Selective Solid Phase Extraction of Rare Earth Elements from Aqueous Solutions

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Lack of supply chain diversity and increasing global demand has positioned rare earth elements (REE) as critical materials for economic development for the forseeable future. Hydrometallurgical separation of REE has been a highly active area of research in recent years, with new approaches continually being developed to meet surging demand for these valuable mineral resources. Solid phase extraction (SPE) remains an attractive method for processing and purifying REE-containing aqueous feedstocks, due to its scalability and well-understood engineering, though commercially available adsorbents suffer from severe limitations in selectivity that reduce their applicability to relatively simple fluids. The goal of this work was to expand the viability of SPE technologies by developing adsorbents with dramatically increased selectivity towards lanthanides through chemical surface modification. Adsorbents were functionalized with three REE-selective ligands – phosphonoacetic acid (PAA), *N,N*-bis(phosphonomethyl)glycine (BPG), and diethylene-triaminepentaacetic acid (DTPA) – and their performance was evaluated in solution conditions designed to mimic a range of aqueous matrices. Very high uptake efficiencies were observed (>99%) for the adsorbents, and the adsorbed REE were successfully eluted with relatively dilute acid (1N HNO_3). Each ligand displayed a unique pH adsorption trend, with strong uptake in acidic (pH 1-4; DTPA), circumneutral (pH 5-9; PAA), or both conditions (BPG). Adsorbent performance improved with additional usage and elution cycles, suggesting durabilty against harsh chemical and temperature conditions.