Development of Self-Assembly Isoporous Supports Enabling Transformational Membrane Performance for Cost Effective Carbon Capture (DE-FE0031596)

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DOE NETL CO_2 Capture Technology Project Review Meeting
Pittsburgh, PA
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Project Overview

- **Award Name:** Development of Self-Assembly Isoporous Supports Enabling Transformational Membrane Performance for Cost Effective Carbon Capture (DE-FE0031596)
- **Project Period:** June 1, 2018 – May 31, 2021
- **Funding:** $2,905,620 DOE; $726,805 cost share (MTR and University of Buffalo)
- **DOE Project Manager:** José Figueroa, Bruce Lani
- **Participants:** Membrane Technology and Research, Inc., University of Buffalo
- **Project Objectives:**
  - Develop supports for composite membranes with highly regular surface pore structures that eliminate the restriction on diffusion in the selective layer that is present with current generation supports
  - Develop improved selective materials with higher permeance and/or higher selectivity compared to the current generation Polaris material
- **Project Plan:**
  - **BP1:** Lab-scale support development, screening of novel selective materials
  - **BP2:** Commercial-scale support development, scale up of 5 selective materials, composite membrane optimization
  - **BP3:** Commercial-scale composite membrane development, lab-scale module testing at MTR, bench-scale module test at NCCC

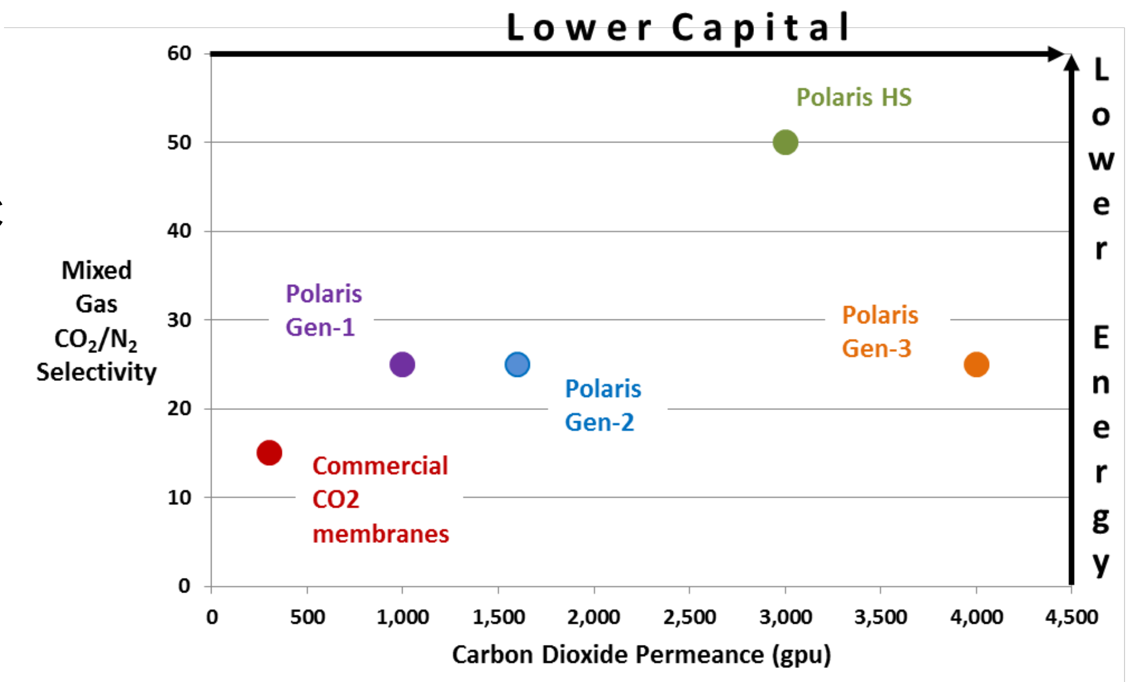
MTR

Project Success Criteria

1. Composite membranes produced with transformational performance, based on improved supports and improved selective materials

