Ionic Liquids in Mixed Matrix Membranes for Highly Selective CO_2/CH_4 Separation

Zoban Singh [C, S], Rich Noble and Doug Gin
University of Colorado Boulder, Boulder, CO, U.S.A.
zoban.singh@colorado.edu

The ability to efficiently separate CO_2 from CH_4 has recently received a great deal of attention due to its importance in enhancing natural gas efficiency and in removing corrosive substances found in the raw gas stream. Nascent advancements in membrane based separations have allowed membranes to become competitive with commercial pressure and temperature swing adsorption processes. Mixed matrix membranes (MMMs) look to be the most promising candidates for commercialization and large scale implementation. These MMMs consist of three individual components: polymerizable room temperature ionic liquids (poly(RTILs), normal RTILs, and zeolite particles. These components synergize to produce enhanced gas transport. The polymer matrix allows for facile and economical fabrication, while the zeolite provides excellent separation performance. The RTIL prevents defect formation within the membrane by acting as a wetting agent to help the polymer matrix interface aptly with the zeolite. In fact, Imidazolium based RTIL materials are widely reported as great compounds for light gas separation due to their negligible vapor pressure, high thermal stability and inherent CO_2 solubility selectivity. We have investigated how varying the three components in our MMMs affects membrane permeability and selectivity. This initial study identified the optimal type of zeolite particles. More in depth analysis of the ionic liquid revealed the significance of molar volume in the RTIL and free volume in the poly(RTIL) on the membrane's gas separation ability. Previous work established the correlation between increasing RTIL molar volume and decreasing CO_2 solubility selectivity. Current work shows how the polymerized analogues (poly(RTILs) display a similar trend with free volume. This resulted in the creation of MMMs made with smaller molar and free volume RTILs and poly(RTILs) that performed above Robeson's 2008 upper bound for CO_2/CH_4. With this knowledge we aim to devise a systematic design approach for creating state of the art MMMs.