake capacity of SIR to 28.2 mg Cr/g SIR (1.0 g SIR contained 0.375 g the extractant) compared to that of 16.9 mg Cr/g resin. Freundlich isotherm was more suitable than Langmuir isotherm and Thomas model described well the adsorption behavior of chromium in column. Chromium was eluted effectively from chromium-loaded SIR by 0.1 M sodium hydroxide solution, and elution efficiency reached 92% in the first stage. The regenerated SIR when reused for adsorption of chromium showed almost the same level of efficiency at least in three cycles.

1. Introduction

In electronic manufacturing industries, chromium is widely used as a plating material (in chromate conversion coatings) to inhibit the corrosion of electronic parts, fasteners and sheet metal and as pigments in plastics used for printed circuit boards (PCBs). The waste effluents of these processes contain hazardous chromium(VI) with the concentration exceeding the local discharge limit. E-waste is reported to be a fastest growing solid waste stream and therefore, recycling of e-waste is considered to be a major issue in conserving resources and reducing environmental pollution. Hydrometallurgical technology is an alternative method to the traditional pyrometallurgy for recycling of e-waste because of its advantages such as low capital cost with suitability for small scale application, reduced environmental degradation and high metal recoveries [1]. In hydrometallurgy, leaching is a fundamental process using lixiviants such as acids, cyanide, thiosulfate or alkaline solutions, to dissolve desired metals. Electro-generated chlorine has been used as a potential method for leaching metals from electronic waste [2,3]. The solutions obtained from leaching process contain valuable metals and hazardous chromium(VI). It is known that chromium(VI) is a highly toxic element to humans and causes lung cancer, liver, kidney and gastric damage [4,5]. Therefore, chromium(VI) must be removed from waste solutions before discharging to the environment because chromium(VI) is soluble and easily transported in water resources [6]. Chromium(VI) ions contaminate the surface and underground water due to the migration of hexavalent chromates. The limit for discharge of Cr(VI) into the land surface waters is 0.1 mg/L [7].

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