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Development of Mixed Matrix Membranes by Using NH_2-Functionalized UiO-66 and [APTMS][AC] Ionic Liquid for the Separation of CO_2

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Abstract : The ever-escalating CO_2 concentration in the atmosphere calls for accelerated development and deployment of carbon capture processes to reduce emissions. Mixed matrix membranes (MMMs), which are fabricated by incorporating the beneficial properties of highly selective inorganic fillers into a polymer matrix, have exhibited significant progress and the ability to enhance the performance of a membrane for gas separation. In this research, an amine-based ionic liquid (IL) [APTMS][AC] was prepared, which has greater CO_2 affinity and greater solubility due to its amine moiety. The metal–organic framework (MOF) UiO-66 with a multidimensional crystalline structure was used as a filler due to its appropriate porosity and tunable properties, and it was functionalized with NH_2. MOFs were further modified with an IL to prepare UiO-66@IL and UiO-66-NH_2@IL, and MMMs incorporating each MOF were fabricated with the polymer Pebax-1657. All the prepared membranes and MOFs were characterized to predict their separation efficiency. Several characterization techniques, namely, FTIR spectroscopy, XRD, and SEM, were used to successfully synthesize UiO-66@IL and UiO-66-NH_2@IL composites and confirmed proper dispersion and excellent polymer– filler compatibility at filler loadings ranging from 0 to 30 wt.%. The separation performances were investigated, and the results showed that the incorporation of RTIL with the highly crystalline structure and large surface area of UiO-66 enhanced the separation efficiency of the membrane. The permeability of CO_2 for all fabricated membranes continuously increased with increasing filler concentration, wherein the permeability was comparatively high for the UiO-66-NH_2 MMMs. The CO_2/CH_4 selectivity improved by 35%, 54%, and 60%, respectively, for UiO-66@IL, UiO-66-NH_2, and UiO-66-NH_2@IL MMMs compared to simple UiO-66 for CO_2/CH_4 and by 28%, 36%, and 63%, respectively, for CO_2/N_2, with an increase in filler loading in the MMMs.

Keywords : gas separation, mixed matrix membranes, CO_2 sequestration, climate change, global warming
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