

# Rational Development of Novel Metal-Organic Polyhedra-based Membranes for CO<sub>2</sub> Capture (FE0031736)

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<sup>6</sup>Trimeric Corporation

NETL CO<sub>2</sub> Capture Technology Project Review Meeting  
Pittsburgh, PA

8/29/2019



# Project Overview

**Award number:** DE-FE0031736

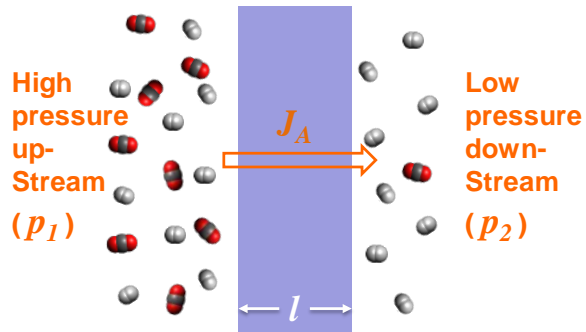
**Project period:** 7/1/19 to 6/30/22

**Program manager:** Isaac Aurelio

## **Project Objectives:**

- Rationally develop solubility-selective mixed matrix **materials** comprising polar rubbery polymers and metal organic polyhedra (MOPs);
- Develop thin film composite **membranes** achieving high CO<sub>2</sub> permeance (3000 GPU) and high CO<sub>2</sub>/N<sub>2</sub> selectivity (75) at 60°C;
- Demonstrate separation **performance** and stability with raw flue gas at NCCC; and
- Perform **techno-economic analysis** on the membrane processes.

# Membrane technology can be attractive



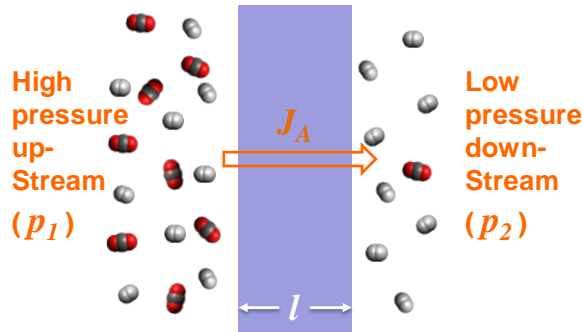
Productivity

$$P_A = S_A \times D_A$$

Selectivity

$$\alpha_{A/B} = \frac{P_A}{P_B} = \left( \frac{S_A}{S_B} \right) \times \left( \frac{D_A}{D_B} \right)$$

