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Gallium Recovery from Bayer Liquor Using a Chelating Resin

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Extended Abstract

This paper investigates the recovery of gallium from the aluminate solution of Bayer process (Bayer liquors), using a synthetic chelating resin. Gallium is extensively used in modern electronics and strategic energy technologies [1, 2]. Today, almost 95% of the global gallium production is used in semiconductor applications, although new uses for the metal in high-tech alloys and energy technologies are constantly being discovered. The strategic importance of gallium in low-carbon technologies makes it critical to the global economy. For the Europe economy, it is considered a highly important raw material of high supply-risk and therefore, it is included in the EU list of Critical Raw Material (CRM), since 2011.

The minerals of gallium are rare and of no significant economic importance to serve as primary sources of the element or its compounds. They are present usually in trace amounts in the aluminum, zinc and iron ores. Generally, gallium is produced as by-product of these ores processing or from other secondary resources, like as fly ash and electronic waste. It is estimated that about 90% of the primary gallium worldwide is produced from the aluminate solution obtained in Bayer process used for the production of alumina from bauxite [3]. The gallium content in Bayer liquor is low (about 200 ppm), making ion-exchange the most efficient method to be industrially applied for its recovery [4].

In this work, the recovery of gallium from the Bayer liquor was studied, using a commercial chelating resin based on the amidoxime functional group, the Puromet MTS9701 (Purolite Ltd., UK). The resin's capacity and selectivity and the kinetics of gallium recovery were experimentally investigated, while an attempt to understand the process mechanism and the factors affecting the process efficiency was also made. The process equilibrium was investigated according to Langmuir and Freudlich isotherms, while its kinetics was analyzed using the pseudo first- and second-order empirical models. Moreover, the regeneration process of resin was investigated with acidic and basic solutions and its performance in sequential cycles' operation was evaluated.

According to the experimental results, the Freudlich isotherm and the pseudo second-order kinetic model were proved more accurate to describe the equilibrium and kinetics, respectively, of gallium loading on the chelating resin used. The ratio of resin to solution was the most important factor of process efficiency. Equilibrium was reached after 5 h, when more than 75% of gallium was selectively extracted from the Bayer liquor, using a resin to solution ratio equal to 50 g/L. The maximum extraction of gallium was about 80%, after 24 h. The used resin was proved to be highly selective for gallium, which was thought to be bound on the nitrogen atom of amidoxime group. The in-depth understanding of the binding mechanism between amidoxime and gallium could result in designing a more efficient process for the recovery of gallium from Bayer liquors.

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