Matthew Cameron

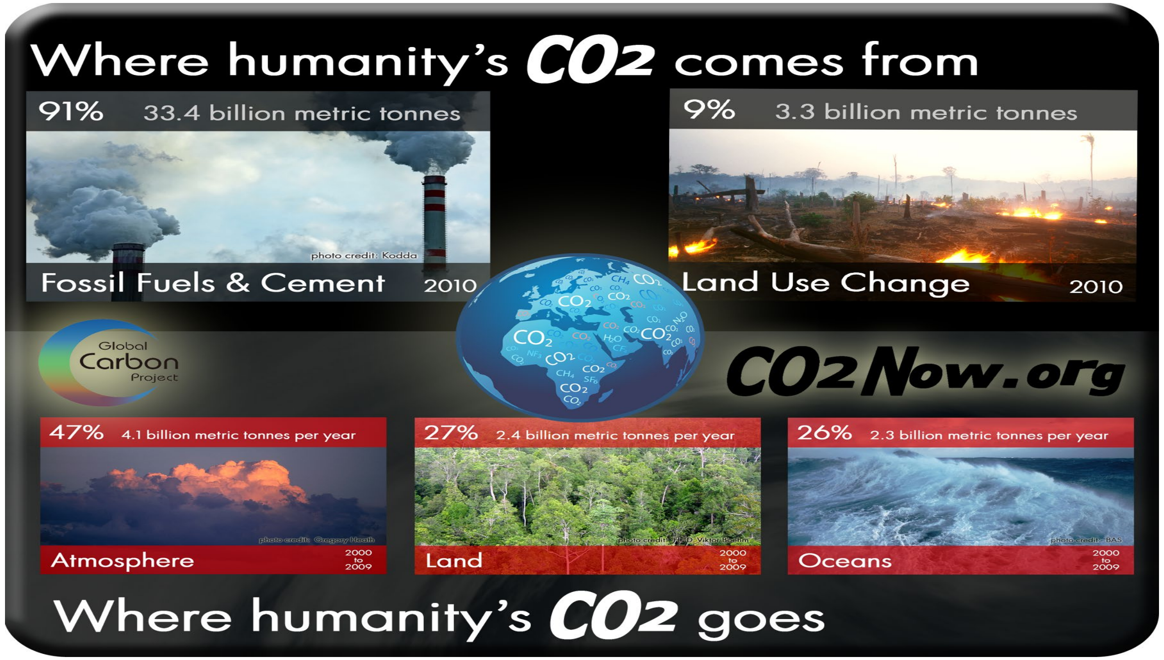
Developing Thin Polymer Membranes for CO_2 Reduction

LEANON SIGMA

Introduction

- In 2011, the Environmental Protection Agency (EPA) reported 6.7 Billion metric tons of carbon dioxide (CO_2) released into the atmosphere.

- In 2014, the Clean Power Plan was introduced to reduce emissions nationwide by 30% before 2030.