# Membrane technology can be attractive

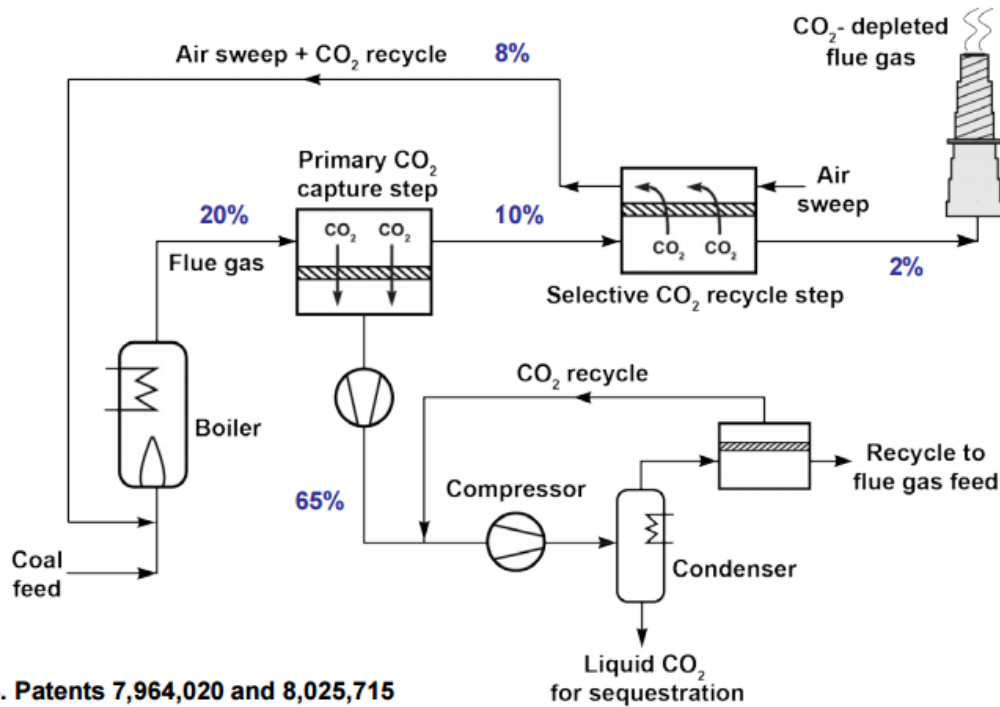


Productivity

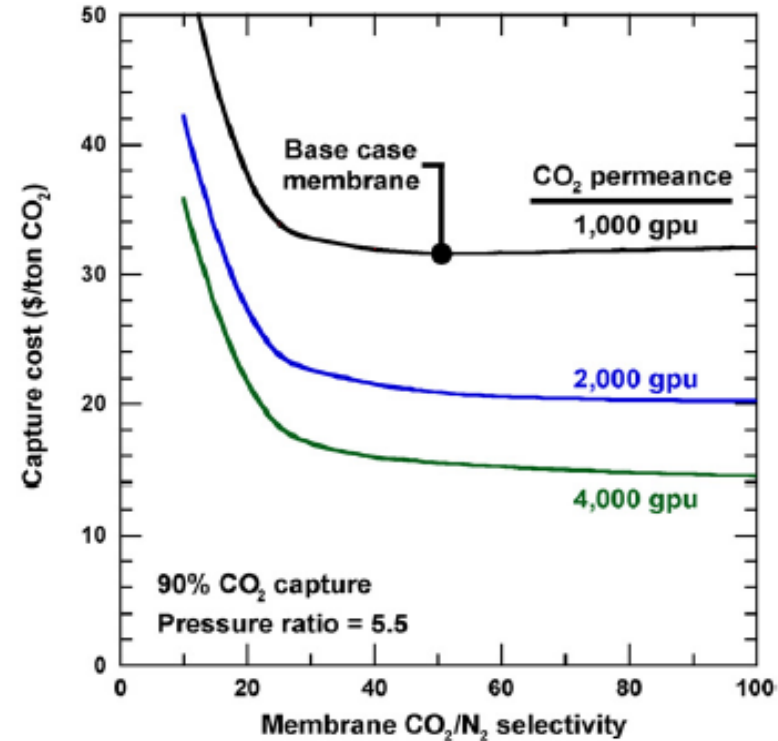
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U.S. Patents 7,964,020 and 8,025,715

