Electrophoretic Nuclei Assembly for Crystallization of High Performance Membranes on Unmodified Supports

Guangwei He, Kumar Varoon Agrawal

Laboratory of Advanced Separations (LAS), École Polytechnique Fédérale de Lausanne (EPFL), Sion, Switzerland

Metal-organic frameworks (MOFs) films have recently emerged as highly permselective membranes yielding orders of magnitude higher gas permeance than that from the conventional membranes[1,2]. However, synthesis of highly-intergrown, ultrathin MOF films on porous supports without complex support-modification has proven to be a challenge[3]. Moreover, there is an urgent need of a generic crystallization route capable of synthesizing a wide-range of MOF structures in an intergrown, thin-film morphology. Herein, we report a novel electrophoretic nuclei assembly for crystallization of highly-intergrown thin-films (ENACT) approach, that allows synthesis of ultrathin, defect-free ZIF-8 on a wide range of unmodified supports (porous polyacrylonitrile, anodized aluminum oxide, metal foil, porous carbon and graphene, Fig. 1a-g)[4]. As a result, a remarkably high H_2 permeance of 8.3 x10^{-6} mol/m^2-s-Pa, and ideal gas selectivities of 7.3, 15.5, 16.2, 2655 for H_2/CO_2, H_2/N_2, H_2/CH_4, and H_2/C_3H_8, respectively, are achieved from an ultrathin (500-nm-thick) ZIF-8 membrane (Fig. 1j). A high C_3H_6 permeance of 9.9 x10^{-8} mol/m^2-s-Pa, and an attractive C_3H_6/C_3H_8 selectivity of 31.6 are obtained. The ENACT approach is straightforward, reproducible and can be extended to a wide-range of nanoporous crystals, and we demonstrate its application in the fabrication of intergrown ZIF-7 films (Fig. 1h and i).

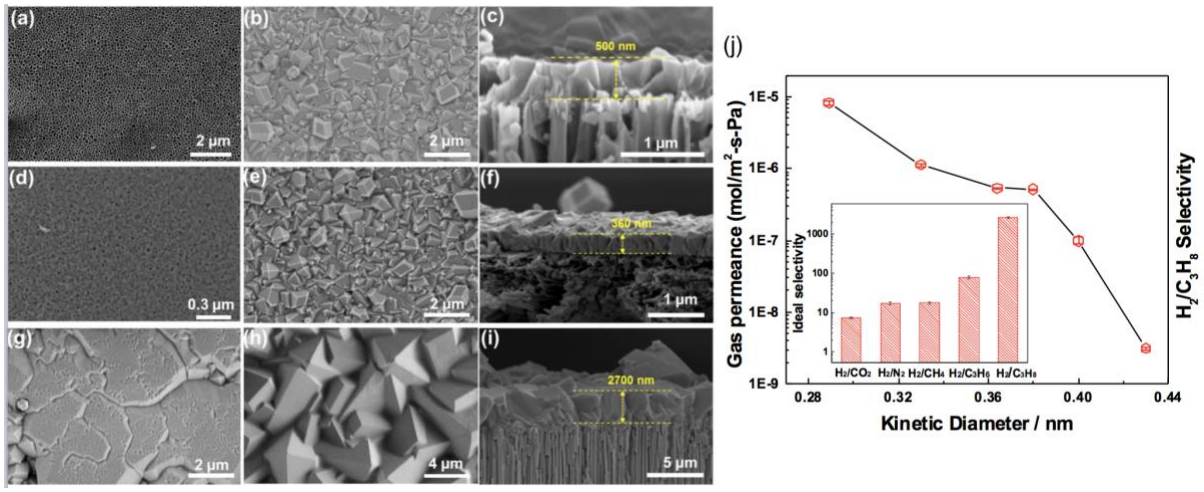


Figure 1: Synthesis of thin MOF films by the ENACT approach. Ultrathin ZIF-8 membranes (b-c, e-f) on an anodized aluminum oxide (AAO) (a), and a porous poly(acrylonitrile) support (d). g) ZIF-8 film on CVD graphene film. h-i) A highly intergrown ZIF-7 film on an AAO support. (j) Gas separation performance of the ZIF-8 membranes prepared by the ENACT approach.

References

1. Knebel, B. Geppert, K. Volgmann, D. I. Kolokolov, A. G. Stepanov, J. Twiefel, P. Heitjans, D. Volkmer, J. Caro, *Science* **2017**, *358*, 347.
2. J. Brown, N. A. Brunelli, K. Eum, F. Rashidi, J. R. Johnson, W. J. Koros, C. W. Jones, S. Nair, *Science* **2014**, *345*, 72.
3. E. Barankova, X. Tan, L. F. Villalobos, E. Litwiller, K. V. Peinemann, *Angew. Chem. Int. Ed.* **2017**, *56*, 2965.
4. He, G.; Dakhchoune, M.; Zhao, J.; Huang, S.; Agrawal, K. V. Electrophoretic Nuclei Assembly for Crystallization of High Performance Membranes on Unmodified Supports. *Submitted.* **2018**.