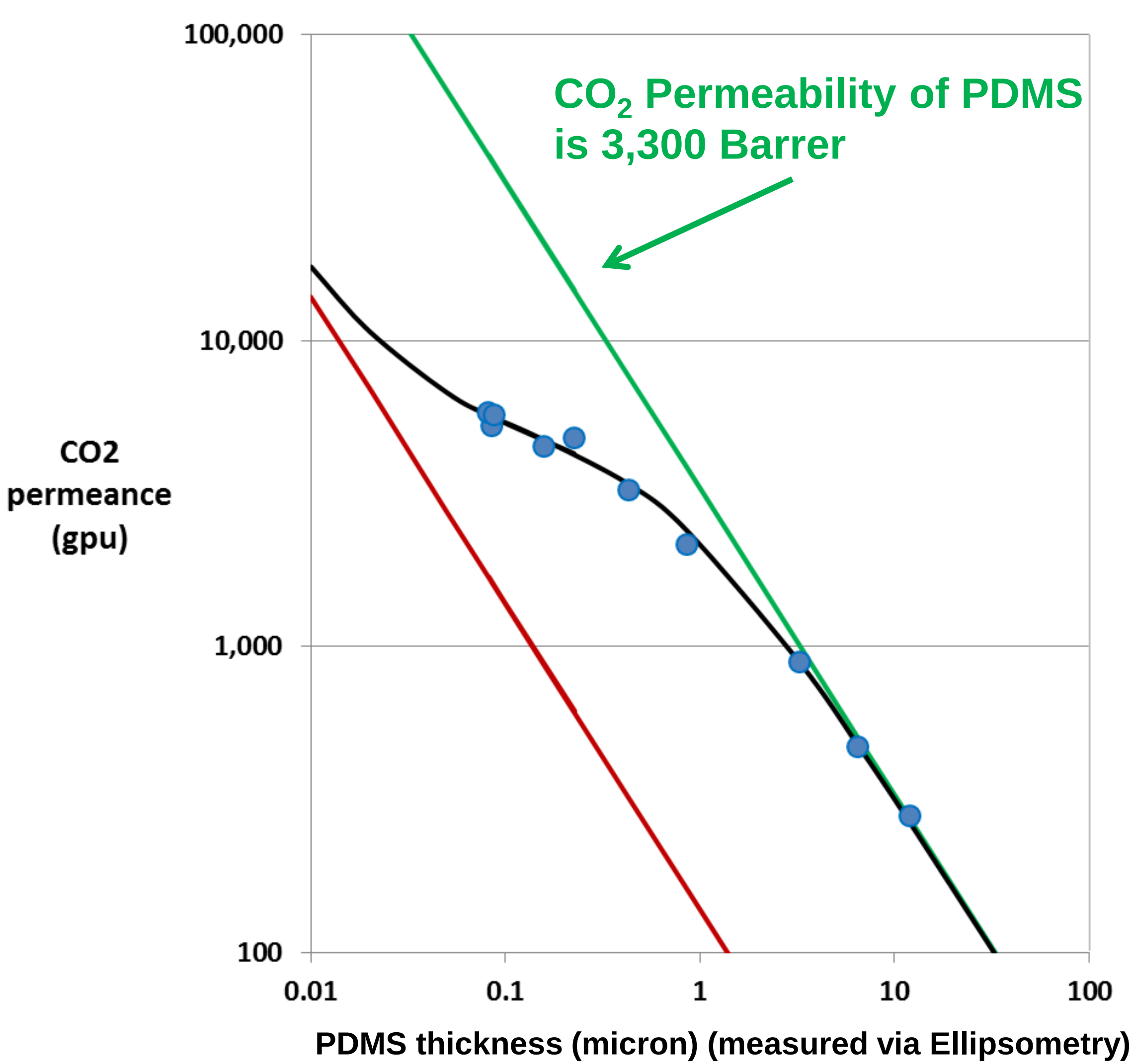
2. Membrane and modules fabricated at MTR, and tested at MTR and at NCCC

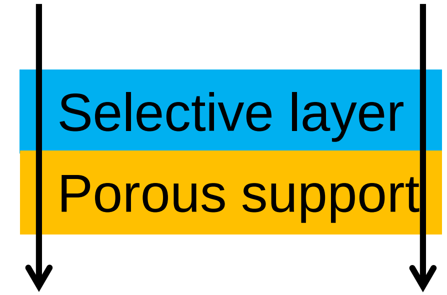
3. Techno-economic analysis validates that the goal of \$30/tonne CO_2 captured can be reached