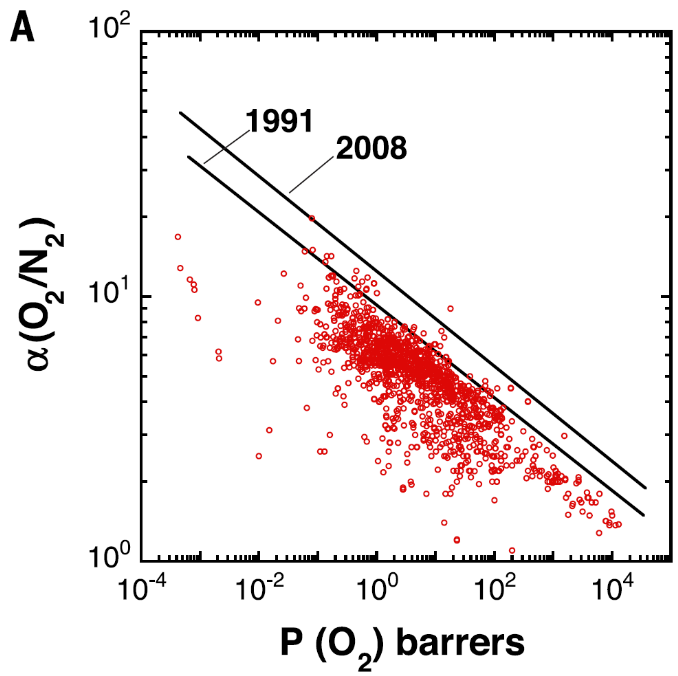
Our Approach

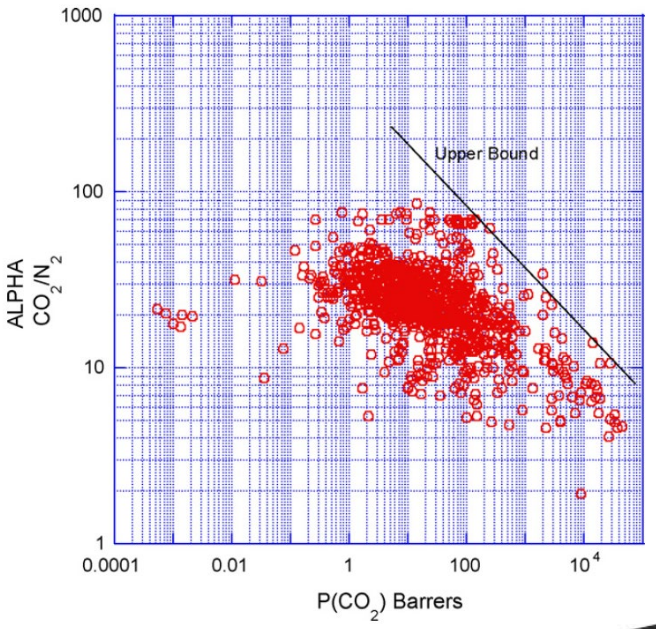
- Industrial gas separation exists in many forms, but require significant energy inputs that involve a gas phase change. (Energy Intensive)

- Our goal was to create thin-film polymer membranes with imbedded CO_2 philicity, or CO_2 loving, that will passively select CO_2 molecules over other flue gas molecules.

Problem and Research Directions

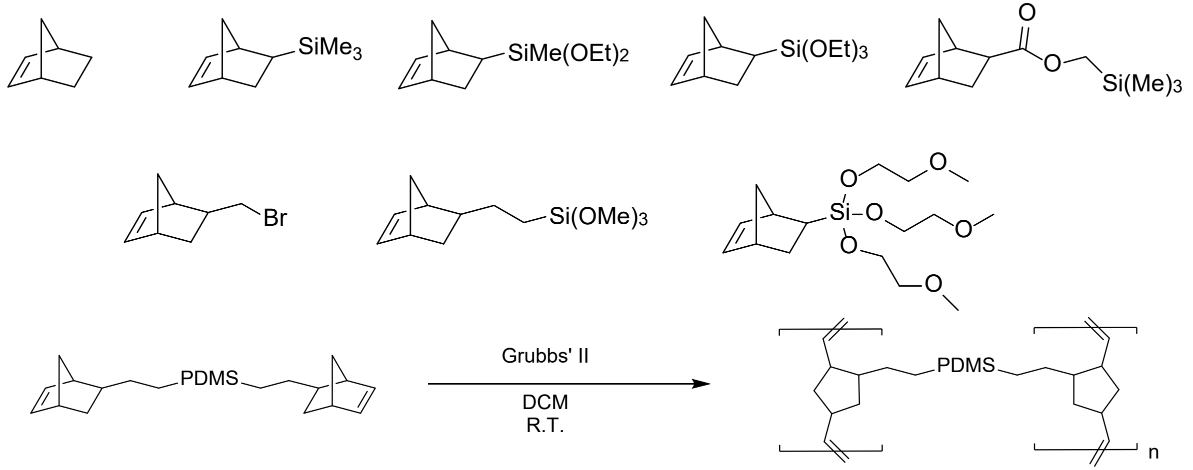
- Robeson's "Upper Bound"
- Permeability and selectivity of polymer membranes



