# Prospects for Separation of Rare Earth Elements by Liquid Extraction with Protonated Betaine Bis(trifluoromethylsulfonyl)imide

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Ionic liquids, molten salts under mild temperature conditions, have been proposed as extractants for separation of metals, including rare earth elements (REEs). In particular, protonated betaine bis(trifluoromethylsulfonyl)imide ([HBet][Tf2N]) can dissolve the oxides of REEs and exhibits phase separation from water with an upper critical solution temperature (UCST). Previously, we have found that the addition of $Nd_2O_3$ to an aqueous [HBet][Tf2N] solution results in a significant lowering of the UCST, and we checked that the same phenomenon happened with loaded other REE oxides.

In the current work we have developed a method to quantify the amount of neutral zwitterionic betaine in the IL sample. Moreover, we have found that neutral zwitterionic betaine generated during synthesis, and the liquid-liquid equilibrium of water with [HBet][Tf2N] is highly sensitive to the presence of neutral zwitterionic betaine. We have been able to synthesize [HBet][Tf2N] with a purity greater than 97 mol %. Using the high purity [HBet][Tf2N], we have measured the influence on the UCST of the system from adding two different concentrations of $La_2O_3$, $Nd_2O_3$, $Eu_2O_3$, $Gd_2O_3$, $Ho_2O_3$, and $Yb_2O_3$. For the higher concentration there are distinct differences in the solubility curves for the light and heavy REEs, indicating that liquid-liquid extraction with [HBet][Tf2N] could be a viable method for separation of REE compounds.