Development of Carbon Molecular Sieves Hollow Fiber Membranes based on Polybenzimidazole Doped with Polyprotic Acids with Superior H_2/CO_2 Separation Properties

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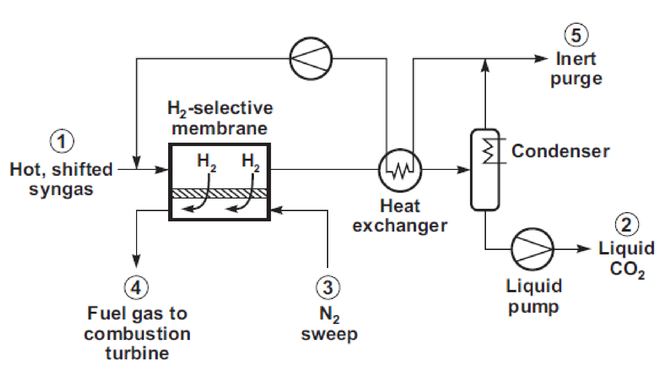
Project Objective

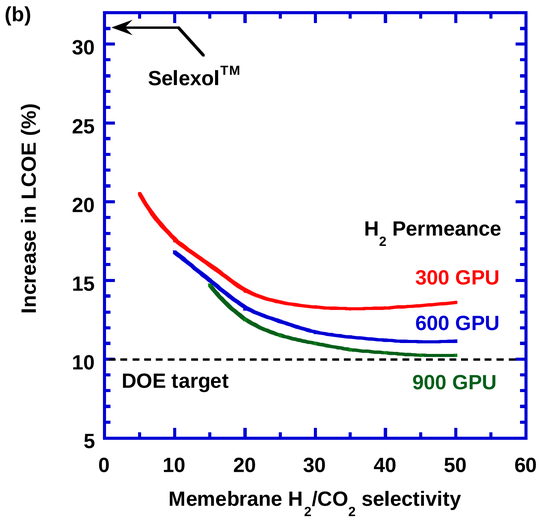
Objective: develop carbon molecular sieves (CMS) hollow fiber membranes with H_2 permeance of 1000 GPU and H_2/CO_2 selectivity of 40 at 200-300 °C.

BP 1 Materials development
- Optimize CMS materials with an H_2 permeability of 200 Barrers and H_2/CO_2 selectivity of 40 with simulated syngas; and
- Optimize the hollow fiber membranes based on PBI doped with polyprotic acids.

BP 2 Membrane development
- Optimize membranes achieving the targeted H_2/CO_2 separation performance;
- Test membranes using simulated syngas containing H_2S, CO and water vapor;
- Determine the efficiency of the membrane reactors for the WGS reaction; and
- Conduct the techno-economic analysis.

Defining Membrane Properties for H_2/CO_2 Separation

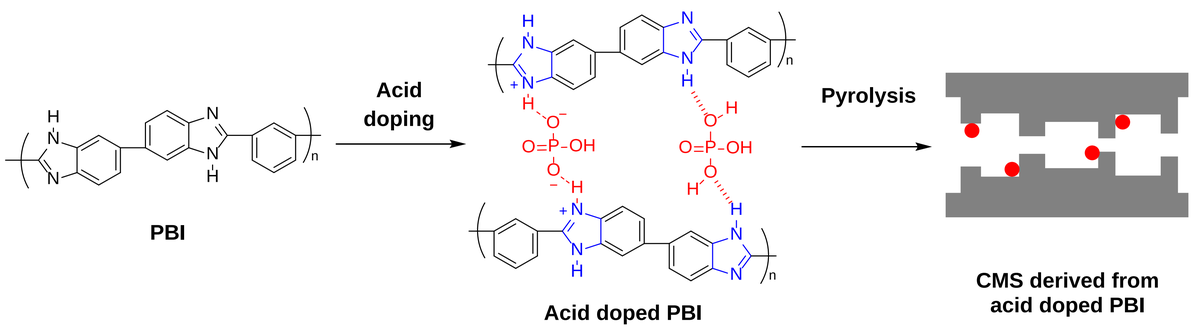




- Hybrid membrane and cryogenic process is effective for CO_2 capture
- Target: H_2 permeance of 1000 GPU, H_2/CO_2 selectivity of 40

Merkel, Zhou and Baker, J. Membr. Sci., 389, 442 (2012)
Merkel, et al., NETL CO_2 Capture Technology Review Meeting, 2011.