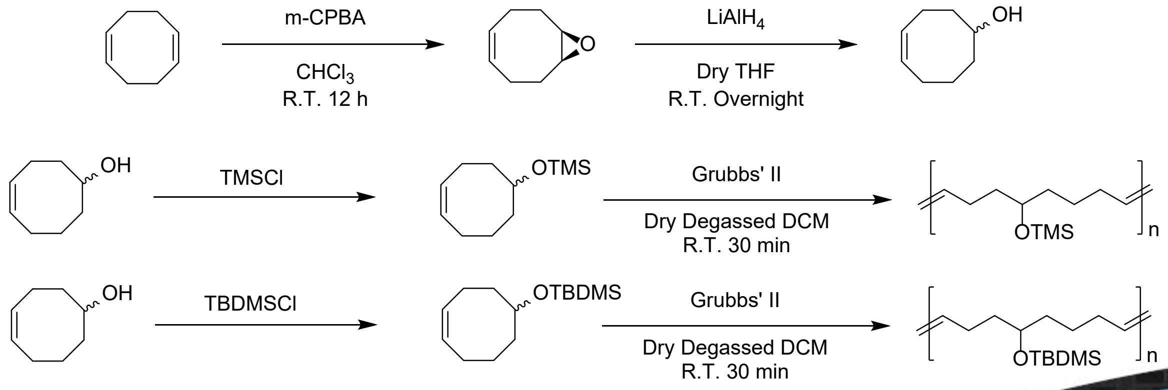


Norbornenes and Cyclooctenes

- Norbornenes:

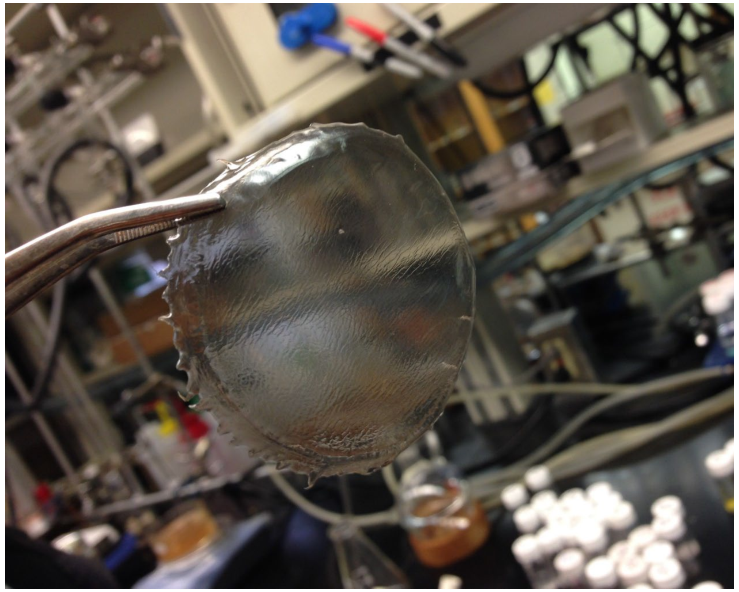


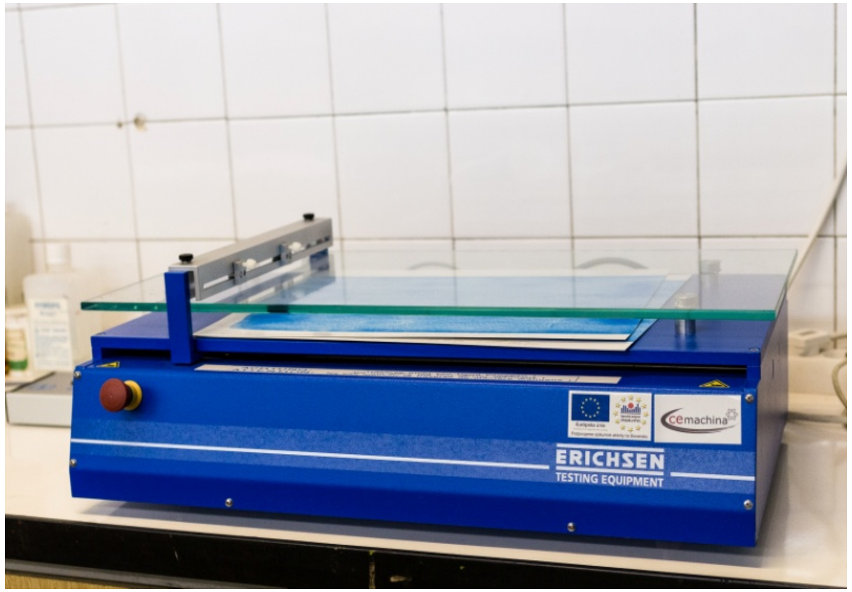
- Cyclooctenes:



