

Author's Accepted Manuscript

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PII: S0376-7388(18)30930-X
DOI: <https://doi.org/10.1016/j.memsci.2018.07.089>
Reference: MEMSCI16368

To appear in: *Journal of Membrane Science*

Received date: 4 April 2018
Revised date: 4 July 2018
Accepted date: 30 July 2018

Cite this article as: Rupesh S. Bhavsar, Tamoghna Mitra, Dave J. Adams, Andrew I. Cooper and Peter M. Budd, Ultrahigh-permeance PIM-1 based thin film nanocomposite membranes on PAN supports for CO₂ separation, *Journal of Membrane Science*, <https://doi.org/10.1016/j.memsci.2018.07.089>

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Ultra-high-permeance PIM-1 based thin film nanocomposite membranes on PAN supports for CO₂ separation

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Abstract

High permeance membranes were produced by addition of highly permeable nanoparticulate fillers (hypercrosslinked polystyrene, HCP, and its carbonized form, C-HCP) to a high free volume polymer (polymer of intrinsic microporosity PIM-1) in a thin film (typically 2 μm) on a porous polyacrylonitrile support. Self-standing mixed matrix membranes (MMMs) of thicknesses in the range 40–90 μm were also prepared with the same polymer and fillers. While robust MMMs could only be formed for moderate filler loadings, thin film nanocomposite (TFN) membranes could be produced from dispersions with filler loadings up to 60 wt%. On increasing the filler loading, CO₂ permeance increased in line with the predictions of the Maxwell model for a highly permeable filler. Physical ageing led to some loss of permeance coupled with an increase in CO₂/N₂ selectivity. However, for TFN membranes the greatest effects of ageing were seen within 90 days. After ageing, TFN membranes showed high permeance with reasonable selectivity; for example, with 60 wt% C-HCP, CO₂ permeance > 9,300 GPU, CO₂/N₂ selectivity ~ 11.

Graphical Abstract:

¹These authors contributed equally to this work

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