High nitrogen impermeabiliy of polyetherimide (PEI) membrane via interfacial nanoconfinement effect

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Abstract:

Membrane technologies have been widely applied in gas separation processes due to the low-cost, low energy consumption and easy scalability. However, the trade-off between gas permeance and selectivity, plasticization and ageing still limits the gas separation membranes for industrial applications [1]. The nanocomposite membrane technologies are one of the methodologies to overcome the trade-off that can combine the abilities of polymer and inorganic materials to maximise the gas separation performances and membrane stability. Such method has been widely investigated to improve the free volume fraction in the polymer membranes or boost the gas permeance for specific gases [2]. The interfacial nanoconfinement effect that appeared between semi-crystalline polymer materials and the inorganic supporting layer can restrict the mobility of polymer chains and form the crystalline structure between the inorganic particles [3]. The phenomenon can be observed via the change of glass transition temperature (T_g) of polymers, but the actual mechanisms and control method still need to be investigated [4, 5]. In this study, three series of PEI membranes were prepared by a dip coating process, which investigated the effects of PEI concentration, coating layer and drying temperature on the membrane structure and separation properties to further gain insight into the interfacial nanoconfinement phenomenon. As shown in our preliminary results (Fig. 1), single gas nitrogen and carbon dioxide permeation tests revealed that the separation performance of PEI membranes coated with 2 and 3 layers of 12 wt.% PEI demonstrated excellent CO_2/N_2 permselectivities of 8360± 70 and 7000± 400, respectively with comparable CO_2 permeabilities (5.8 ± 0.5 Barrer) on average. These results overcame the 2008 Robeson upper bound and the revised upper bound in 2019[1, 6], indicating that the 2 and 3 layers of PEI membranes are suitable for high nitrogen removal application.

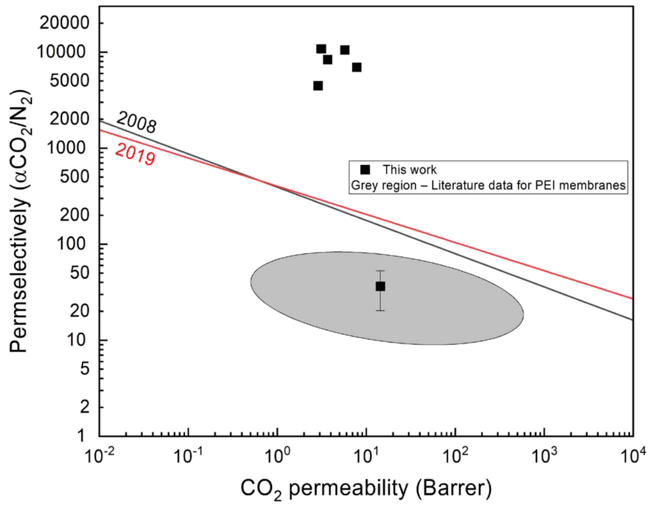

Fig. 1. The single gas permeation performance of PEI-alumina supported tubular membranes compared with the 2008 Robeson upper bound and 2019 revised upper bound[1, 6].

Keywords: polyetherimide, nanoconfinement, inorganic-organic interface, dip coating, ultra-high gas impermeability.

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