

CO₂-philic Block Copolymers with intrinsic Microporosity for Post-combustion CO₂ Capture (SC0020730)

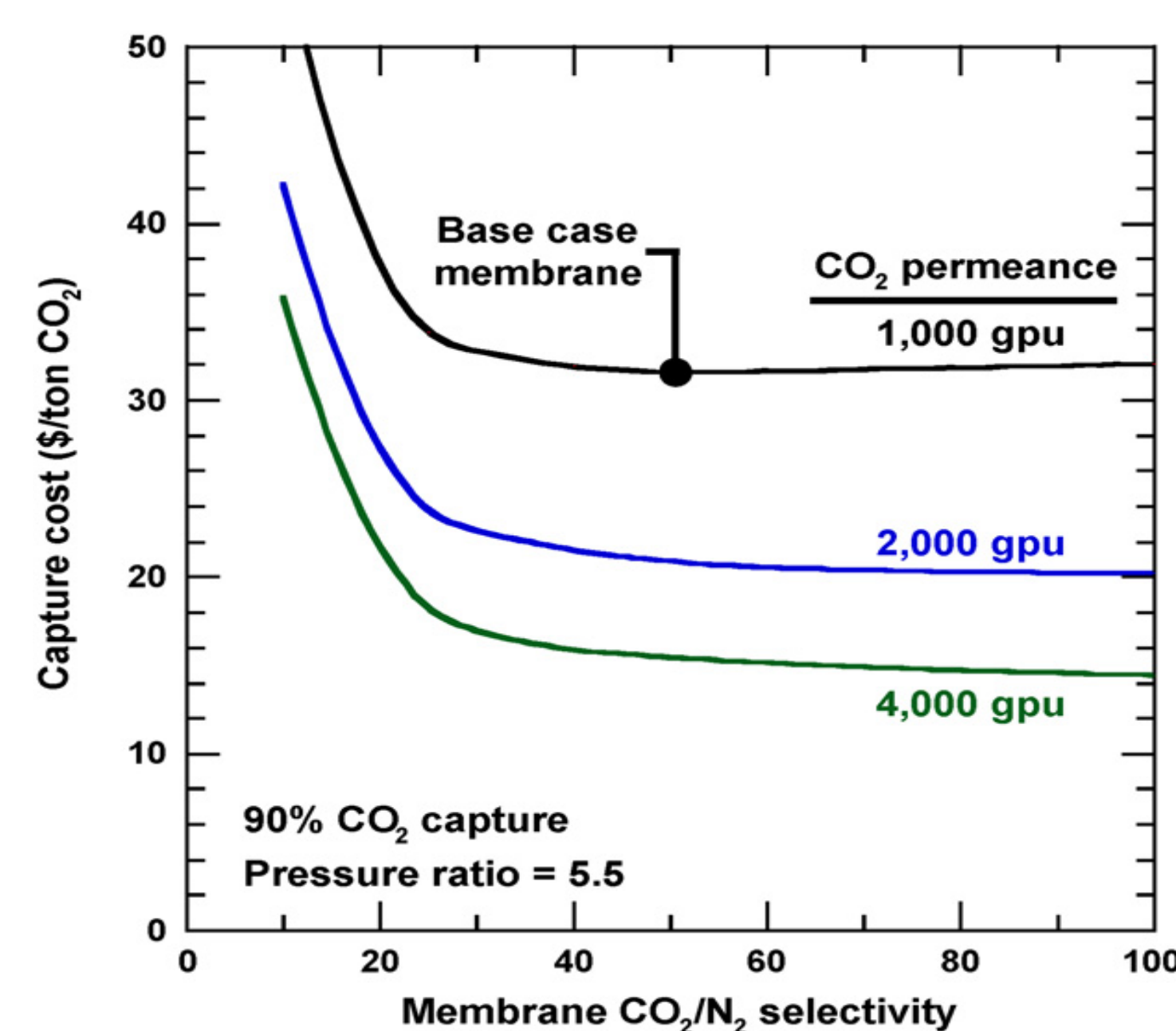
J. Maloney¹, B. Lam¹, M. Wahl¹, O. Rondon¹, R. Prasad¹, G. Zhang², H. Lin², J. Kniep³, and L. Zhu⁴

¹Helios-NRG, LLC, ²University at Buffalo, State University of New York, ³Membrane Technology & Research, ⁴National Energy Technology Laboratory

Objectives of DOE STTR Project

- Objective 1:** Optimize TFC membrane for CO₂ permeance $\geq 4,500$ GPU and CO₂/N₂ selectivity ≥ 40 at 35-60°C;
- Objective 2:** Scale-up TFC membrane fabrication;
- Objective 3:** Validate resistance to contaminants in the long-term test;
- Objective 4:** Fabricate small modules and validate performance in process tests;
- Objective 5:** Define the best process and refine TEA.

