Emerging Strategies for Separation of Rare Earth Elements

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The rare earth elements (REEs) consist of scandium, yttrium, and the lanthanides. While often overshadowed in chemistry courses and research by transition metals, REE-containing materials play significant roles in several technologies we use every day, including as catalysts in catalytic converters and phosphors in electronic device screens. Although these materials see ubiquitous usage, their low natural abundance and difficulty of purification mean they face considerable supply risk. The U.S. Department of Energy and European Commission have accordingly classified REE-containing materials as "critical" raw materials due to this combination of importance for use and supply risk[1–3]. To alleviate supply risk concerns, researchers have focused on developing separation techniques aimed at recovering REEs from common REE-containing feedstocks like electronic waste. Separating REEs from one another is inherently challenging due to their similar chemical properties, so efficient REE separation necessitates overcoming this low-selectivity barrier. Countercurrent solvent extraction serves as the present industrial standard for REE separation. This process utilizes chemical extractants that preferentially complex with REEs based on Lewis acidity differences, enabling ultrapure separation after multiple cycles. However, countercurrent solvent extraction consumes large quantities of electricity and volatile organic solvents that render it environmentally unfriendly and unsustainable; modifications of separation techniques therefore need to address these concerns to mitigate long-term risk to REE supply. This seminar will highlight three emerging REE separation strategies (ionic liquid extraction, magnetic field-directed separation, and lanmodulin binding) that could help phase out countercurrent solvent extraction and provide means for recycling REEs.

References:

1. Higgins, R. F.; Ruoff, K. P.; Kumar, A.; Schelter, E. J. Coordination Chemistry-Driven Approaches to Rare Earth Element Separations. *Acc. Chem. Res.* **2022**, *55*, 2616–2627.
2. Bauer, D.; Diamond, D.; Li, J.; McKittrick, M.; Sandalow, D.; Telleen, P. Critical Materials Strategy, 2011. U.S. Department of Energy. https://www.energy.gov/sites/prod/files/DOE_CMS2011_FINAL_Full.pdf (accessed Nov 21, 2022).
3. Communication COM(2020) 474 Final, 2020. European Commission. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52020DC0474&from=EN (accessed Nov 21, 2022).