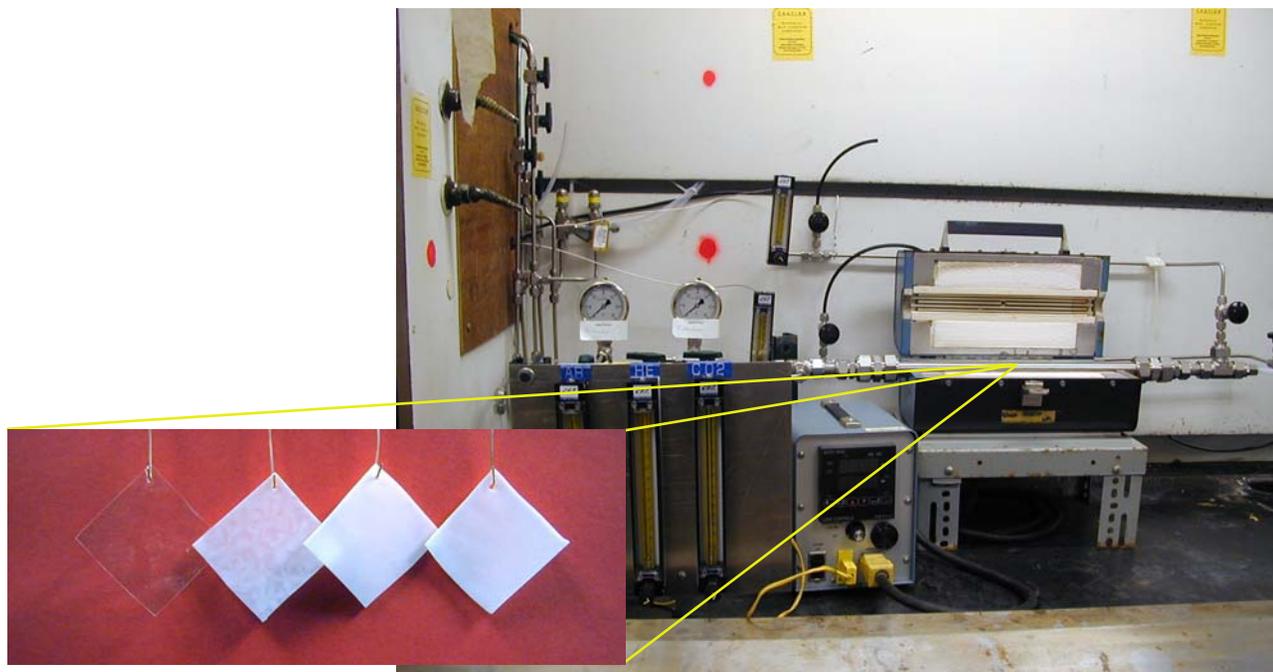


# Supported Ionic Liquid Membranes for Carbon Dioxide Separation



*David Luebke, Jeffery Ilconich, Christina Myers, Henry Pennline*

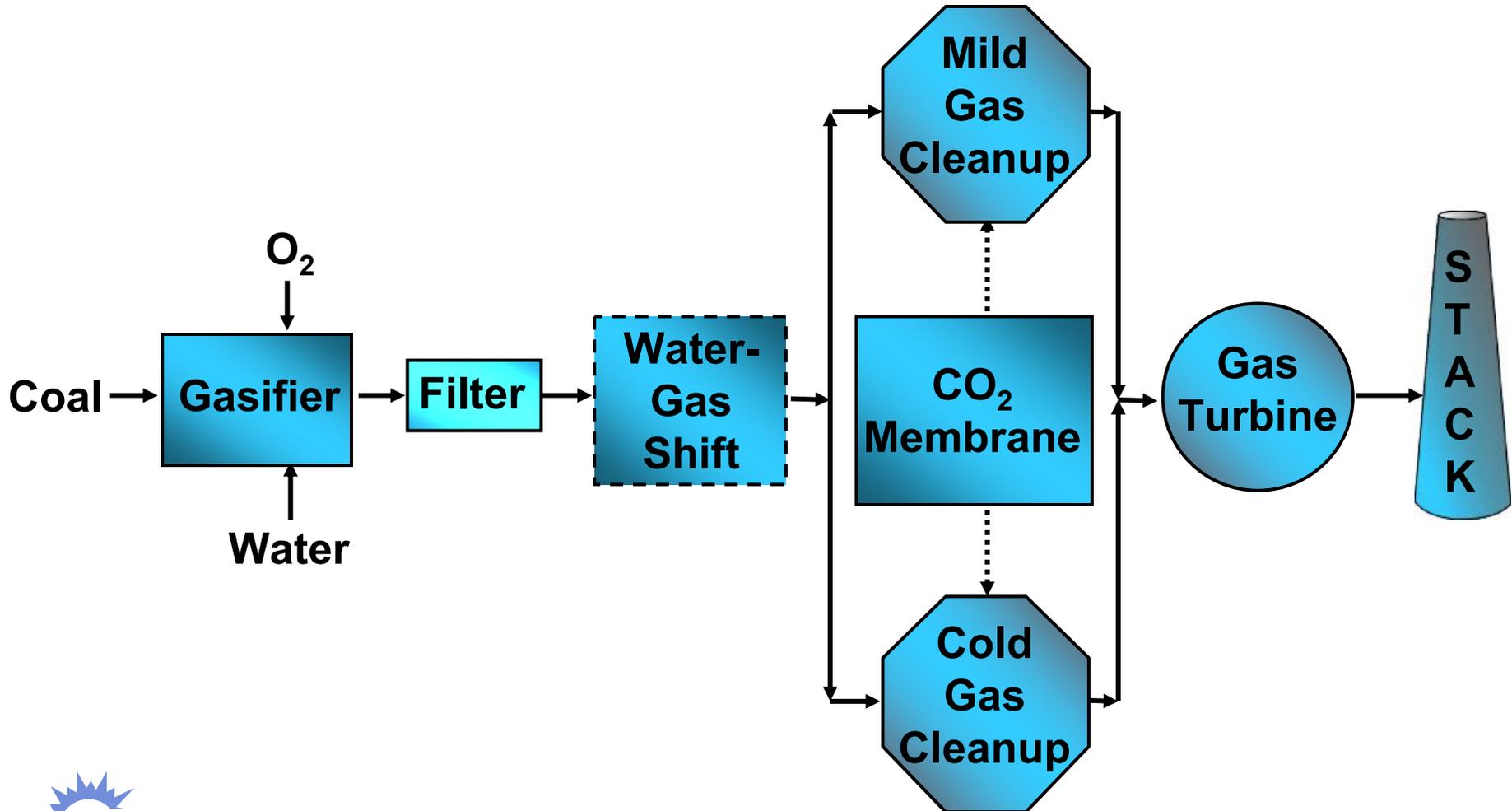
*May 9, 2006*



*5<sup>th</sup> Conference on Carbon Capture & Sequestration*

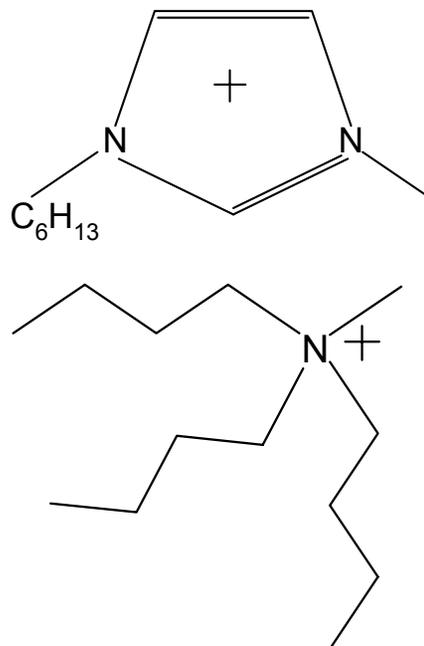
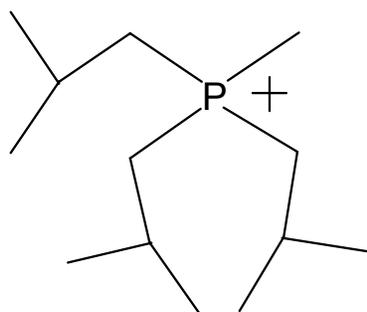