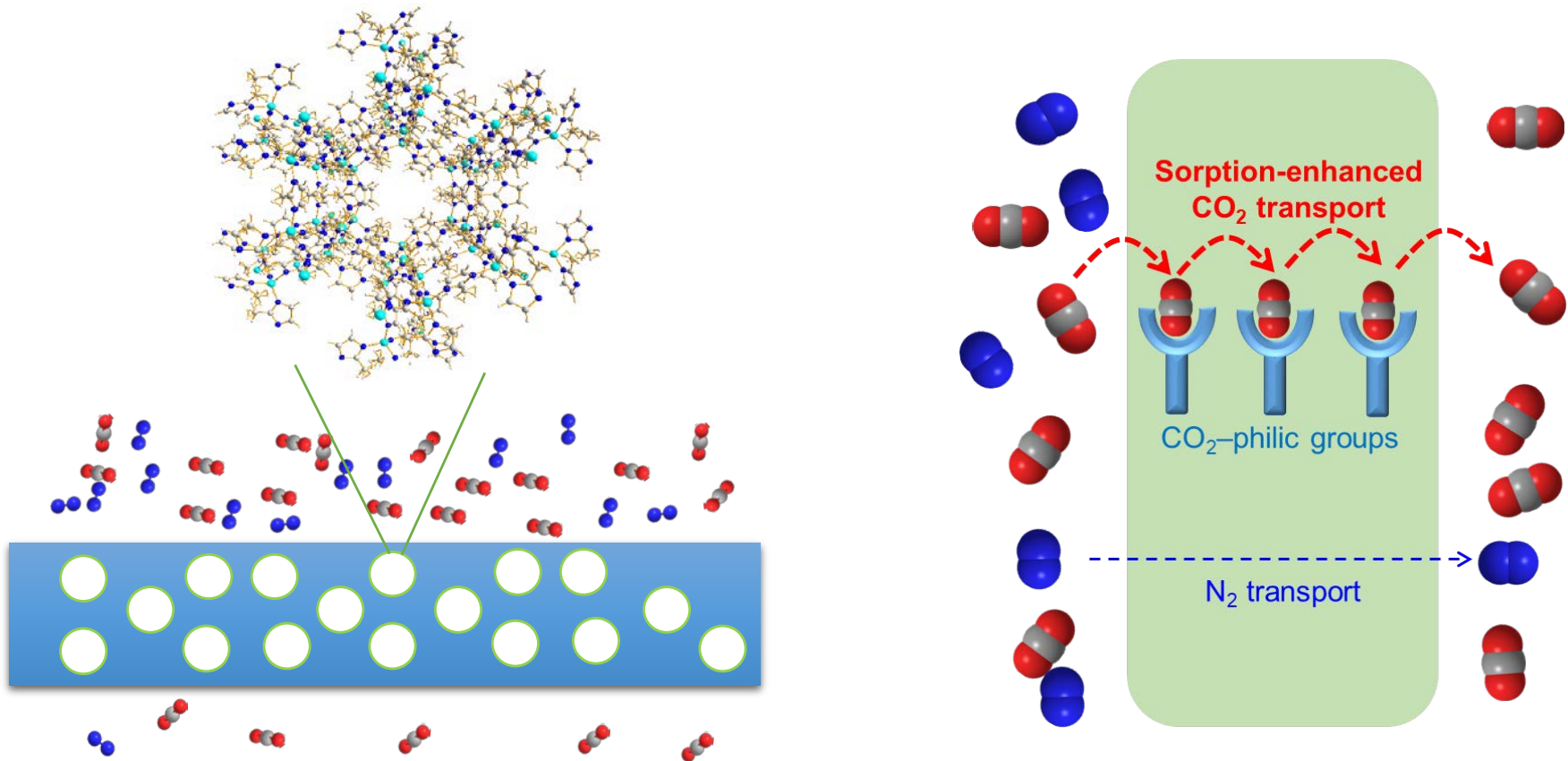


Merkel, Lin, Wei and Baker, *J. Membr. Sci.*, 359, 126 (2010)

Merkel, et al., *NETL CO2 Capture Technology Review Meeting*, 2015.