Film-preparation

- Solution-casting
- Doctor blade





Testing/Analysis

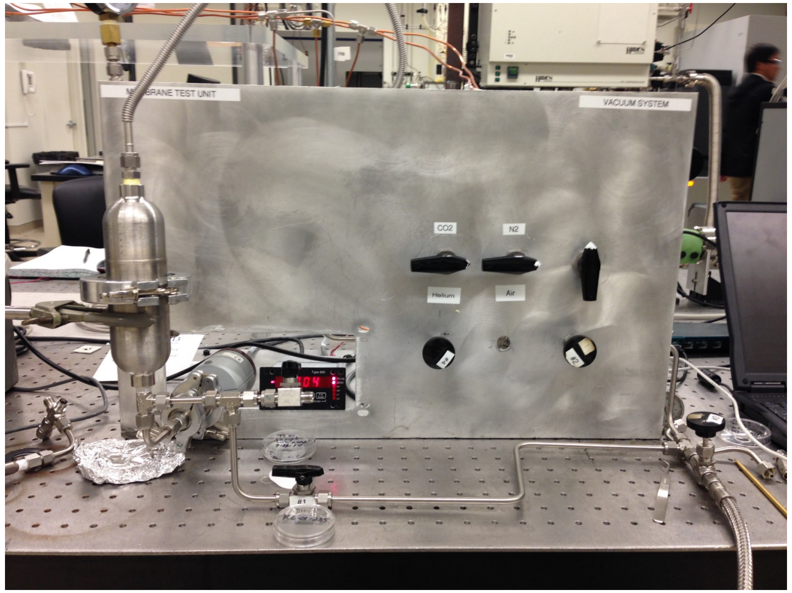
$$\text{Permeance} = \frac{V_c}{RTA_m\Delta P}\frac{\partial P}{dt}$$

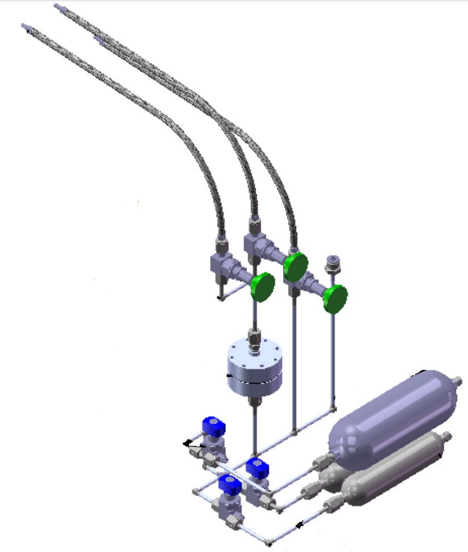
$$\text{Permeability} = \text{Permeance} \cdot \text{Thickness}$$

$$\text{Selectivity } (\alpha) = \frac{\text{Permeability of } CO_2}{\text{Permeability of } N_2}$$

- V_c = Permeate Volume
- R = *.3145 J/mol K
- T = 296 K
- A_m = Membrane Area
- ΔP = Ballast pressure
- $\frac{\partial P}{dt}$ = CO_2 flux slope