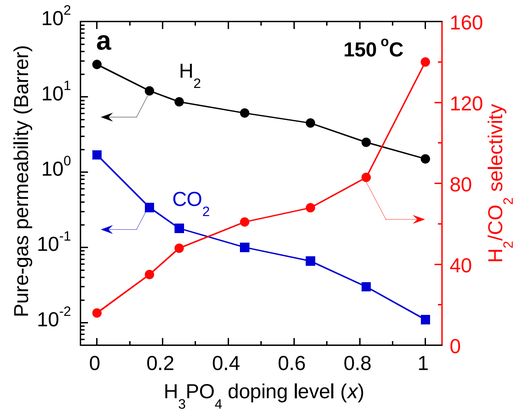
Our Approach: Carbonizing PBI/Polyprotic Acids

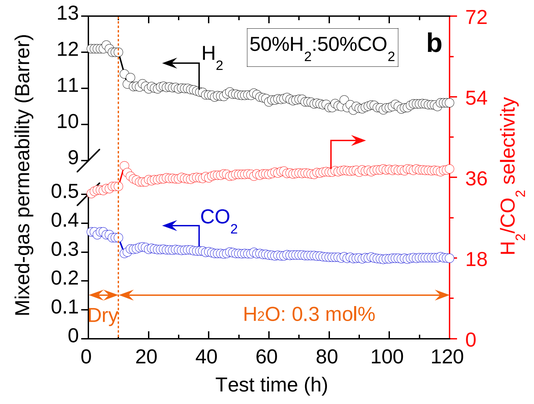


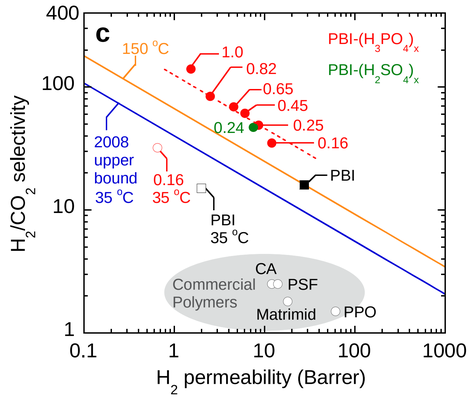
Three steps:

1. PBI with superior H_2/CO_2 separation properties
2. Doping PBI with polyprotic acids to improve H_2/CO_2 selectivity
3. Carbonizing to enhance H_2 permeance

Preliminary Data on PBI Doped by H_3PO_4



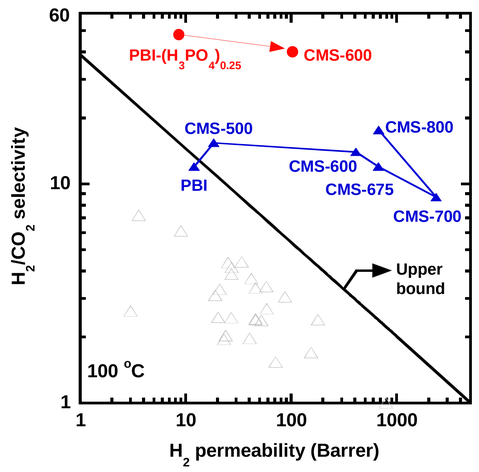


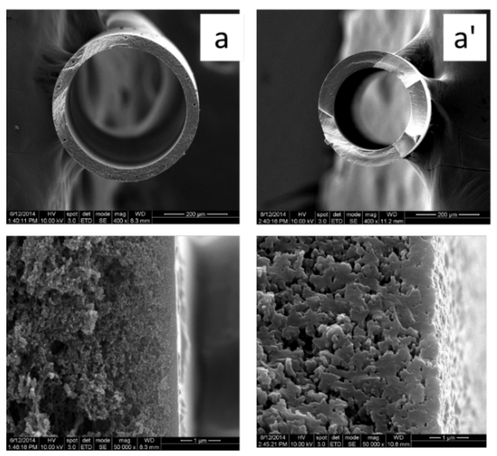


- Doping PBI with H_3PO_4 dramatically increases H_2/CO_2 selectivity
- PBI/H_3PO_4 is stable in the presence of water at 150 °C

Zhu, Swihart and Lin, *Energy Environ. Sci.*, 11 (1), 94-100 (2018)

Preliminary Data on Carbonized PBI or PBI/H_3PO_4

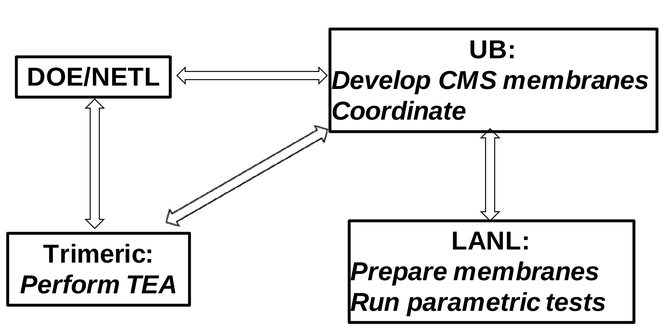




Thin film studies
- Carbonizing PBI increases H_2 permeance
- Carbonized PBI/H_3PO_4 shows superior H_2/CO_2 separation properties

Hollow fibers of PBI: Carbonizing PBI increases H_2 permeance

Collaboration



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