# Precombustion CO<sub>2</sub> Capture in IGCC

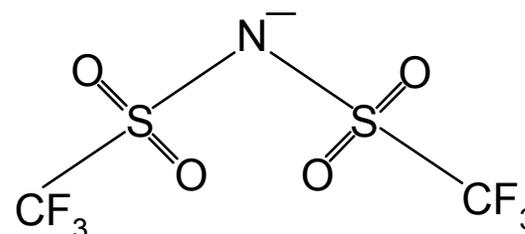
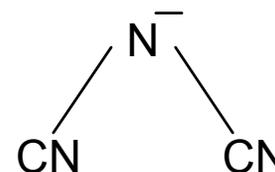
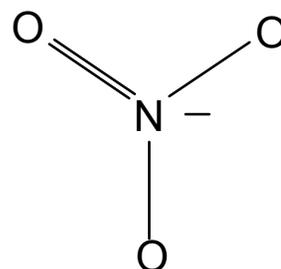


# Potential of Ionic Liquids

## Cations

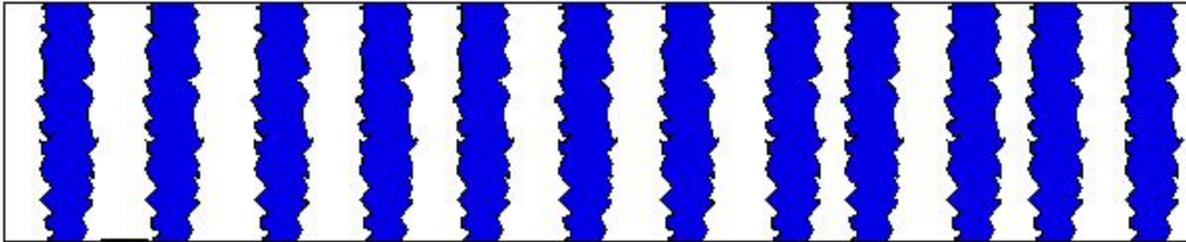


## Anions

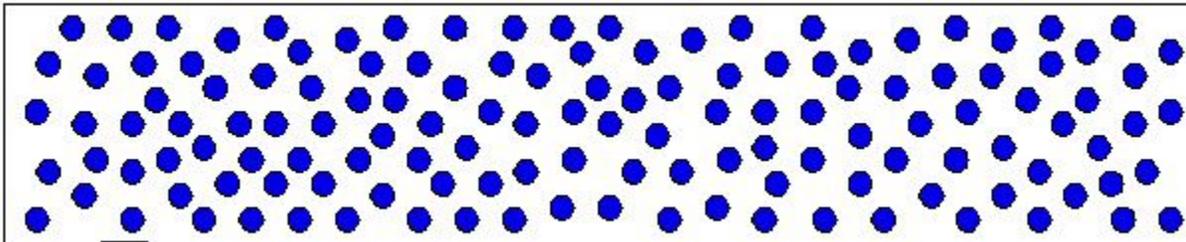


- Negligible Vapor Pressure
- Thermally Stable above 200°C
- High CO<sub>2</sub> Solubility Relative to H<sub>2</sub>, N<sub>2</sub>, and CH<sub>4</sub>