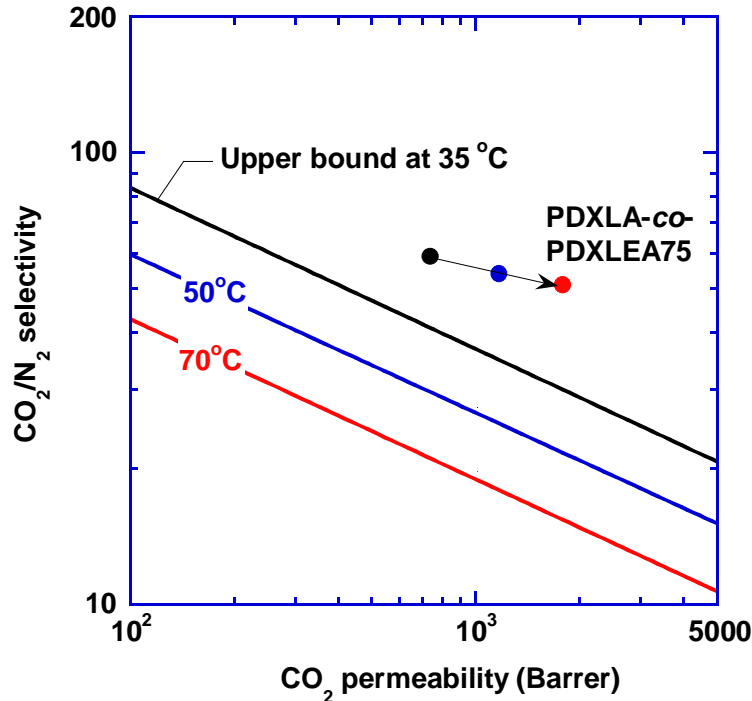
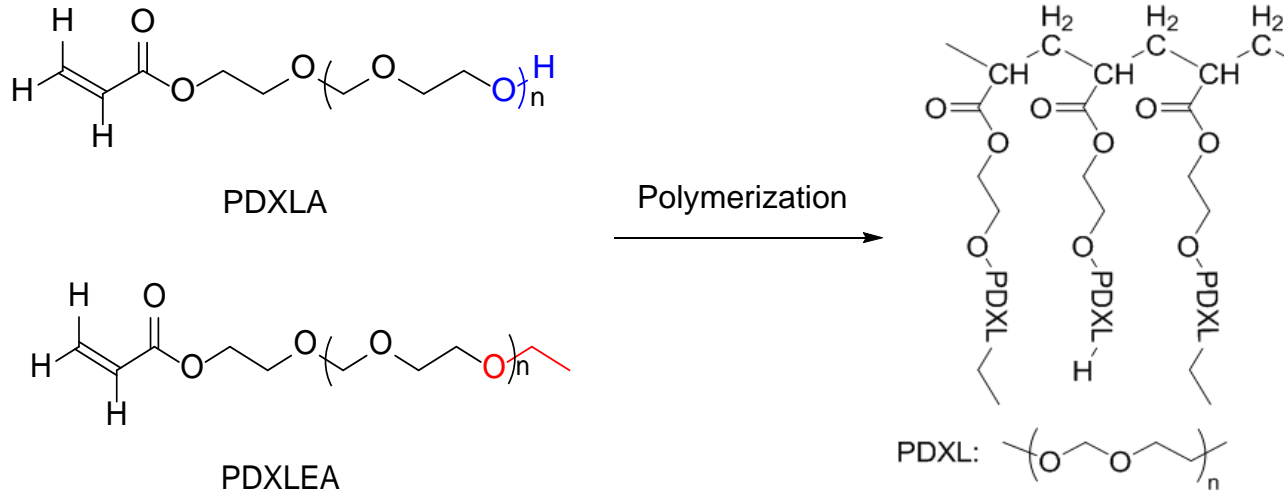