Defining Membrane Properties for CO₂/N₂ Separation



Target: CO₂ permeance of 4500 GPU and CO₂/N₂ selectivity of 40 or greater at 35-60 °C

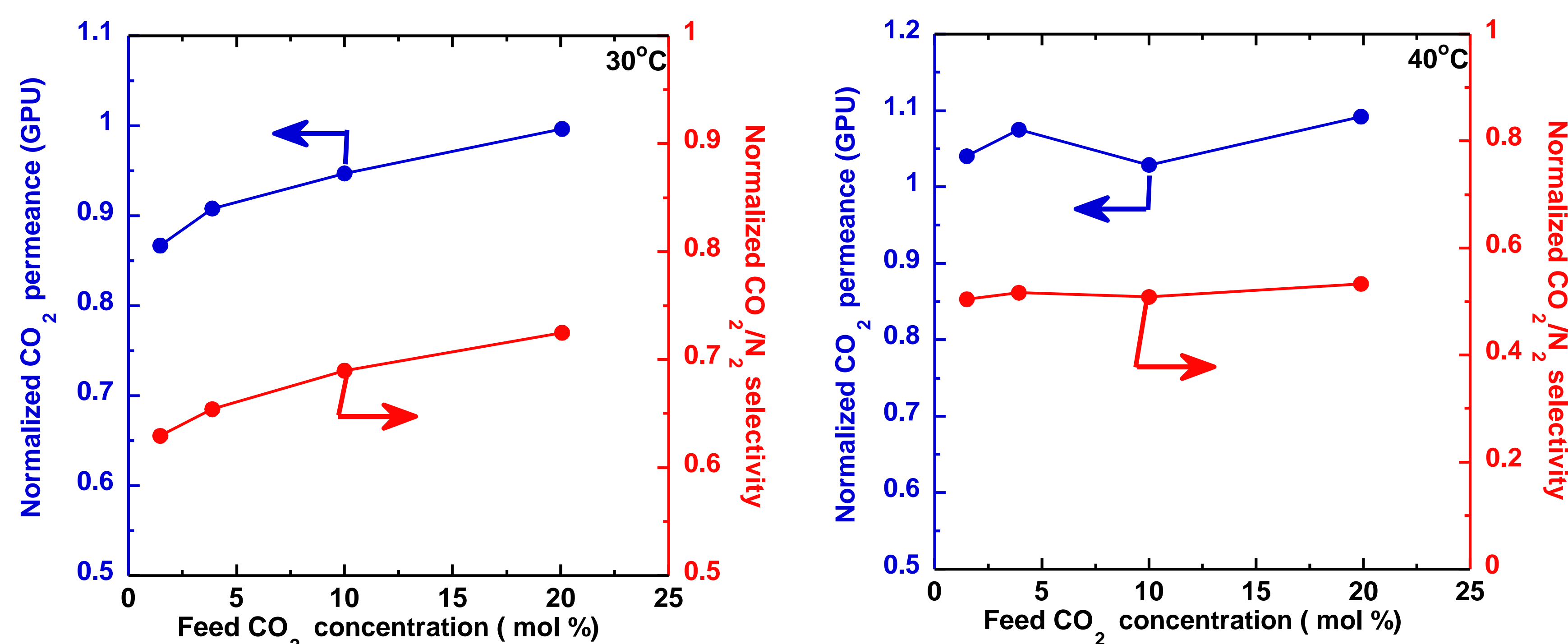
Merkel, et al., Pilot testing of a membrane system for post-combustion CO₂ capture (DE-FE0005795), Membrane Technology and Research, Inc., final report to DOE NETL, 2015.

Our Approach: TFC Membranes Based on Poly(ethylene oxide) and UiO-66-NH₂

Three steps:

1. Synthesize high molecular weight poly(ethylene oxide) (aPEO);
2. Optimize the gutter layer to increase gas permeance of the membrane;
3. Add UiO-66-NH₂ into the selective layer to further increase gas permeance

Mixed-gas Separation Performance of aPEO/UiO-66-NH₂ TFC Membranes



CO₂ permeance and CO₂/N₂ selectivity increase with feed CO₂ concentration at 30°C and remain almost the same at 40°C.

