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Masoud Aghajani, Mengyuan Wang, Lewis M. Cox, Jason P. Killgore, Alan R. Greenberg, Yifu Ding

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Influence of support-layer deformation on the intrinsic resistance of thin film composite membranes

Masoud Aghajani[1], Mengyuan Wang[2], Lewis M. Cox[3], Jason P. Killgore[3], Alan R. Greenberg[1], Yifu Ding[1,2*]

[1] *Membrane Science, Engineering and Technology Center, Department of Mechanical Engineering, University of Colorado Boulder, Boulder, CO 80309-0427, USA*

[2] *Materials Science and Engineering Program, University of Colorado, Boulder, CO 80309-0596, USA*

[3] *Applied Chemicals and Materials Division, National Institute of Standards and Technology (NIST), Boulder, Colorado 80305, USA*

*Corresponding author: Department of Mechanical Engineering, 427 UCB, University of Colorado, 1111 Eng. Drive, Boulder, CO 80309-0427; Tel.: +1 303 492 2036; E-mail address: Yifu.Ding@Colorado.Edu; Fax: +1 303-492-3498.

Abstract

It is commonly believed that the overall permeation resistance of thin film composite (TFC) membranes is dictated by the crosslinked, ultrathin polyamide barrier layer, while the porous support merely serves as the mechanical support. Although this assumption might be the case under low transmembrane pressure, it becomes questionable under high transmembrane pressure. A highly porous support normally yields under a pressure of a few MPa, which can result in a significant level of compressive strain that may significantly increase the resistance to permeation. However, quantifying the influence of porous support deformation on the overall resistance of the TFC membrane is challenging. In particular, it is difficult to determine the deformation/strain of the membrane during active separation. In this study, we use nanoimprint lithography (NIL) to achieve precise compressive deformation in commercial TFC membranes. By adjusting the NIL conditions, membranes were compressed to strain levels up to 60 %. SEM and AFM measurements showed that the compression had minimal impact on the barrier-layer surface morphology and total surface area with most of the deformation occurring in the support layer. DI water permeation measurements revealed that the water flux reduction decreases with an increase of strain level. Most significantly, the intrinsic membrane resistance showed negligible changes at strain levels lower than 30 % - 40 %, but increased exponentially at higher strain levels, reaching 250% - 500 % of pristine (unstrained) membrane values. Using a resistance-in-series model, the strain dependency of the TFC membrane resistance can be described.