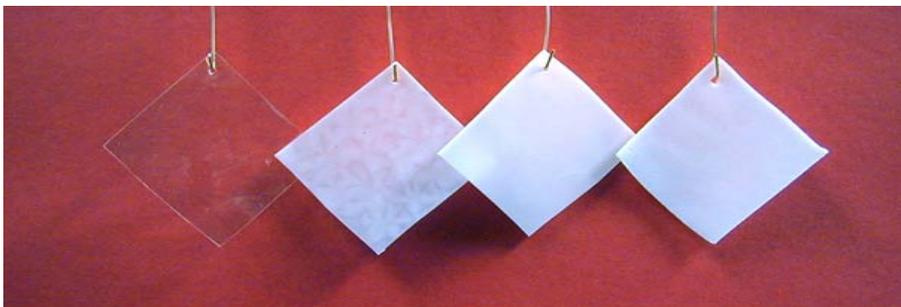
# Several Fabrication Options



Porous Substrate



Dense Substrate



# Selection of Support Material Significant

## PES Support-Supor<sup>®</sup>

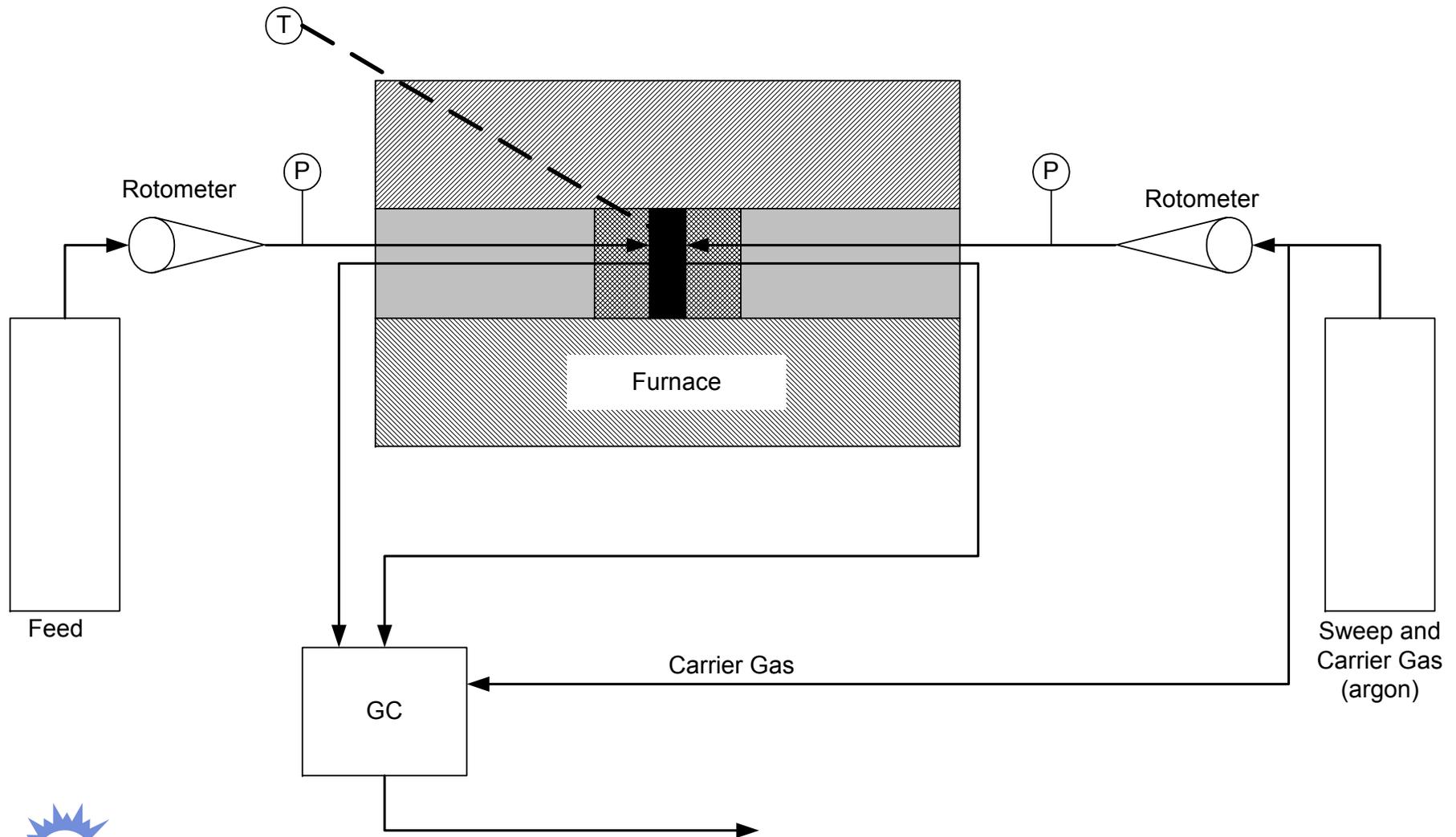
- Suggested by Noble et al. as a useful support\*
- $T_g \sim 210^\circ\text{C}$
- Visible change when heated to  $100^\circ\text{C}$  in the presence of [hmim][Tf<sub>2</sub>N]
- Membrane failure occurs at less than  $50^\circ\text{C}$