MTR

The Issue: Reducing the Thickness of the Selective Layer Improves Permeance, but Less than Expected

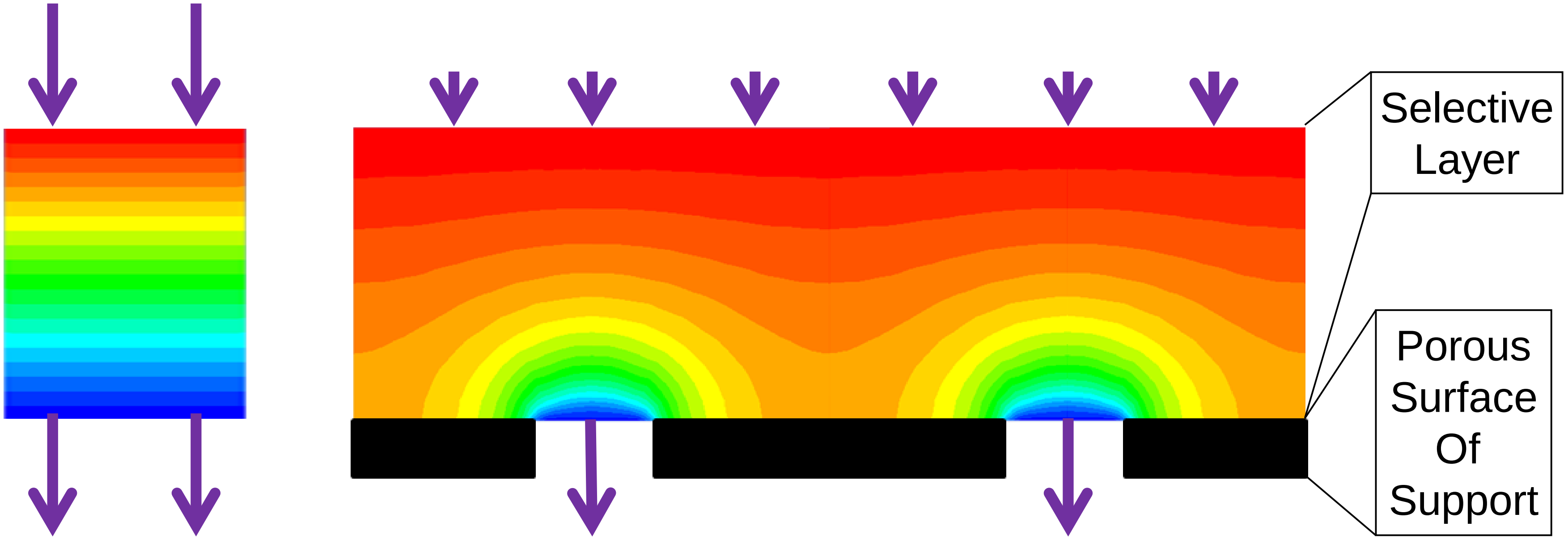




Influence of the support is significant for selective layers below 1 micron thickness

MTR

Analysis of Support Influence using Computational Fluid Dynamics



What the CDF results tell us:

- Currently used supports reduce membrane permeance by several factors if the selective layer is thinner than one micron
- Higher porosities and smaller pore sizes reduce this effect (as expected)
- Uniform distribution of the pores is VERY beneficial in reducing the effect (this is a new observation)

Highly Ordered Surfaces can be Obtained by Combining Self-Assembly and Phase Inversion

