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Key Words

solvent extraction

Dysprosium (Dy)

Neodymium (Nd)

recycling

Organophosphorus extractants

Objective

1. Highlight Resource Recycling Strategies: The paper aims to emphasize the strategies for recycling permanent magnets to recover dysprosium and neodymium using solvent extraction methods.
2. Discuss Role of Organophosphorus Extractants: The study discusses the role of organophosphorus extractants in the extraction, separation, and recovery processes of Dy and Nd from waste materials.
3. Present Comparative Analysis of Extractants: A case study is presented comparing two organophosphorus extractants di(2-ethyl-hexyl) phosphoric acid (D2EHPA) and 2-ethyl-hexyl phosphonic acid mono-2-ethyl-hexyl ester (PC 88A) used for the recovery of Dy and Nd.
4. Review Experimental Conditions: The article reviews various experimental conditions such as loading rates, theoretical extraction stages, scrubbing processes, and stripping processes for both extractants.
5. Provide Flow-Sheets for Commercial Operations: The study provides flow-sheets discussing the use of organophosphorus extractants in commercial operations to recover Dy and Nd products.

Methodology

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1. Solvent Extraction Process:

- The paper discusses the use of organophosphorus extractants, particularly di(2-ethyl-hexyl) phosphoric acid (D2EHPA) and 2-ethyl-hexyl phosphonic acid mono-2-ethyl-hexyl ester (PC 88A).

- The extraction process involves mixing the aqueous solution containing Dy and Nd with an organic phase containing the extractant.

2. Comparative Analyssi of Extactants:

- A case study is conducted to compare D2EHPA and PC 88A extractants.

- Experimental conditions such as maximum loading rates, theoretical extraction stages, scrubbing processes, and stripping processes are reviewed for both extractants.

- The study explores different experimental parameters to optimize the extraction efficiency for Dy and Nd.

3. Experimental COnditions:

- Various experimental conditions are tested, including:

-- Initial pH of the feed solution.

-- Concentration of the extractant.

-- Phase ratio (aqueous to organic).

-- Temperature and contact time.

4. Flow-Sheet Development:

- Flow-sheets are developed to illustrate the commercial operations using organophosphorus extractants.

- The flow-sheets include stages for extraction, scrubbing, and stripping processes.

- These flow-sheets are designed to optimize the recovery and purity of Dy and Nd products.

5. Leaching and Pretreatment:

- The methodology includes leaching processes where permanent magnets are treated with acidic or alkaline solutions to dissolve the rare earth elements.

- Pretreatment steps such as demagnetization, oxidation, and roasting at high temperatures are performed to prepare the materials for leaching.

6. Stripping and Purification:

- The loaded organic phase (containing Dy and Nd) is subjected to stripping processes using appropriate reagents to recover the metals.

- Purification steps are conducted to enhance the purity of the recovered Dy and Nd.

7. Comparison of Experimental Data:

- Experimental data from different studies are compared to evaluate the effectiveness of the extraction processes.

- Parameters such as distribution ratios, separation factors, and extraction efficiencies are analyzed and discussed.

Key Findings

1. Effectiveness of Organophosphorus Extractants:

- Di(2-ethyl-hexyl) phosphoric acid (D2EHPA) and 2-ethyl-hexyl phosphonic acid mono-2-ethyl-hexyl ester (PC 88A) were found to be effective in the extraction, separation, and recovery of dysprosium (Dy) and neodymium (Nd).

- Both extractants showed high loading capacities and selectivity for Dy and Nd under optimized conditions.

2. Optimal Experimental Conditions:

- Optimal extraction conditions included an initial pH of 3.0   0.1, an equilibrium pH of 1.5   0.1, and a phase ratio (aqueous to organic) of 1.5.

- For Dy, complete extraction was achieved within 5 minutes, while Nd required 5 to 20 minutes with

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D2EHPA and 5 to 10 minutes with PC 88A.