## PSF Support-HT Tuffryn<sup>®</sup>

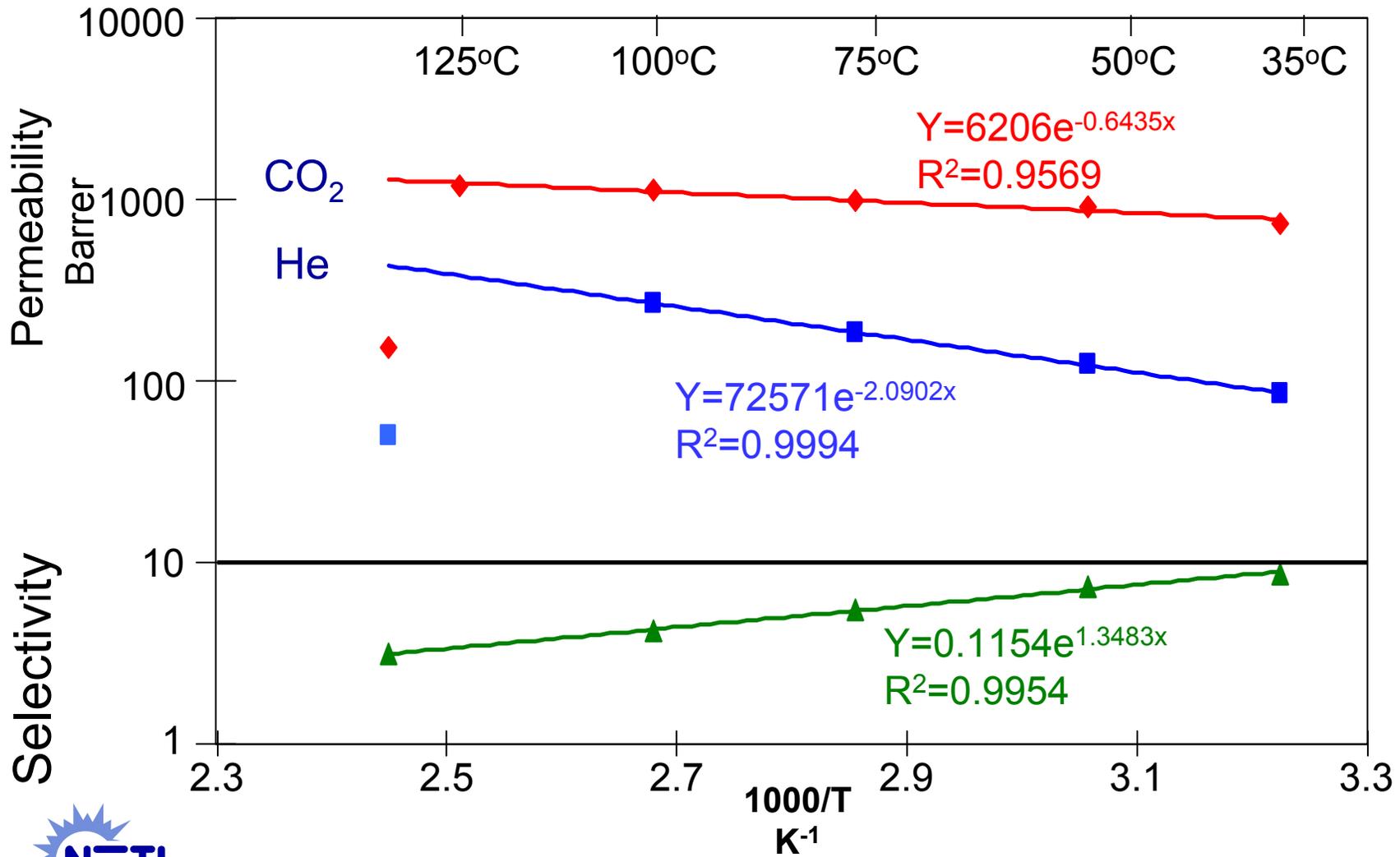
- Unmodified  $T_g \sim 150^\circ\text{C}$
- Membrane stable to  $125^\circ\text{C}$



