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Rare Earth Elements Purification using Ligand-Assisted Displacement Chromatography

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ABSTRACT

Rare Earth Elements (REEs) including the lanthanide series, Yttrium, and Scandium play a critical and essential role in various industries such as electronics, power, and defense. Traditional methods have difficulties in separating REEs due to their high similarities in chemical and physical properties. With increasing demand of REEs, current industrial techniques of REE extractions, two phase liquid-liquid extraction, are not efficient enough to meet the market's need without causing serious environmental problems. Specifically, two phase liquid-liquid extraction uses a large number of mixer-settler units in series and parallel for purification of REEs. This method consumes excessive solvents and chemicals that are environmentally hazardous. Spedding and Powell studied ligand-assisted displacement chromatography of REE recovery in 1950's, which showed high yields and high purity but low productivity. Their process was designed based on trials and errors and was not optimized. The first goal of this study is to develop and test a systematic design and optimization method to increase sorbent productivity and reduce separation cost. The second goal is to understand the dynamic separation mechanism using rate model simulations. We tested the design method experimentally using three REEs, Nd, Sm and Pr. Ammonium citrate was used as a ligand displacer. Frontal tests were used to estimate the various parameters corresponding to adsorption, reaction and mass transfer. Rate model simulations were conducted to verify experimental data. The experimental design aimed to achieve an average yield of each product of 97% with a purity of 99%, and sorbent productivity an order of magnitude higher than that of Spedding and Powell.

KEYWORDS

REE, separation, chromatography, ligand-assisted displacement chromatography