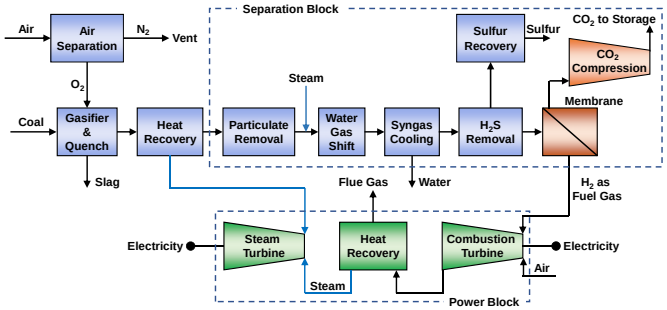
Transformational Membranes for Pre-combustion Carbon Capture – DE-FE0031635

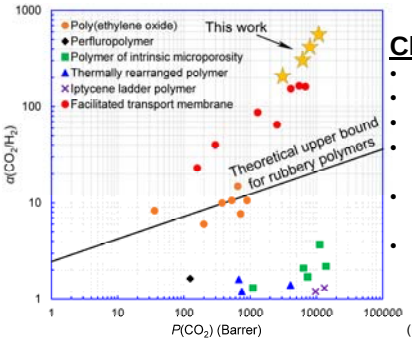
Yang Han and W.S. Winston Ho

William G. Lowrie Department of Chemical and Biomolecular Engineering, The Ohio State University

Pre-combustion Carbon Capture



Membranes for CO_2/H_2 Separation

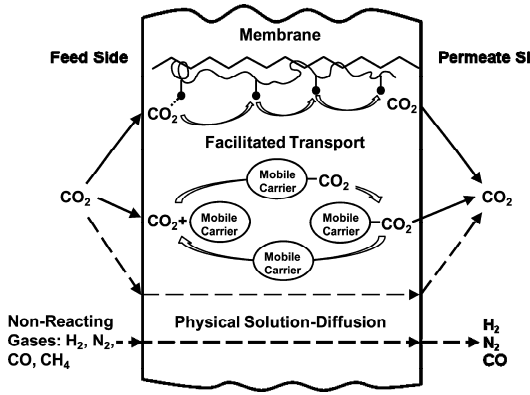


Challenges

- 90% CO_2 recovery
- >95% CO_2 purity
- >99% H_2 recovery
- Permeability/selectivity trade-off
- More permeable → small footprint
- More selective → low H_2 loss

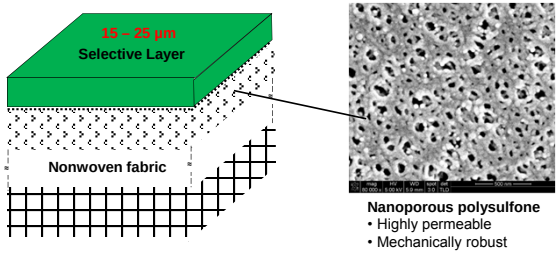
(Han & Ho, Chinese J. Chem. Eng. (2018))

Facilitated Transport Membrane



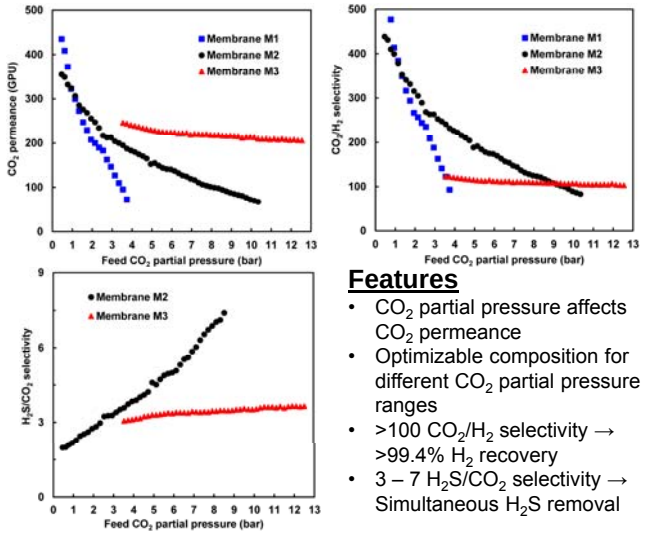
- Facilitated transport of CO_2 via reversible reaction with amine
  $CO_2 + R\text{-}NH_2 + H_2O \rightarrow R\text{-}NH_3^+ + HCO_3^-$
- Facilitated transport = flux augmentation via reaction

