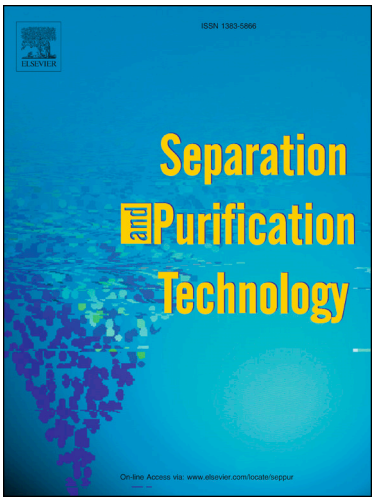


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Dariush Azizi, Faï çal Larachi

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# Immiscible dual ionic liquid-ionic liquid mineral separation of rare-earth minerals

**Dariush Azizi, Faïçal Larachi***

**Department of Chemical Engineering, Université Laval, 1065 Avenue de la Médecine, Québec, Québec G1V 0A6 Canada (*corresponding author faical.larachi@gch.ulaval.ca)**

**Abstract** The potential of ionic liquid-ionic liquid mineral separation process as a novel ionic liquid-based system to beneficiate rare earth element (REE) bearing minerals was investigated. This multiphase beneficiation system was prepared using two mutually immiscible ionic liquids (IL) as dispersed and continuous phases. A phosphonium/ammonium based ionic liquid as droplet phase and three different ionic liquids as continuous phase were applied to evaluate this approach of beneficiation of REE complex ore. Ionic liquid-ionic liquid mineral separation tests were performed on an actual rare earth complex ore with its main composing minerals consisting of monazite, bastnäsite, ankerite, calcite and dolomite. Fourier Transform Infrared (FTIR) spectroscopy, Atomic Force Microscopy (AFM) and X-ray Photoelectron Spectroscopy (XPS) analyses were performed to unveil the nature of interactions between IL droplet phase and each of the minerals composing the ore. Bastnäsite and monazite have been found to exhibit stronger chemisorption interactions with phosphonium/ammonium based ionic liquid in comparison with calcite, ankerite and dolomite. Density Functional Theory (DFT) simulations were also conducted to reveal the configuration of ionic liquid moieties on the surface of the minerals through ionic liquid adsorption. It was found that the IL anionic moiety directly interacts with the metal cations on the mineral surfaces through covalent bonds, at the expense of the cationic moiety which is only involved in weaker solvophobic interactions. DFT simulation also indicated that the adsorption geometry of IL is based on *cis*-conformation where the cationic and anionic moieties adsorb next to each other on the mineral surfaces.

**Keywords** Ionic liquid; rare earth elements; liquid-liquid separation; interfacial interactions; DFT simulation