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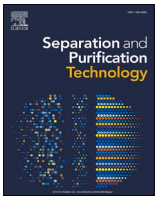

Solvent extraction for high separation strategy of light and heavy rare earth elements from a sulfate-leached solution of low-grade monazite

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ABSTRACT

A novel separation strategy for light REEs (Ce^{4+} and La^{3+}) and heavy REEs (Y^{3+} and Eu^{3+}) from a low-grade monazite ore leached solution in a sulfate medium was studied to achieve a higher selectivity of metal ions. A prior separation of higher valence Ce^{4+} was performed using 8.0 vol% Cyanex 923, 0.2 mol/L H_2SO_4 in the aqueous feed, an organic-to-aqueous (O/A) phase ratio of 1, and a temperature of 25 °C, yielding the separation factor $\beta_{(Ce4+/REEs3+)} = 9424$. A reductive back-extraction of $Ce_2(SO_4)_3$ was efficiently performed using a solution mixture of $H_2SO_4 + H_2O_2$ with concentrations $\geq$1.0 mol/L each. Further, Y^{3+} from Ce^{4+}-depleted solution was selectively extracted using 2.0 vol% Cyanex 572 organic extractant and 0.2 mol/L H_2SO_4 in aqueous feed at an O/A ratio of 1, yielding a separation factor of 6438 at 25 °C. The subsequent extraction of Eu^{3+} over La^{3+} was carried out at 2.5 vol% D2EHPA, 0.05 mol/L H_2SO_4 in the aqueous feed, an O/A ratio of 1, and a temperature of 55 °C, yielding $\beta_{(Eu3+/La3+)} = 5787$. Both Y^{3+} and Eu^{3+} from the individually loaded organics were stripped with an efficiency of ~ 99.9% by contact with 2.0 mol/L $(COOH)_2$ prepared in a 1.0 mol/L HCl solution. The remaining La^{3+} in the raffinate was directly precipitated by adding $\geq$0.01 mol/L $(COOH)_2$ crystals at 90 °C. This article provides an efficient and highly selective recovery of REEs from a low-grade monazite leached solution with higher separation values $\beta_{(Ce4+/REEs3+)} = 9424$ and $\beta_{(Eu3+/La3+)} = 5787$.

1. Introduction

To achieve the carbon neutrality target by 2050, the global community has pledged to shift towards renewable energy practices that could significantly reduce the environmental burden. Rare earth elements (REEs), a group of 17 elements that comprise 15 lanthanides, scandium, and yttrium in the periodic table with unique properties [1,2], are useful for the development of green and energy-efficient technologies [3,4]. Besides their indispensable role in green energy technologies, REEs have a major role in many other industrial areas like petro-refinery, catalysts in organic synthesis, metallurgy, luminescent materials, permanent magnets, superconductor materials, etc. [5,6]. Due to the soaring demand for REEs and a wider gap between their supply and demand, they are listed as the most critical elements by the United States of America, the American Physical Society, and the European Union [7,8].

On the contrary, China alone is dominating more than 70% of the global market for REEs, with a restricted export quota of only 31,000 tons since 2012 [9,10], which creates pressure on the businesses that consume REEs as their raw materials. To cope with this situation, the worldwide search for new deposits that include the potential exploitation of low-grade ores has become attractive for the metallurgical industries. South Korean industries are also struggling to receive the unrestricted flow of rare earths because it is one of the topmost consumers of REEs, mainly in the electronics and automobile industries [11]. Vein-deposited Korean monazite accumulated by hydrothermal and weathering effects along with the development of iron ore mines is one of the potential sources identified by the Korea Resources Corp. [12]. However, the mitigation of rare earths' criticality is quite difficult without simple and efficient processing techniques [13] due to the recent export bans on rare earths' processing technology by China [14]. In particular, their effective separation from each other is highly desirable to keep the entire extraction process viable, as the criticality of REEs is directly associated with the difficulties in their isolation [15,16].

Hydrometallurgy is potentially applied to REEs' extraction and downstream processing steps, involving the combination of solvent

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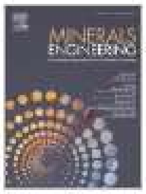

Comparative study of limonitic and saprolitic laterite ores on the leaching characteristics under atmospheric pressure

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Highlights

- Sulfuric acid leaching was performed at room temperature and atmospheric pressure.
- Leaching mechanisms of different laterite types were studied.
- Serpentine-type mineral is easier to leach than goethite and talc.
- Leaching of laterite ores employed in the present work matched the shrinking core model.

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