Scalable Membrane Synthesis



Nanoporous polysulfone
- Highly permeable
- Mechanically robust

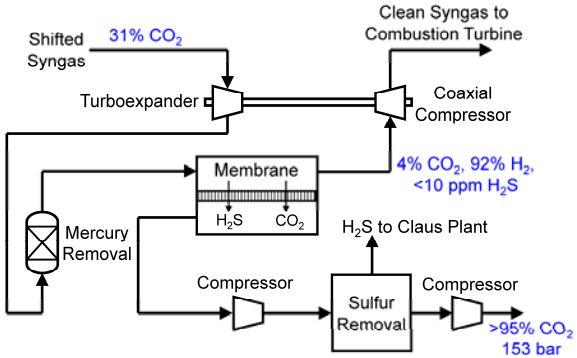
CO_2/H_2 Separation Properties



Features

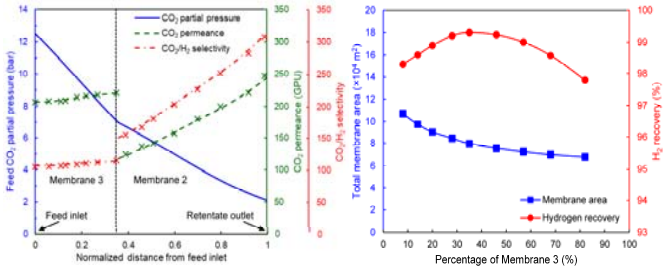
- CO_2 partial pressure affects CO_2 permeance
- Optimizable composition for different CO_2 partial pressure ranges
- >100 CO_2/H_2 selectivity → >99.4% H_2 recovery
- 3 – 7 H_2S/CO_2 selectivity → Simultaneous H_2S removal

Single-Stage Membrane Process

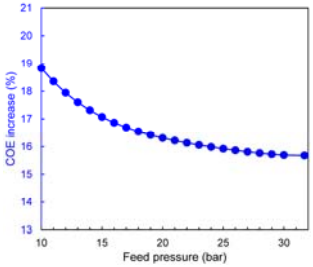


Techno-economic Analysis

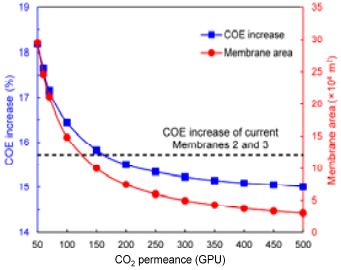
CO_2 Partial Pressure Change and Membrane Allocation



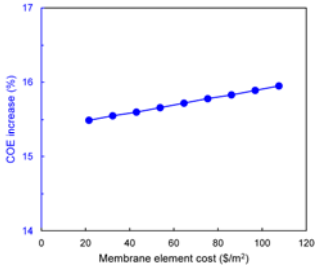
Effect of Feed Pressure



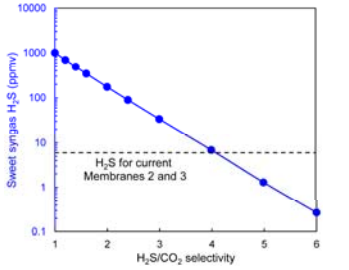
Effect of CO_2 Permeance



Effect of Membrane Cost



Effect of H_2S/CO_2 Selectivity



Techno-economic Analysis

- Based on Cases B5A and B5B in NETL baseline
- Feasible separation performance at >30-bar feed pressure
- Considerable reduction in gas cooling requirement compared to Selexol
- 15.7% COE increase for current compositions, >50% less than Selexol
- >99.4% H_2 recovery achieved by high CO_2/H_2 selectivity
- <6 ppm H_2S in sweet syngas, promising for use in chemical synthesis

Acknowledgements

- David Lang, DOE-NETL
- José Figueroa, DOE-NETL
- U.S. Department of Energy

2018 NETL CO_2 Capture Technology Project Review Meeting, Pittsburgh, PA