Continuous Flow Processing of Inorganic Membranes on Polymeric Hollow Fiber Supports

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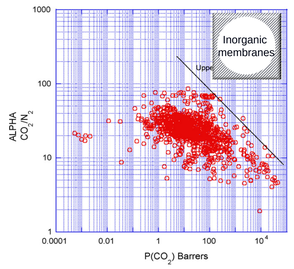
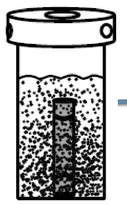
Objective : Fabricate thin, defect-free, mechanically strong, highly CO_2 selective ZIF-8 membranes on Torlon® porous supports using an economically-viable and scalable flow synthesis method

Inorganic membranes



Inorganic membranes show high gas separation performance compared to polymers

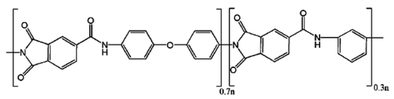


Problems with traditional solvothermal processes for inorganic membrane fabrication:

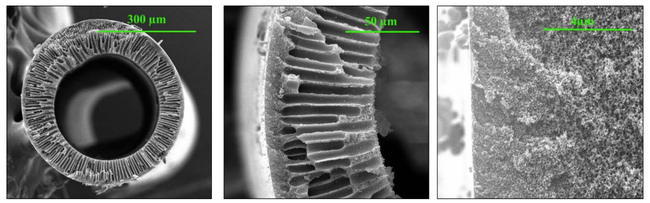
- Require high pressure and temperature
- Not reproducible
- Not scalable
- Costly ceramic supports

Porous Torlon® supports

- Torlon® is a well known polymer for its chemical and mechanical strength.
- Torlon hollow fiber supports are cheap and easily scalable.

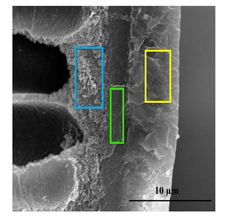


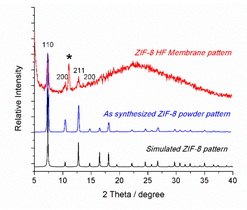
Torlon 4000T



Highly porous and permeable Torlon® supports

Membrane characterization





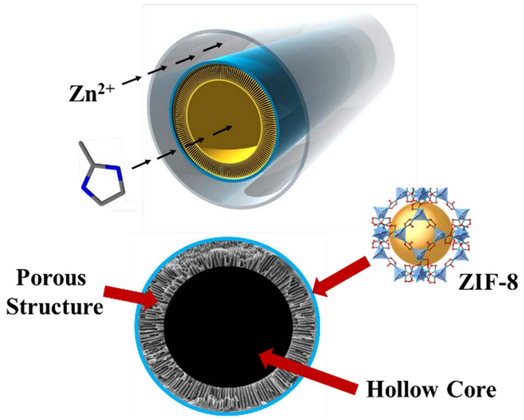
XRD and EDAX confirmed the ZIF-8 formation and its location in fiber cross section

Point and ID	Carbon wt.% ± 1%	Zinc wt. % ± 1%
Spectrum 1	51	27
Spectrum 2	60	10
Spectrum 3	65	8

Membrane	Thickness (µm)	CO_2 Permeance (GPU)	CO_2/N_2 Selectivity
This work	8.5	22	52
ZIF-8 on alumina HF support[2]	2.5	~ 1200	~ 2.7
ZIF-8 in bore of Polysulfone HF support[3]	1.3	4.8 ± 0.5	7.1 ± 4

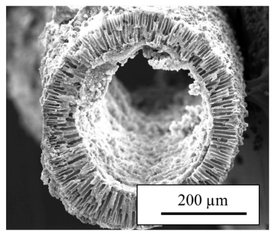
Our approach

- Minimize fabrication steps for reduced cost of membrane.
- Use a reproducible, scalable fabrication method.[1]
- Use an environmental friendly approach: using water as solvent and fabricating at room temperature.

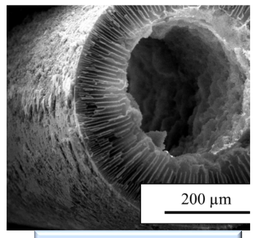


Flow MOF precursors along shell and bore of the fiber with different flow rates.

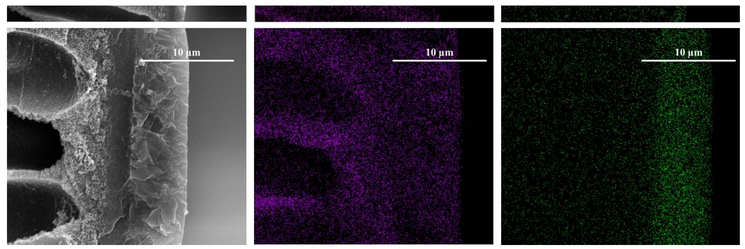
Effect of processing conditions



Low precursor flow rates



High precursor flow rates



Membrane formed on the outer surface with optimized precursor flow rates

Conclusions

- **Successfully fabricated a continuous, defect-free ZIF-8 membrane.**
- **ZIF-8 was anchored to microporous region of supports for good mechanical stability.**
- **Demonstrated highest reported CO_2/N_2 selectivity of 52 for a continuous flow synthesized ZIF-8 membrane.**

References:

1. A. J. Brown, N. A. Brunelli, K. Eum, F. Rashidi, J. R. Johnson, W. J. Koros, C. W. Jones, S Nair, Science, 345 (6192), 72-75 (2014).
2. Kong, L.; Zhang, X.; Liu, Y.; Li, S.; Liu, H.; Qiu, J.; Yeung, K. L. *Mater. Chem. Phys.* **2014**, *148*, 10-16.
3. Cacho-Bailo, F.; Catalán-Aguirre, S.; Etxeberría-Benavides, M.; Karvan, O.; Sebastian, V.; Téllez, C.; Coronas, J. *J. Membr. Sci.* **2015**, *476*, 277-285.

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