# Our Approach: Sorption-Enhanced Mixed-Matrix Membranes



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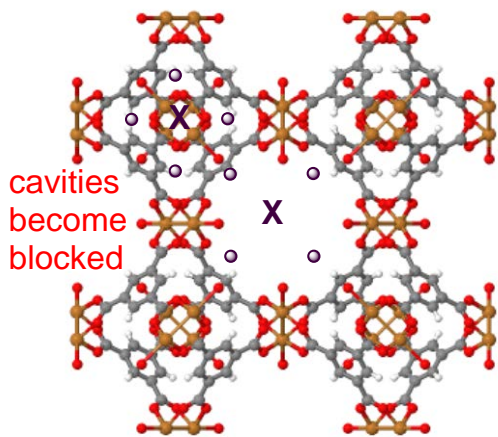
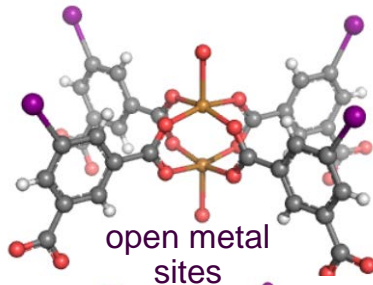
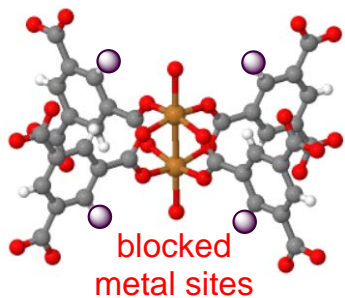
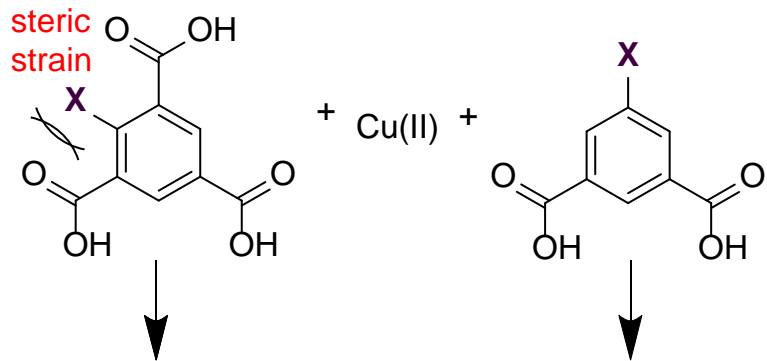
# Highly Polar Rubbery Polymers



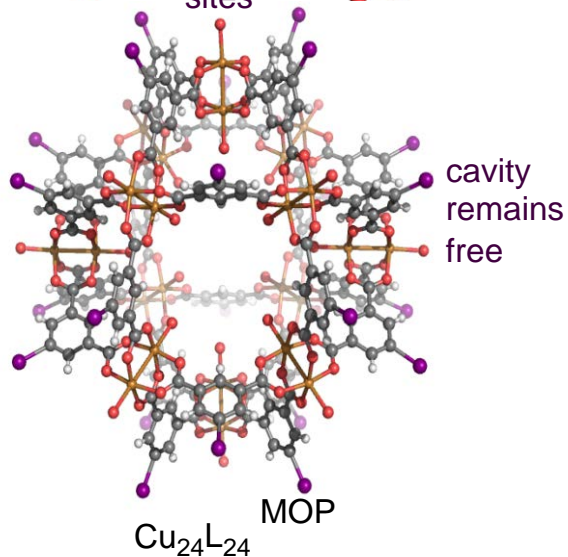
$$\alpha_{A/B} = \frac{P_A}{P_B} = \left( \frac{S_A}{S_B} \right) \times \left( \frac{D_A}{D_B} \right)$$

