High CO$_2$ permeability polymer-based membrane materials can address large-scale separations such as CO$_2$ removal from flue gas and natural gas purification [1]. We have explored several approaches to designing membranes having both high gas permeability and high permselectivity. Two approaches are as follows:

The alignment of filler materials creates fast and selective gas transport channels to improve membrane performance. The vertical alignment of highly CO$_2$-permeable covalently-anchored Montmorillonite (MT) clay fillers is achieved by interspersing the filler with polymer. The resulting mixed matrix membrane is anchored to a supporting substrate, creating a membrane with transport channels that are selective for carbon dioxide [2]. The selective top mixed-matrix layer is only ~100 nm thick. Hydroxyl groups on the inter-layered walls have a strong affinity and reversibly interact with acidic CO$_2$ molecules, facilitating CO$_2$ transport, while restraining the adsorption of N$_2$, CH$_4$ and H$_2$ gases. A high CO$_2$ permeance is achieved combined with high mixed CO$_2$/gas selectivity for several gas pairs that is stable over a period of 600 h and is independent of water content in the feed gas.

Microporous polymers are recently being explored for high gas permeability membranes. Intrinsic microporosity is defined as a continuous network of interconnected intermolecular microcavities, which is formed as a consequence of the contorted shape and chain rigidity of the polymer structure. The restricted chain rotation originating from sites of contortion or spiro centers leads to an inefficiently packed matrix with high fractional free volume (FFV), typically above 20%. ‘Polymers of Intrinsic Microporosity’ (PIMs) are microporous solvent-soluble polymers considered as promising materials for membrane-based separations because of high product throughput or flux. Highlights of some of the speaker’s and several other researchers’ work on PIMs will be given, particularly on more recent work on a related class of microporous polyimides.


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