Pyridinium-based Poly(Ionic Liquid) membranes for water vapor removal from hydrogen-rich gas streams

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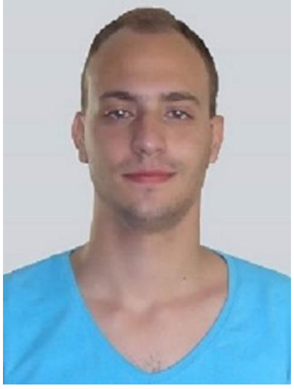
Abstract

Hydrogen is one of the key commodities in chemical industry. It is produced mainly by steam reforming of a fuel (hydrocarbons, alcohols) followed by high and low temperature water-gas shift processes. Hydrogen is also an environmentally attractive energy carrier, and high-purity standards are required for hydrogen used either in chemical industry or in fuel cells. Water vapor condensation is an energy-intensive process while membrane-based technology is an attractive alternative for water vapor separation, reducing the energy consumption and the overall operational cost. Polymeric membranes exhibiting high water vapor permeability and selectivity are promising candidates for water removal towards hydrogen-rich gas.

In this work, pyridinium-based polymeric ionic liquid (PIL) films containing different counter anions ($MeSO_4^-$, BF_4^-, $TFSI^-$) were prepared. They were physiochemically characterized using differential scanning calorimetry (DSC) for identification of phase transitions and thermogravimetric analysis (TGA) to determine their thermal stability. PIL films were also evaluated as dehumidification membranes by conducting single gas and water vapor permeation measurements. Among all membranes, PIL-$MeSO_4$ had the highest water vapor permeability of 1.84×10^5 Barrer (1 Barrer $= 10^{-10}\ \mathrm{cm^3_{STP}\ cm\ cm^{-2}\ s^{-1}\ cm\ Hg^{-1}}$) combined with the highest H_2O/gas selectivity. The activation energies of water vapor and single gas (H_2, CO_2, CH_4) permeation through the PIL-$MeSO_4$ membrane were also calculated and mixed gas permeation experiments were carried out to study the water vapor effect on gas permeation under realistic gas stream compositions.



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