TFC Membrane Stability Test under Sim. Flue Gas



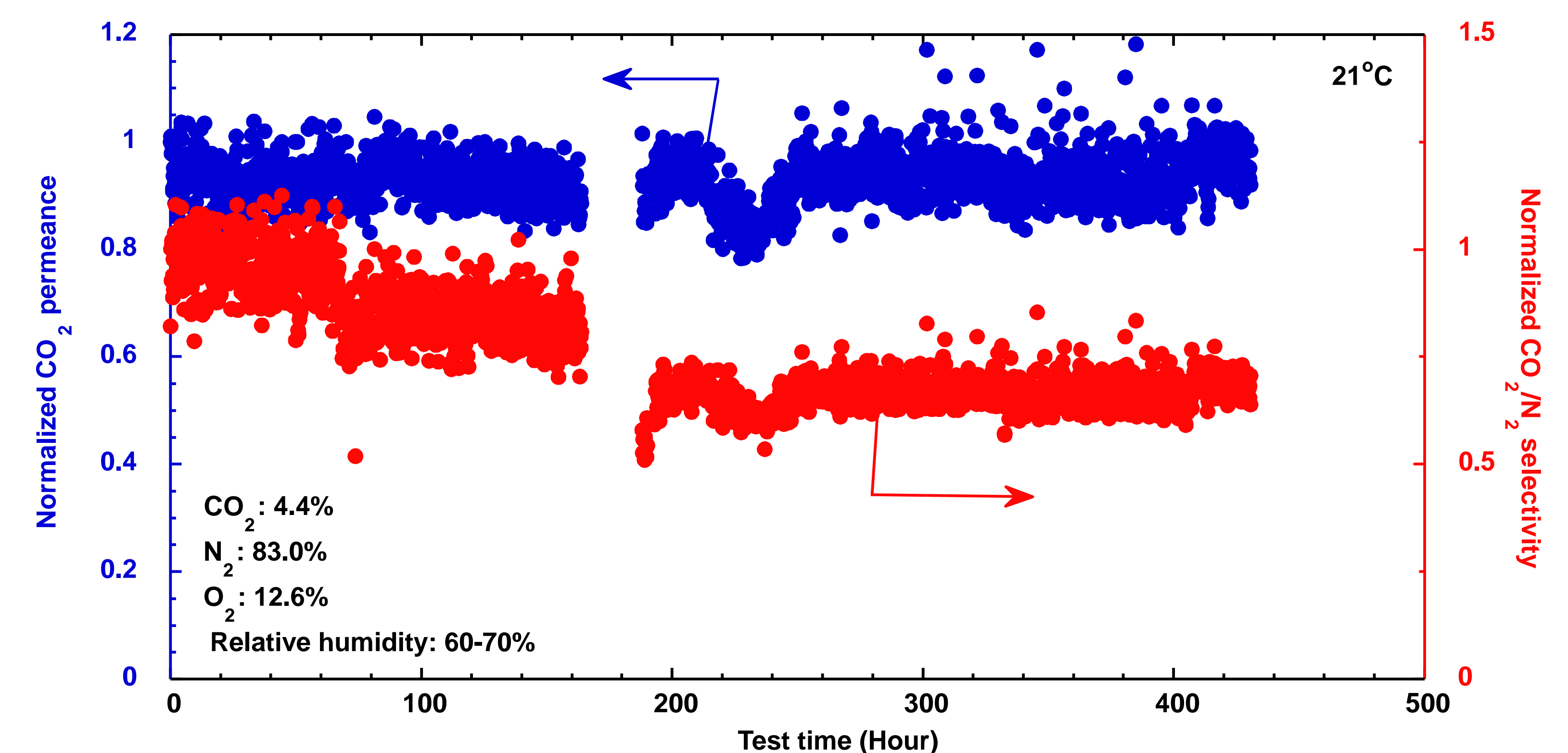
Post-Exposure >200hr

Sim. FG: ~5ppm SO_x, ~5ppm NO_x, H₂O, CO₂, N₂ bal

Series	Sample	Gas	Normalized CO ₂ Permeance		Selectivity (α CO ₂ /N ₂)	
			Pre-Exposure	Post-Exposure	Pre-Exposure	Post-Exposure
#1	PDMS	N/A	1.00	1.03	9.1	9.0
		Sim. FG	1.00	1.09	8.9	8.9
#2	HPEO	N/A	1.00	0.97	43.3	40.4
		Sim. FG	1.00	0.96	40.8	42.0
#3	HPEO + MOF (Type #1)	N/A	1.00	0.94	24.6	23.8
		Sim. FG	1.00	1.04	38.3	34.1
#4	HPEO + MOF (Type #2)	N/A	1.00	1.04	41.1	38.3
		Sim. FG	1.00	1.03	39.2	36.4

TFC membrane properties stable over time; Pre-treatment of flue gas entering membrane likely not required in commercial application

NCCC Field Test



The aPEO/UiO-66-NH₂ TFC membranes present stable CO₂/N₂ separation properties in a field test.

Process Development and Economic Analysis

- 550MW SCPC plant
- **Process:**
 - 2-Stg Cascade + Cryo or MTR 3-Stg + Cryo
 - Capture efficiency: 91.5%
- **Membrane properties:**
 - CO₂ perm: 3000-4500 GPU
 - CO₂/N₂ selectivity: 40-48
- 64 mil Power; \$50/m²

Metric	Mem 1 - High End		Mem 2 - Low End	
	Wo Cryo	Wi- Cryo	Wo Cryo	Wi- Cryo
Overall Capture Efficiency	91.5%	91.5%	91.5%	91.5%
Prod CO ₂ Concentration	87.0%	100.0%	87.0%	100.0%
Relative Capital	100%	116%	120%	136%
CO ₂ Capture Cost (\$/ton)	23.8	33.8	26.7	36.7