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Phosphonium-based poly(ionic liquid) membranes: the effect of cation alkyl chain length on light gas separation properties and ionic conductivity

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Abstract

Phosphonium poly(ionic liquid)s (PILs) have been studied as alternatives to more common ammonium and imidazolium PILs for potential transport and separation applications. This work characterizes the CO_2, H_2, N_2, O_2, CH_4, and C_2H_4 single-gas permeability, diffusivity, solubility, and selectivity of free-standing films of poly([(tri-*n*-alkyl)vinylbenzylphosphonium][bis(trifluoromethylsulfonyl)imide]) PILs (i.e., poly([P_{nnnVB}][Tf_2N] where n = 4, 6, 8). The gas permeability was found to increase approximately linearly with increasing alkyl chain length on the phosphonium group. To our knowledge, the CO_2 permeability of 186 barrers observed for poly([P_{888VB}][Tf_2N] is the highest reported for neat PIL materials. In contrast, gas selectivity was observed to decrease with an increase in phosphonium alkyl chain length from n = 4 to n = 6, then remain approximately constant between n = 6 and n = 8. Additionally, the ionic conductivity of these materials was observed to increase from ca. 10^{-8} to ca. 10^{-5} S cm^{-1} as the measurement temperature was increased from 25 to 105 °C. At 25 °C, the PIL with the shortest cation alkyl chain (n = 4) was observed to have the lowest ionic conductivity. However at ca. 90 °C, the expected trend of increasing ionic conductivity in the order n = 4 > n = 6 > n = 8 was observed.

Keywords: phosphonium, poly(ionic liquid)s, gas separations, ionic conductivity, alkyl chain length