Asymmetric superstructure formed in a block copolymer via phase separation

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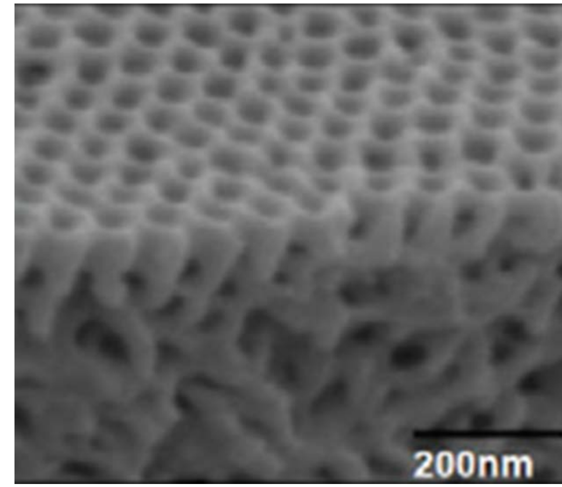
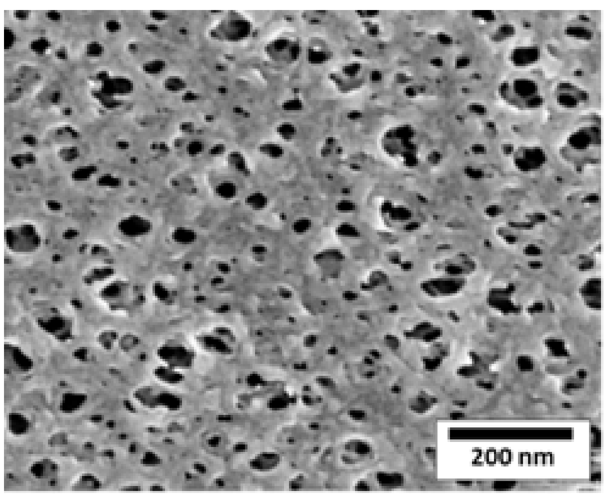
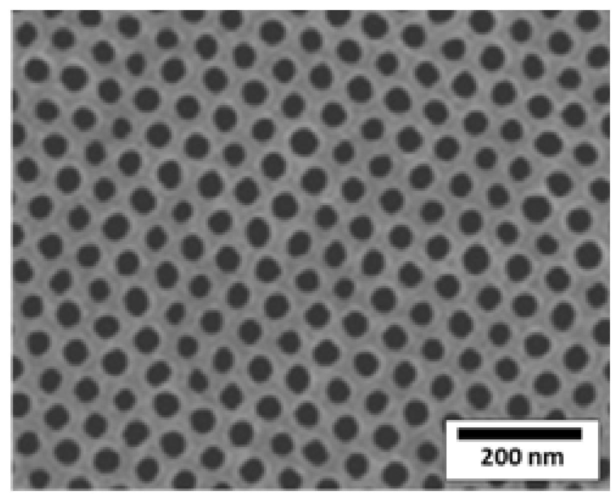


- Amphiphilic Block Copolymer in mixed solvent, evaporation step followed by immersion precipitation
- Creates top surface with highly ordered porous structure
- “Perfect” support for composite membranes



