

Designing Ionic Liquids for CO₂ Capture

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Abstract

Ionic liquids (ILs) present intriguing possibilities for removal of carbon dioxide from a wide variety of different gas mixtures, including post-combustion flue gas, pre-combustion gases, air, and raw natural gas streams. Even by physical absorption, many ILs provide sufficient selectivity over N₂, O₂, CH₄ and other gases. However, when CO₂ partial pressures are low, the incorporation of functional groups to chemically react with the CO₂ can dramatically increase capacity, while maintaining or even enhancing selectivity. We will demonstrate several major advances in the development of ILs for CO₂ capture applications. First, we will show how the reaction stoichiometry can be doubled over conventional aqueous amine solutions to reach one mole of CO₂ per mole of IL by incorporating the amine on the anion. Second, we will show how we have been able to virtually eliminate any viscosity increase upon complexation of the IL with CO₂, by using aprotic heterocyclic anions (AHA ILs) that eliminate the pervasive hydrogen bonding and salt bridge formation that is the origin of the viscosity increase. Third, we will describe the discovery of AHA ILs whose melting points when reacted with CO₂ are more than 100 °C below the melting point of the unreacted material. These materials allow one to dramatically reduce the energy required for CO₂ release and regeneration of the absorption material because a significant amount of the energy needed for the regeneration comes from the heat of fusion as the material releases CO₂ and turns from liquid to solid.