Liu, Lin, et al., *Joule*, 3(8), 1881-1894, 2019

# Metal-Organic Polyhedra (MOPs)



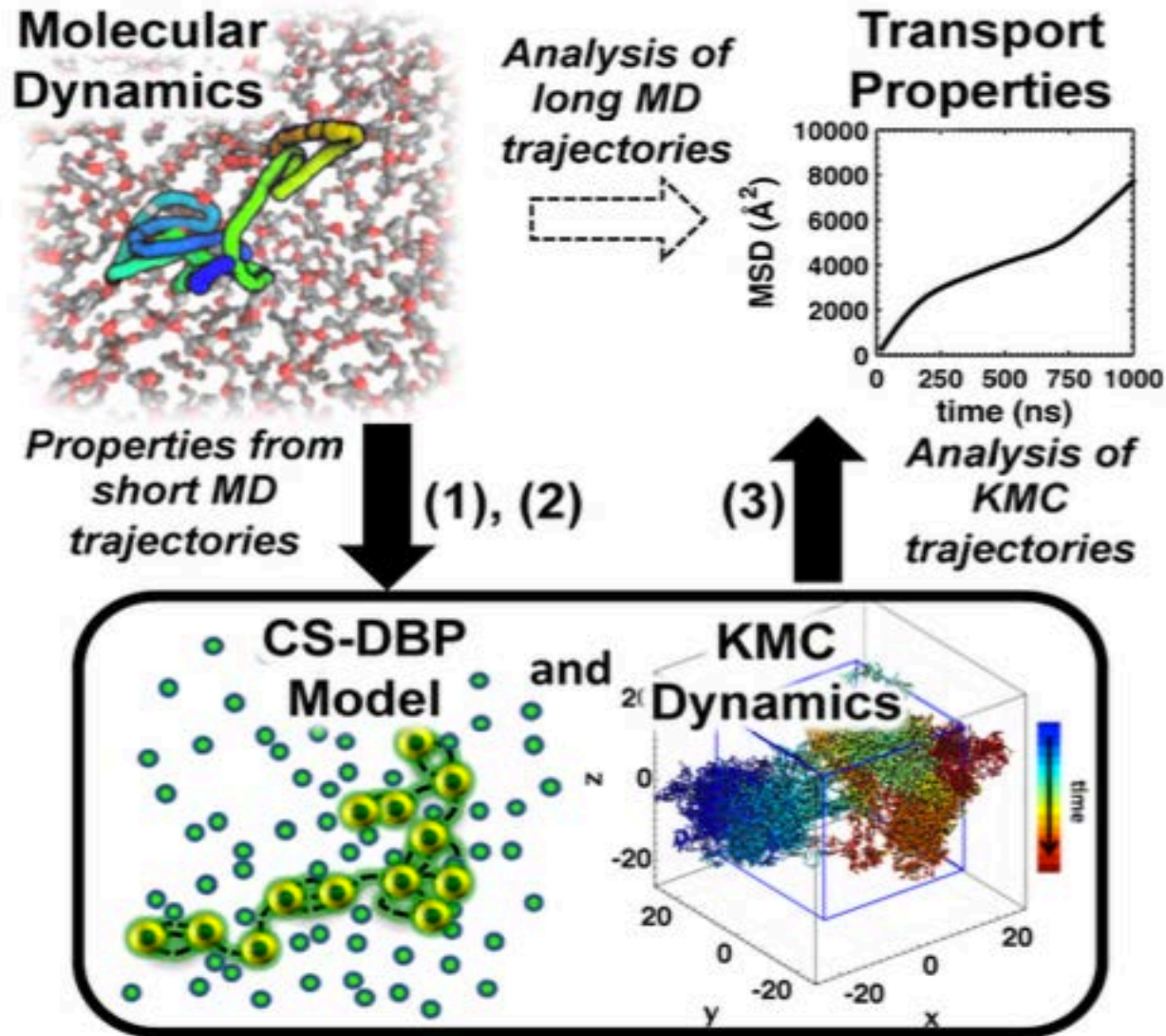
HKUST-1



## MOPs

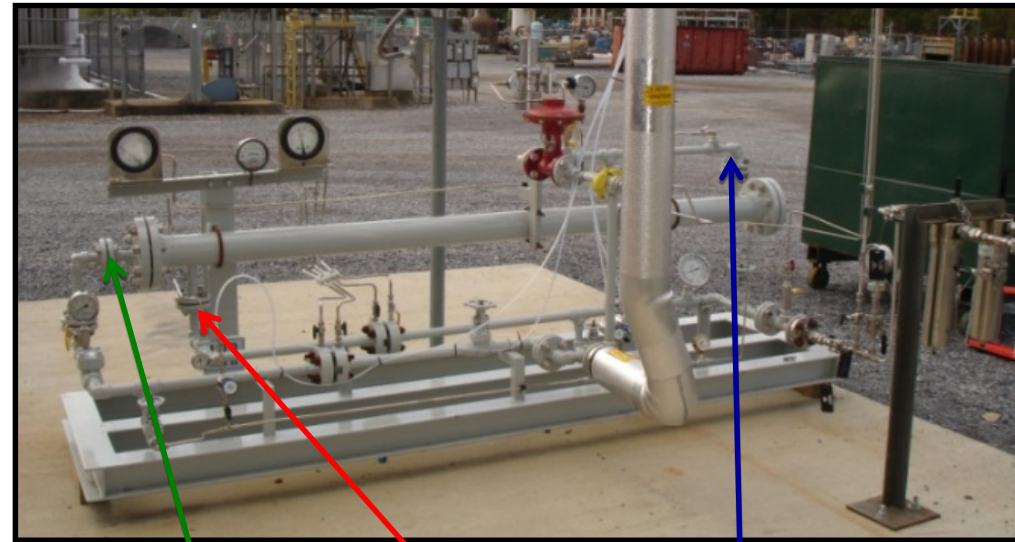
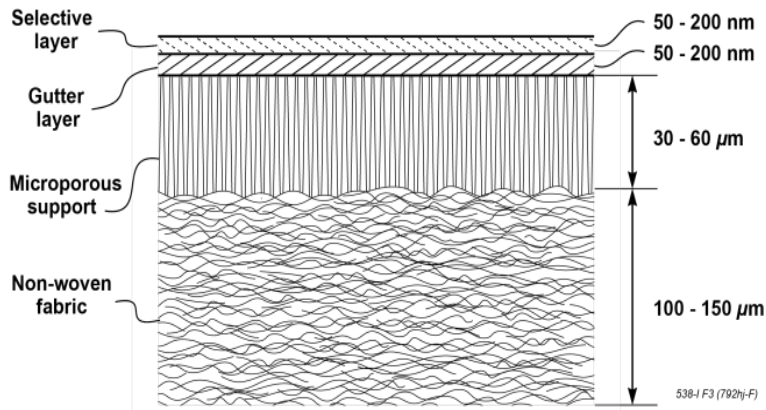
- 2 – 5 nm in size
- Soluble in solvents
- Permanent pores to increase gas diffusivity
- Open metal sites to interact with  $CO_2$

# High Throughput Simulations





# Membrane Development and Field Test



Permeate

Feed

Residue



## National Carbon Capture Center



Power Systems Development Facility

Post-Combustion Carbon Capture Center (PC4)

Alabama Power Plant E. C. Gaston

Logos of sponsors and funding information:

- U.S. DEPARTMENT OF ENERGY
- NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY
- Southern Company
- AMERICAN FACTORY
- CLEARPATH
- CLOUD PEAK ENERGY
- DUKE ENERGY
- ExxonMobil
- EPRI
- PEABODY
- Hydrex

2014 - 2020  
DOE & Industrial Sponsors  
80/20 \$187.5 million -  
Continue CO<sub>2</sub> Capture R&D  
for Cost Reduction

NC NATIONAL CARBON CAPTURE CENTER

- Develop industrial membranes and modules
- Test with real flue gas

# Project Budget and Team Roles

	Govt Share	Cost Share	Role
<b>UB</b>	<b>\$1,259,501</b>	<b>\$599,997<sup>†</sup></b>	<b>Materials development</b>
Subcontracts:			
RPI	\$400,000	\$102,913	Polymer synthesis scale-up
Caltech	\$388,130	\$97,508	Computational simulation
MTR	\$599,468	\$174,987	Membranes development and field test
Trimeric	\$110,000	0	TEA analysis
NCCC	0	0	Host site
Total	\$2,857,577	\$975,405	

<sup>†</sup> UB cost-share is provided by Empire State Development's Division of Science, Technology and Innovation (NYSTAR)