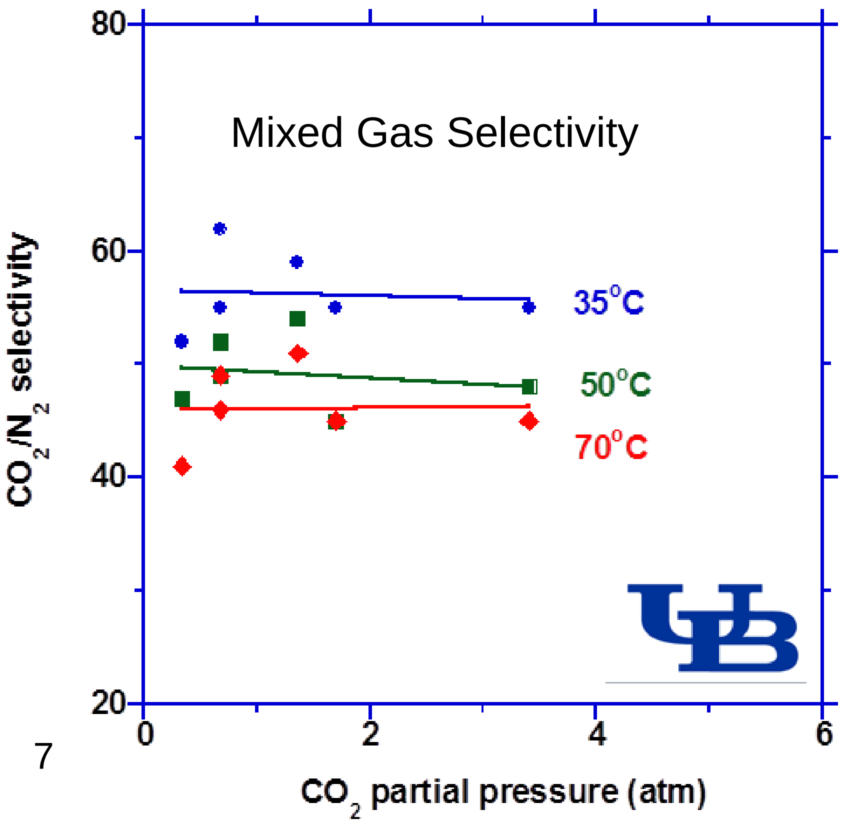
Surface of Conventional Support



Surface of Isoporous Support

New Selective Materials (NYU Buffalo)

- Improved supports will allow fabrication of membranes with higher permeances (existing materials)
- Improved supports will make it possible to use less permeable selective materials with higher selectivity



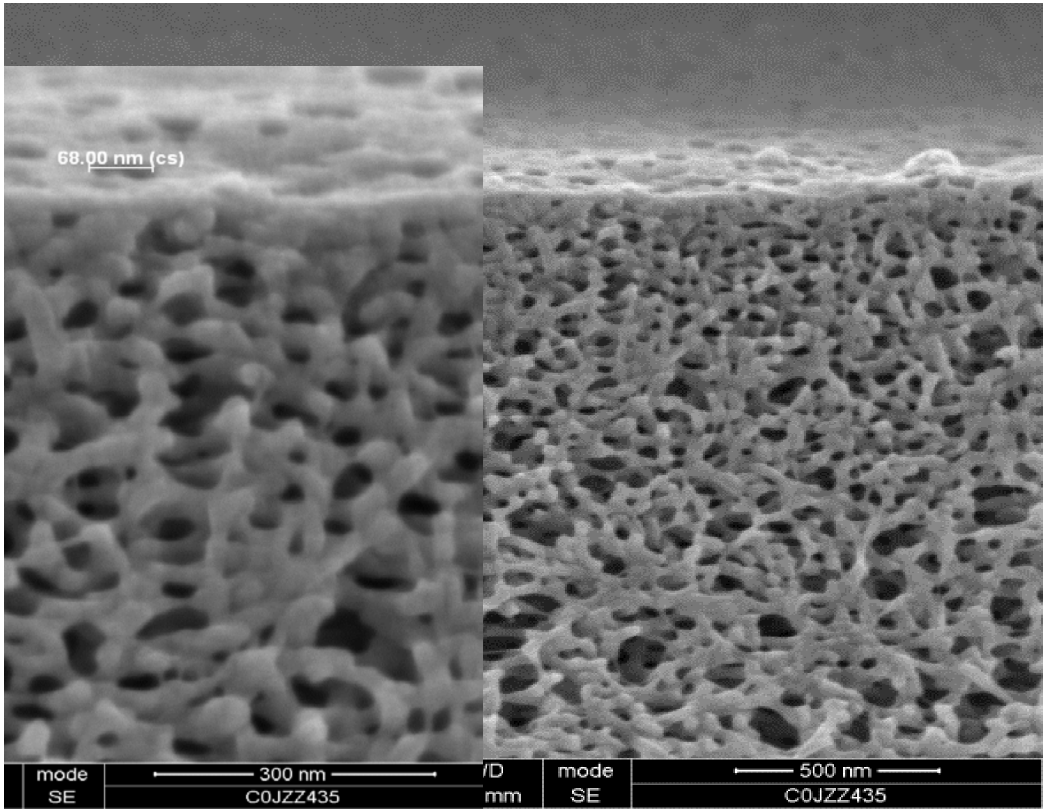
- Ether-based polymer chemistries developed at University of Buffalo have high selectivities, even at high CO_2 partial pressures as well as at high temperatures
- Benefits:
  - Higher temperature operation in coal fired power plants
  - Reduced oxygen loss in sweep step
  - Higher pressure operation in gasification, steel and cement applications

Project Status

- Project started two months ago

- Purchased commercially available block copolymers

- Produced the first examples of block copolymer phase inversion at MTR



- University of Buffalo has started synthesis of the first ether-based selective materials

THANK YOU!

QUESTIONS?