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ע״ש וולפסון
The Wolfson Department of Chemical Engineering

Wolfson Department of Chemical Engineering Seminar

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Development of carbon molecular sieve membranes for CO_2 separation

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PhD Final-Seminar

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Abstract: Carbon dioxide (CO_2) is a prominent greenhouse gas that can trap the heat emitted from the surface of the earth to the atmosphere, leading to global warming. Membrane gas separation technologies have emerged as highly prospective avenues to limit carbon emissions, thus achieving the goal of "carbon neutrality". The main research works are as follows:
(1) A novel 6FDA-based polyimide precursor (called 6FDA-AB-TFMB) with non-coplanar and rigid aromatic structures was designed and synthesized to fabricate highly permeable carbon membranes for CO_2/N_2 separation. The prepared carbon membranes demonstrate outstanding gas separation performances to far surpass the 2019 upper bound for the CO_2-N_2 gas pair. Especially, CMS-800 prepared at a final carbonization temperature of 800 ℃ present a superior CO_2 permeability of 17351 barrer and a CO_2/N_2 selectivity of 38.9, which is attributed to the synergistic contributions from adsorption-selective and molecular sieving mechanisms for CO_2 transport through carbon membranes.
(2) Based on 6FDA-AB-TFMB, to further improve discontinuous pore structures and non-selective pores in carbon matrix structure thus simultaneously increasing permeability and selectivity of carbon membranes, we report a novel carbon membrane prepared from an asymmetric and rigid structure copolyimide (co-PI) precursor consisting of three monomers 6FDA, DAM, and AB-TFMB (named 6FDA-DAM: AB-TFMB (3:2)) and the precisely controlled carbonization procedure. Specifically, the separation performances of the carbon membranes prepared at 800 ℃ far exceed the 2019 upper bounds for CO_2/N_2 and CO_2/CH_4 gas pairs, which exhibits a superior CO_2 permeability of 15700 barrer and a CO_2/N_2 selectivity of 63 (and a CO_2 permeability >7300 barrer and CO_2/CH_4 >52) at 25 ℃.
(3) Based on 6FDA-DAM: AB-TFMB (3:2), to improve the gas selectivity of carbon membranes under low carbonization temperature, we fabricated co-PI derived hybrid carbon membranes (HCMS) in conjunction with a highly thermally stable metal azolate framework of Zn(imPim) to prevent CO_2 adsorption loss from the decomposition of filler during carbonization and achieved high CO_2/N_2 selectivity. The best hybrid carbon membrane shows a high CO_2/N_2 selectivity of 61.4 and a high CO_2 permeability of 11040 barrer, far exceeding the 2008 and 2019 upper bounds.