3. Comparative Performance of Extractants:

- D2EHPA and PC 88A demonstrated different extraction efficiencies and separation factors. D2EHPA showed a higher separation factor for Dy over Nd compared to PC 88A.

- The separation factor (SF) between Dy and Nd was highest for D2EHPA (SF = 410.6) and slightly higher for PC 88A (SF = 492.2).

4. Recycling Potential:

- The study highlighted the potential of recycling strategies for permanent magnets to recover valuable rare earth elements (REEs), reducing environmental impact and resource wastage.

- Recycling processes using solvent extraction methods were shown to be feasible for recovering high-purity Dy and Nd from end-of-life permanent magnets.

5. Flow Sheet Development:

- The article provided detailed flow-sheets for commercial operations, illustrating the stages of extraction, scrubbing, and stripping to recover Dy and Nd products.

- The flow-sheets emphasized the use of organophosphorus extractants in commercial-scale recovery processes, demonstrating practical applicability.

Relevance to Study

Chemical Stability: The study focuses on the use of organophosphorus extractants (D2EHPA, PC 88A) that demonstrate chemical stability under various acidic conditions, which is crucial for nuclear fuel reprocessing where stable ligands are required to handle harsh chemical environments

Radiolysis Resistance: Although not directly discussed, the study implies that the selected organophosphorus extractants (D2EHPA, PC 88A) are used in environments that could be adapted for radiolytic resistance, a critical factor in nuclear applications

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Thermodynamics: The thermodynamic data presented, including distribution ratios and separation factors, are essential for understanding the feasibility of separating similar actinides and lanthanides, similar to the needs in nuclear fuel cycle chemistry

Kinetics: The extraction kinetics detailed in the study, such as the required contact times for complete extraction, are relevant for ensuring efficient and rapid separations in nuclear fuel reprocessing operations

Operational Condition Range: The extractants are tested under various pH conditions and temperatures, showcasing their versatility. This broad operational range is beneficial for adapting the ligands for different stages of nuclear fuel reprocessing

Critical Parameters Identified

High Importance

1. Chemical Stability:

- The study demonstrates that organophosphorus extractants (D2EHPA and PC 88A) maintain their functionality under various acidic conditions, indicating their chemical stability.

- The extractants' ability to handle different acid concentrations suggests they can withstand reactive chemical environments, which is essential for nuclear fuel reprocessing.

2. Radiolysis Resistance:

- While the study does not directly address radiolysis resistance, the use of organophosphorus extractants in environments that could be adapted for radiolytic conditions implies potential relevance for ligands that need to resist radiation degradation in nuclear applications.

3. Thermodynamics:

- The study provides detailed thermodynamic data, including distribution ratios and separation factors for Dy and Nd.

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- These data are crucial for understanding the selectivity and binding strength of the extractants, which are fundamental for the feasibility of separation processes in nuclear fuel reprocessing.

Medium Improtance

1. Kinetics:

- The extraction kinetics discussed in the study, such as the required contact times for complete extraction, highlight the efficiency and speed of the separation process.
- Efficient kinetics are essential for practical nuclear fuel reprocessing to ensure timely separations.

2. Loading Capacity:

- The study mentions the maximum loading rates of the extractants, which is important for determining how much material can be processed before the ligands become saturated.
- This information is valuable for assessing the efficiency of the separation process.

3. Operational Condition Range

- The extractants are tested under various pH conditions and temperatures, showcasing their ability to operate under a broad range of conditions.
- This versatility increases the flexibility and applicability of the ligands for different stages of nuclear fuel reprocessing.

Low Improtance

1. Solubility:

- The solubility of the extractants in the organic phase and their low solubility in the aqueous phase are discussed.
- While important, solubility can often be managed through solvent selection, making it less critical than other parameters.

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2. Dispersion Numbers:

- The study does not specifically address dispersion numbers, making this parameter less relevant in the context of this research.

3. Phase Disengagement:

- The practical separation of phases after the extraction process is not a primary focus of the study.
- This aspect is more dependent on the specific system design and operation parameters, making it of lower importance.