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Studies on extraction of Gallium (III) from chloride solution using Cyphos IL 104 and its removal from photodiodes and red mud

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Abstract

An efficient solvent extraction process was developed for extraction of gallium (III) from acidic chloride medium using the ionic liquid Cyphos IL 104 diluted with toluene. The kinetics of gallium extraction was very fast. The extraction percent of gallium was found to increase with increase in hydrochloric acid concentration in the feed and 99.8% extraction of gallium was achieved with 3 M HCl. The stoichiometry of the formation of gallium-Cyphos IL 104 complex was found to be 1:1 and the corresponding extracted species was proposed as $[R_3R' PGaCl_4]$. Presence of sodium chloride increased the percentage extraction of gallium. The thermodynamic parameters calculated from the temperature variation study suggested the process was spontaneous and endothermic. Loading capacity of the ionic liquid was executed and the stripping study of the loaded organic phase was investigated using four stripping agents namely HCl, H_2SO_4, NH_3 and HNO_3 each having concentrations of 0.5 mol/ L. It was found that HCl performance was poor and the rest three could recover > 90% gallium from the loaded organic phase. Binary separation studies were carried out using commonly associated metal ions with gallium (Al (III) / Zn (II) / Fe (III) /Cu (II) /Ni (II)) and the process was extended to study the recovery of gallium from leach liquors of photodiodes and red mud sample.

Key words: Gallium, Cyphos IL 104, extraction, separation, photodiode

1. Introduction

Gallium is one among the fourteen energy critical elements labelled in the periodic table by the American physical Society (APS) and Materials Research Society (MRP). The energy critical elements have the capacity to capture, transmit and store energy. Gallium is used in semiconductors, mobile phones, blue and green LEDs, solar panels etc. It is also used to create brilliant mirrors. Unfortunately, it is a scarce metal having no primary source and mostly associated with ores of aluminium (bauxite) and zinc (sphalerite). So the important sources of gallium are the alkaline Bayer's solution (Hoffmann, 1989) and acidic sulfate solution of zinc resulted from hydrometallurgical route (Mihaylov and Distin, 1993). Recovery of gallium from aqueous solution is commonly achieved by complexation (Dumortier et al., 2005), precipitation (Sadeghi and