Testing/Analysis

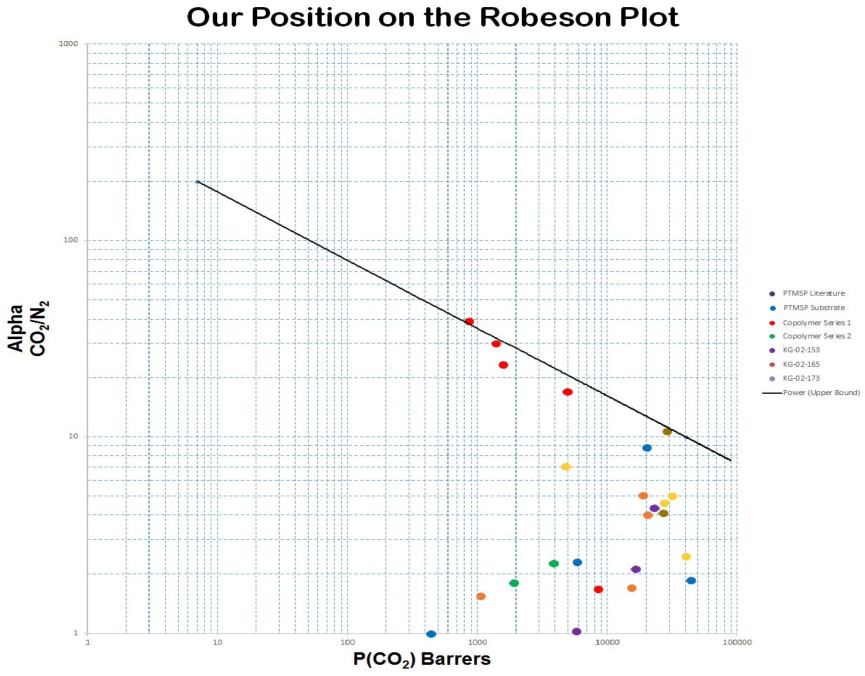


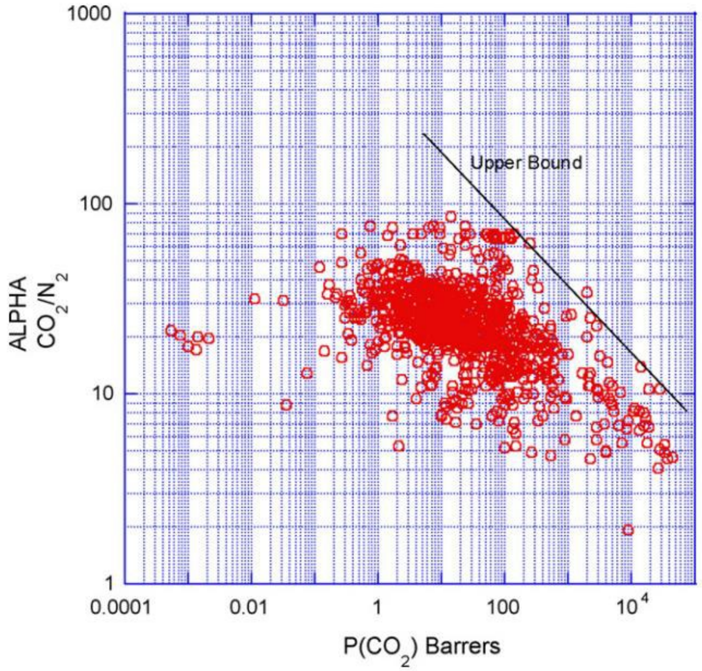


- High-vacuum gas permeation system – Pressure differential in between the top and bottom of the sample chamber that is separated only by the polymer membrane.

Results

- Although not surpassing the upper bound, we were able to produce high weight polymers, with excellent thermal stability $T_d \geq 362°$, that displayed high CO_2 permeability and enhanced CO_2/N_2 selectivity.





Special Thanks

University of Tennessee †

Oak Ridge National Laboratory ‡

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†‡ Jimmy Mays,†‡ Shannon Mahurin, and Brian Long†

References

- 1. Agency, E. P. Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units
- 2. Robeson, L. M., Journal of Membrane Science 2008, 320 (1-2), 390-400.
- 3. Finkelshtein, E.; Makovetskii, K.; Gringolts, M.; Rogan, Y.; Golenko, T.; L., S.; Yampolskii, Y.; Shantarovich, V.; Suzuki, T., Macromolecules 2006, 39, 7022-7029.
- 4.. Conticello, V.; Gin, D.; Grubbs, R. H., Journal of the American Chemical Society 1992, 114, 9708-9710.
- 5. Sanders, D. F.; Smith, Z. P.; Ribeiro, C. P.; Guo, R.; McGrath, J. E.; Paul, D. R.; Freeman, B. D., Journal of Membrane Science 2012, 409-410, 232-241.
- 6. Rhinehart, J. L.; Brown, L. A.; Long, B. K., Journal of the American Chemical Society 2013, 135 (44), 16316-9.
- 7. Mahurin, S. M.; Lee, J. S.; Baker, G. A.; Luo, H.; Dai, S., Journal of Membrane Science 2010, 353 (1-2), 177-183.
- 8. H. B. Park et al., Science 356, eaab0530 (2017). DOI: 10.1126/science.aab0530
- 9. Mustafa et al., J Membra Sci Technol 2016, 6:2 DOI: 10.4172/2155-9589.1000153
- 10. "Hybrid Membrane-absorption CO2 Capture Process". Energy Procedia. 63: 605–613. doi:10.1016/j.egypro.2014.11.065. Retrieved 2019-07-5.

Questions?

Thank you for your time!