Hydrogen Stable Ionic Liquids Systems for Olefin/Paraffin Separation

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Olefins are a key building block of the petrochemicals industry because they are precursor materials for numerous chemical products and plastics. The current commercial production method is steam cracking of ethane followed by cryogenic distillation of olefin/paraffin mixtures, which involves large energy consumption and greenhouse gas footprint (0.3% of world energy use). Membranes using facilitated transport show promising olefin/paraffin selectivity due to the presence of carriers that specifically complex with olefins. We have developed facilitated transport-based supported ionic liquid membranes (SILMs) with excellent olefin/paraffin selectivity and permeability, using mixtures of silver salts and ionic liquids (ILs). The metal ions dissolved in the IL act as carriers and the IL medium allow the carriers to be mobile in the membrane pores. Previously, facilitated transport-based membranes for olefin/paraffin separation have not been viable because the silver carriers deactivate rapidly in the presence of any H2, which chemically reduces the silver salts to inactive silver metal. We show that the proper choice of IL results in stable olefin/paraffin separation performance even after extended exposure to H2. Using Raman spectroscopy, we show how the formation of anion aggregates play a key role in the suppression of silver metal nanoparticle formation. Amazingly, thermophysical properties (density and viscosity) of the IL/silver salt mixtures support the molecular interpretation of the protection mechanism. This innovation paves the way for selective olefin/paraffin separation with dramatically reduced energy consumption, that is viable from laboratory to commercial scale operation.