Ionicity of Silylamine Reversible Ionic Liquids

Researcher: Juan D. Jimenez, Sungyup Jung, and Elizabeth J. Biddinger
Research Advisor: Elizabeth J. Biddinger
Department of Chemical Engineering, The City College of New York,
City University of New York, 140th ST. and Convent Ave., New York, NY 10031

Abstract

Ionic Liquids (ILs) are molten salts with a melting point below 100°C. Ionic liquids are best characterized by their high conductivity, high viscosity and low vapor pressure. Reversible ionic liquids (RevILs) are unique in the fact they can be converted from a molecular state to an ionic state, which display the defining characteristics of a traditional ionic liquid, and can be reverted back into a molecular by adding heat. The novelty of RevILs is the fact the molecular and ionic states have different polarities, allowing for facile separations after the desired electrochemical process has been carried out in the reversible ionic state.

The RevIL that will be discussed in detail is (3-aminopropyl)triethoxysilane which upon addition of CO_2 forms an ammonium-carbamate ion pair. The properties that will be discussed will be conductivity, molar conductivity, and viscosity. These properties were chosen since they provide the sufficient information to determine the ionicity of an electrolyte, where ionicity is defined as the extent of ion dissociation of an ion pair with respect to 0.010M KCl. The key components required to determine ionicity are viscosity, which influences ion mobility, and conductivity, which is a measure of a substance's ability to carry a charge or ion flow. In order to normalize the conductivity with respect to concentration, molar conductivity will be used to determine ionicity, which is conductivity of the solution per mol of ions in solution. The Walden Plot then plots molar conductivity vs. (1/viscosity) on a log scale which compares the ionicity of the solution with 0.010M KCl, which is regarded as an ideal ionic species. However, when the RevIL is in its pure ionic state the conductivity is completely inhibited by the viscosity and ion pairing. In an attempt to elucidate the ionicity of the RevIL several different mixtures with varying solvents based on their dielectric constants will be investigated and their effects on both conductivity and viscosity.

The solvents that will be investigated will be methanol, acetonitrile, DMSO, and THF, which cover a wide range of dielectric constants as well as differences in protic vs. aprotic solvents. All of the solvent mixtures displayed a maximum in conductivity between 0-10mol% RevIL, which is consistent with what is found in the literature for tradition ionic liquids in organic solvent. It was found that after the addition of methanol to the RevIL (~1-10mol% RevIL mixture range) the conductivity of the solution increased by about 3 orders of magnitude, bringing the relatively non-conductive pure RevIL state into an acceptable region under which electrochemical processes can be carried out. In the case of the other 3 solvents, each exhibited a similar trend in conductivity as a function of mol% RevIL, except 1 one order of magnitude lower conductivity, and similar trends in viscosity as a function of mol% RevIL.