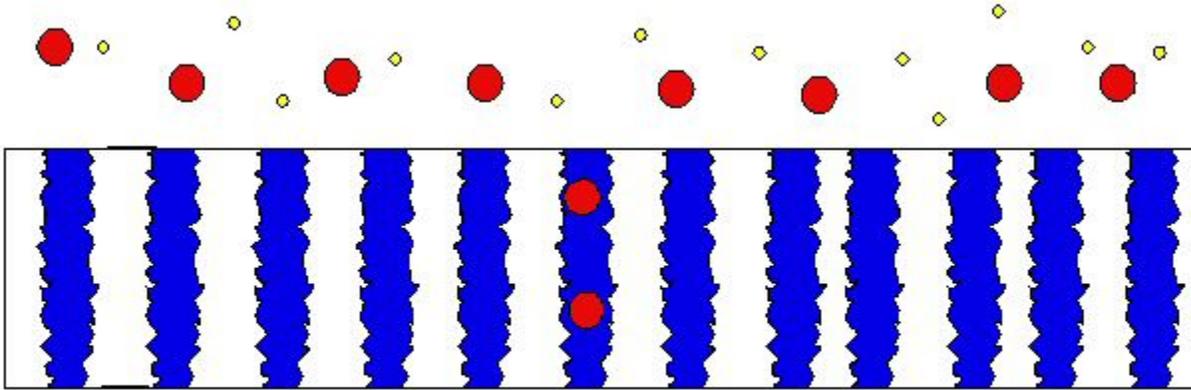
# Constant Pressure Flux Measurements



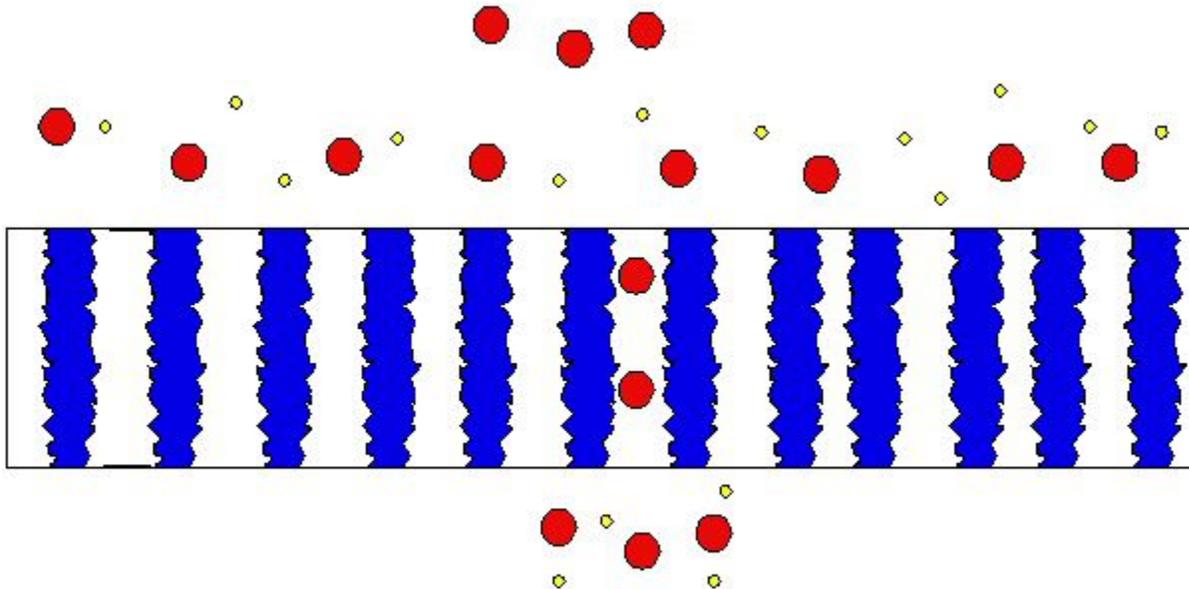
# Support Failure Limits Performance



# Other Mechanisms Inconsistent

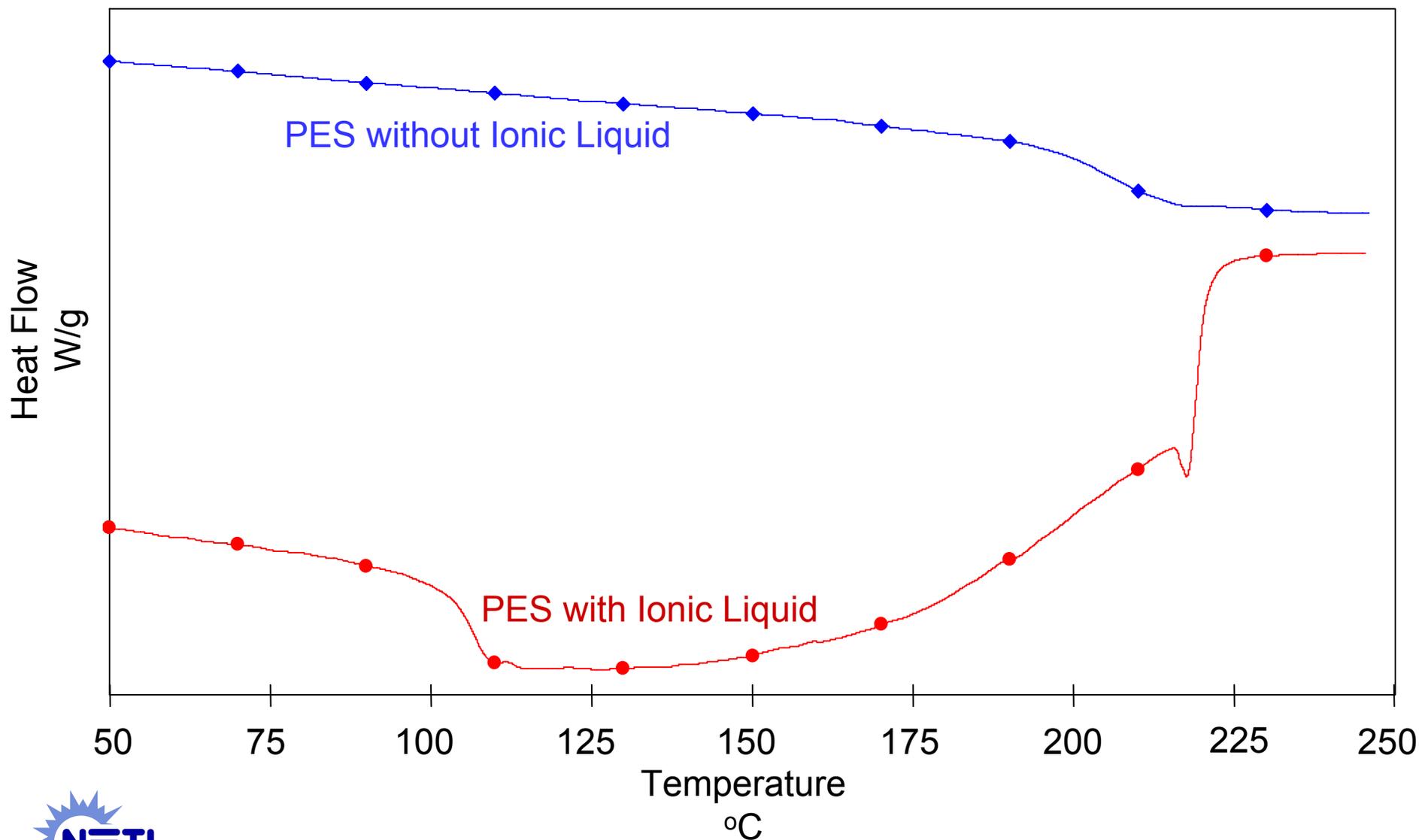


