Mixed matrix membranes (MMMs) using an emerging metal-organic framework (MUF-15) for CO_2 separation

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Abstract:

The inorganic fillers largely determine the ultimate gas separation performance of mixed matrix membranes (MMMs). The identification of new inorganic fillers is therefore crucial for the continued development of MMMs. Metal-organic frameworks (MOFs), a superior filler option, have been extensively studied for preparing MMMs. However, high-performance MOF fillers remain scarce and are in high demand. To tackle this challenge, we are promoting MUFs (Massey University Frameworks), a series of emerging MOF fillers that possess exceptional physicochemical properties for MMM development. In this study, a MUF-15-based MMM was prepared for the first time by pairing it with PIM-1. Owing to its intrinsic ability to discriminate different guest molecules, this MUF-15 incorporated MMMs exhibited exceptional CO_2 separation properties. Also, the layered structure of MUF-15 enabled the exfoliation of crystalline nanosheets leading to the significant enhancements of both CO_2 permeability and selectivity even when only a small quantity of <5 wt% was incorporated. In addition, MUF-15 fillers could effectively inhibit the physical aging process of PIM-1 membranes. After 35 days, MMMs with a 2 wt% loading of MUF-15 nanosheets showed 155 % higher CO_2 permeability, with identical CO_2/N_2 selectivity (25.5), relative to pristine PIM-1 membranes, which all still surpassed the 2008 upper bound. The isoreticular chemical modification of MUF-15 is under development to further improve the MMM performance.

Keywords: Mixed matrix membrane, inorganic filler, Metal-organic frameworks, MUF-15, carbon dioxide separation.