Designing hydrophobic deep eutectic solvents for the selective leaching of critical metals

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Abstract

Rare earth elements are important raw materials needed for a renewable energy society. Due to their limited reserves and the uneven distribution of production across countries, it is necessary to develop green recycling techniques for these metals. In this study, we investigate the impact of the steric hindrance of hydrogen bond acceptors (HBAs) in hydrophobic DESs on the dissolution behavior of metal oxides. DESs with the same coordination group but different steric environments were prepared. Cobalt (Co), iron (Fe), neodymium (Nd), and dysprosium (Dy) were employed to facilitate the study of the separation behavior of metal oxides with different charges and ionic radii. Two DESs composed of a beta-diketone and a phosphine oxide were prepared. Benzoyltrifluoroacetone (HBTA) as a hydrogen bond donor (HBD) and trioctylphosphine oxide (TOPO) or tributylphosphine oxide (TBPO) as HBAs were employed to prepare DESs. Because these two HBAs have different alkyl chain lengths but the same coordination group, only the steric environment of the DESs was varied. In dissolution experiments, the dissolution selectivity of the metal oxides into DESs differed significantly. HBTA/TOPO provided a selective Nd oxide dissolution, while HBTA/TBPO allowed Co, Nd, and Dy oxide dissolution. These results suggest that the steric environment of DES is a key factor for improving the dissolution selectivity of metal oxides including the traditionally difficult rare earths.