Original  
Mechanism

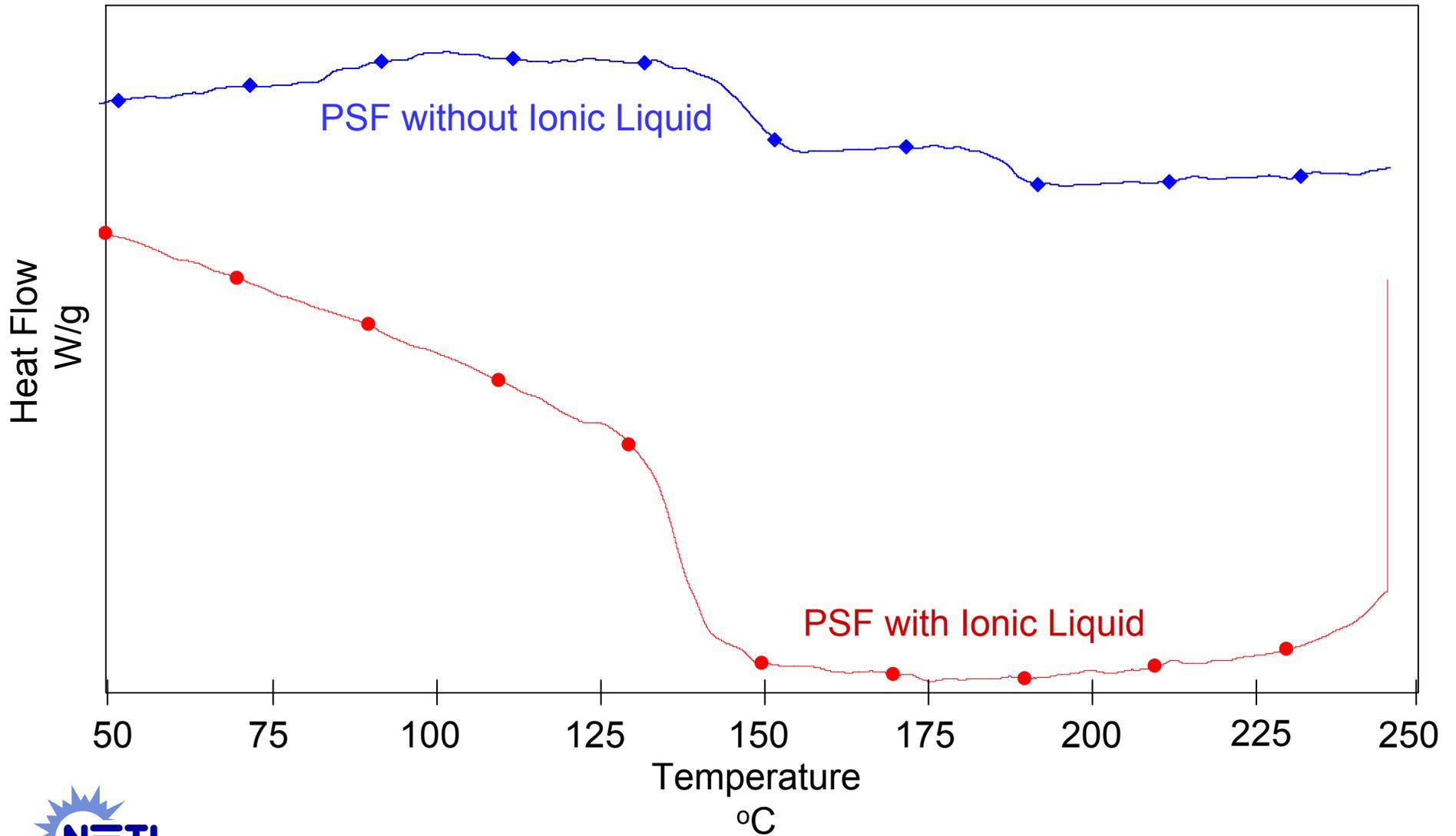


New  
Degradation  
Mechanism

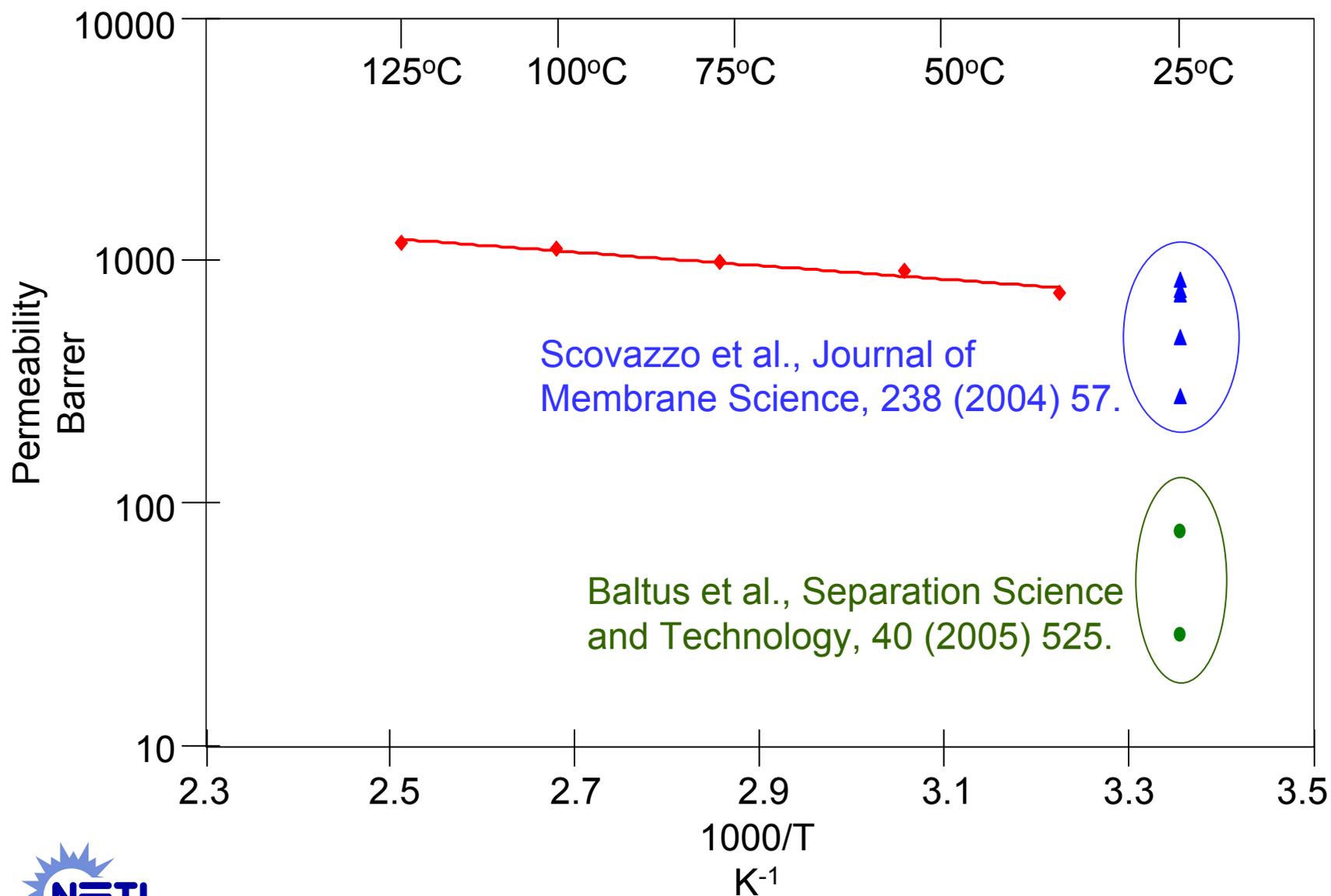
# DSC Confirms Large $T_g$ Reduction for PES



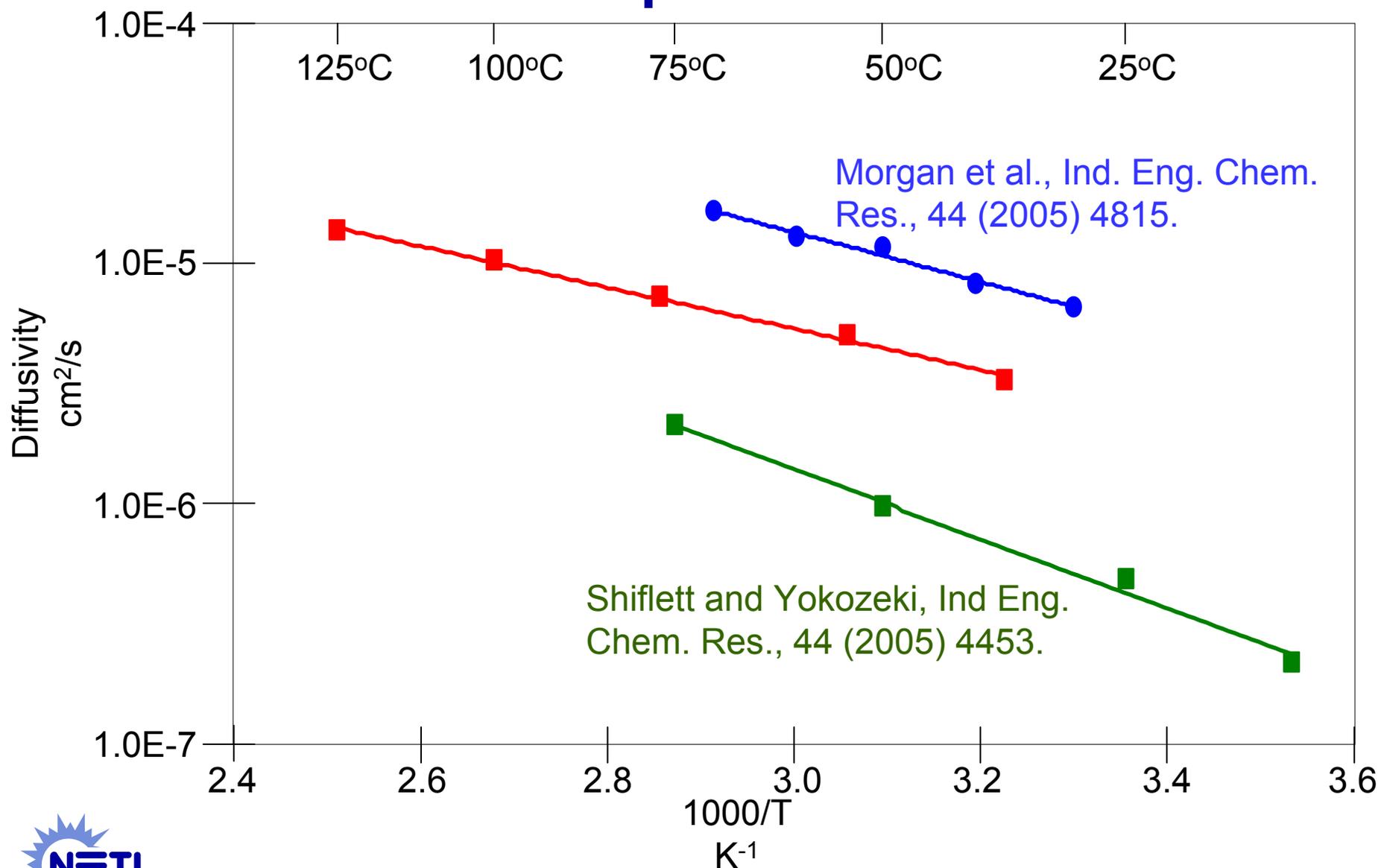
# PSF Less Affected



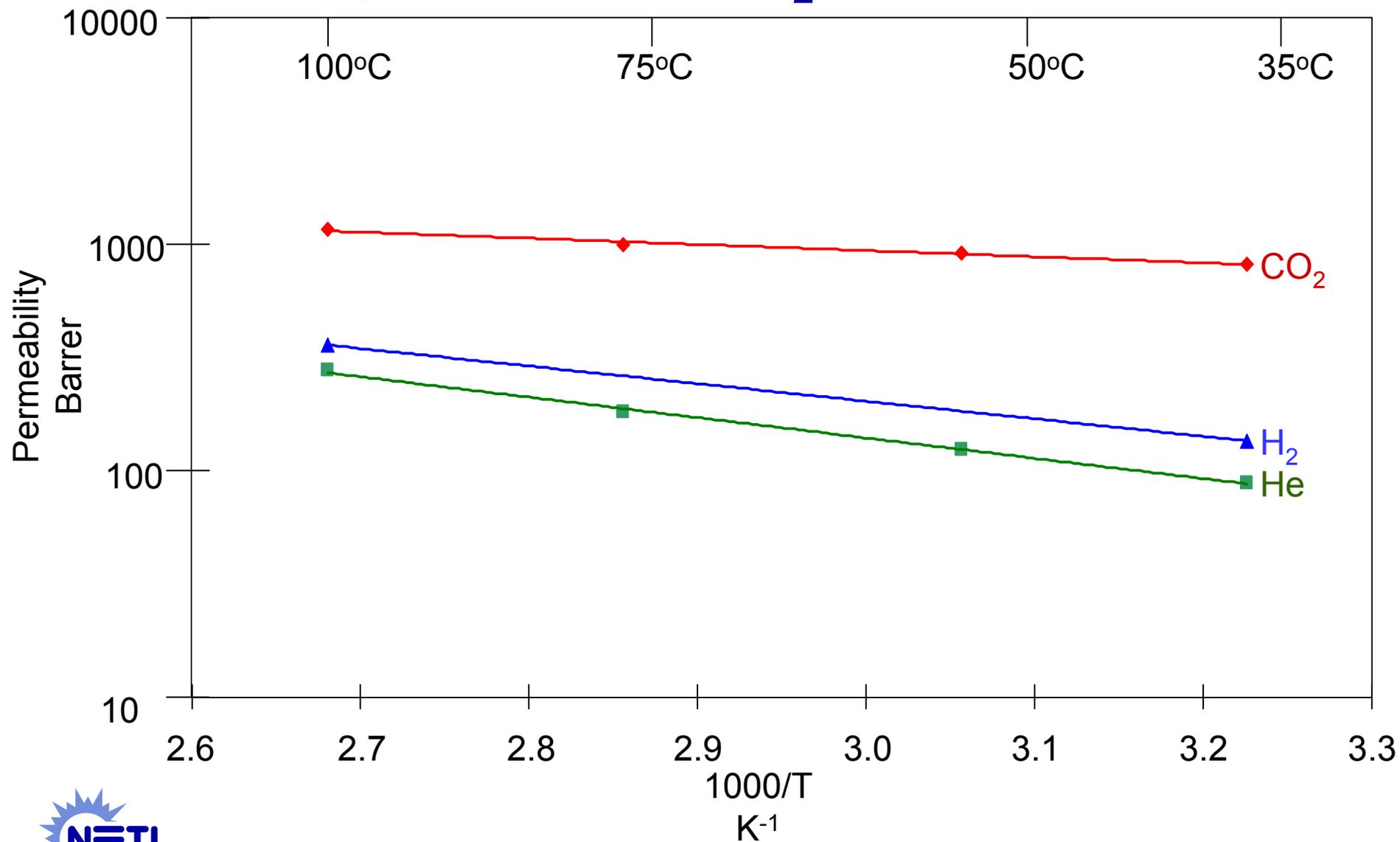
# Permeabilities Similar to Literature



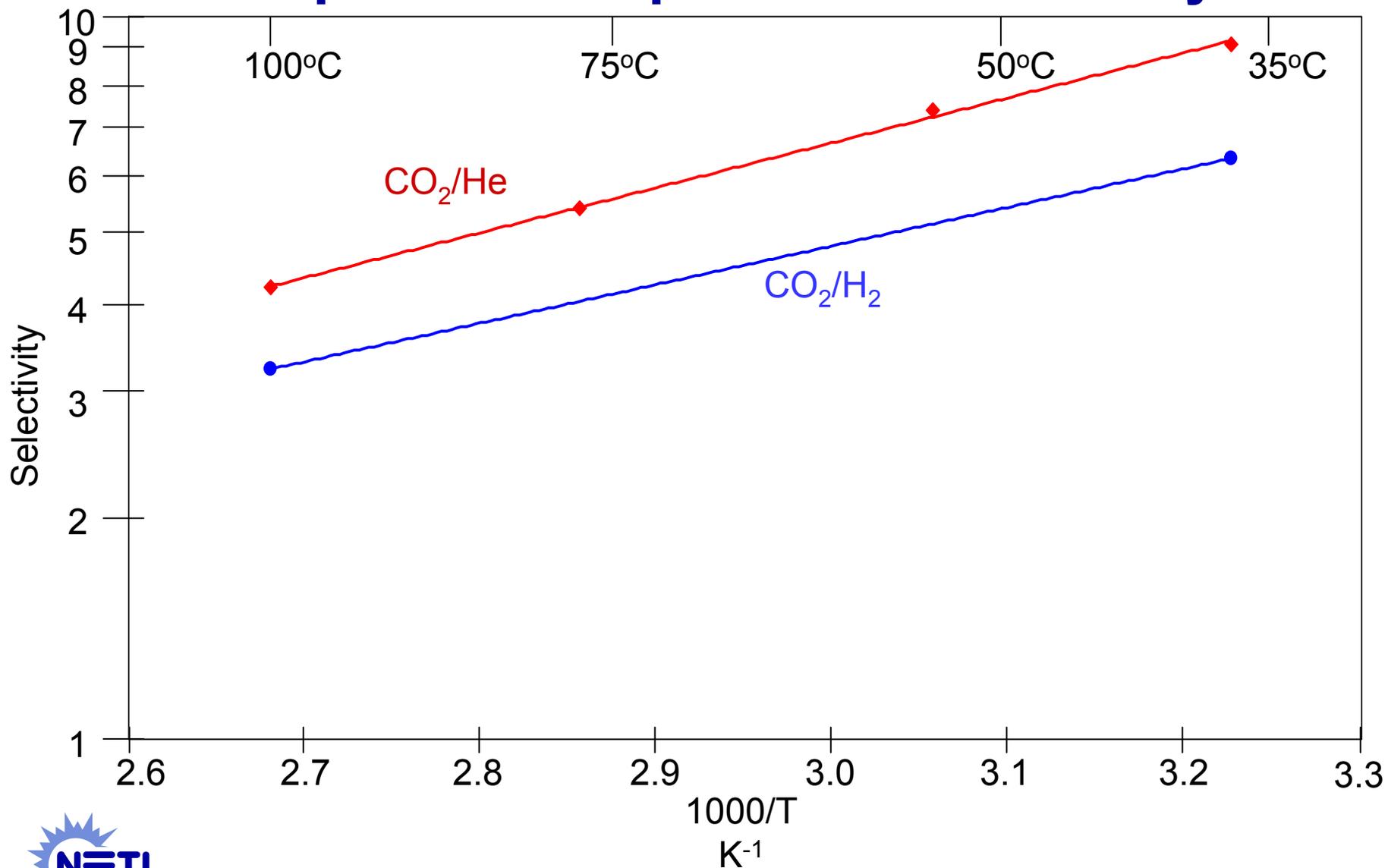
# Diffusivities Comparable to Literature



# Separation from H<sub>2</sub> Favorable



# Temperature Dependence Similarity

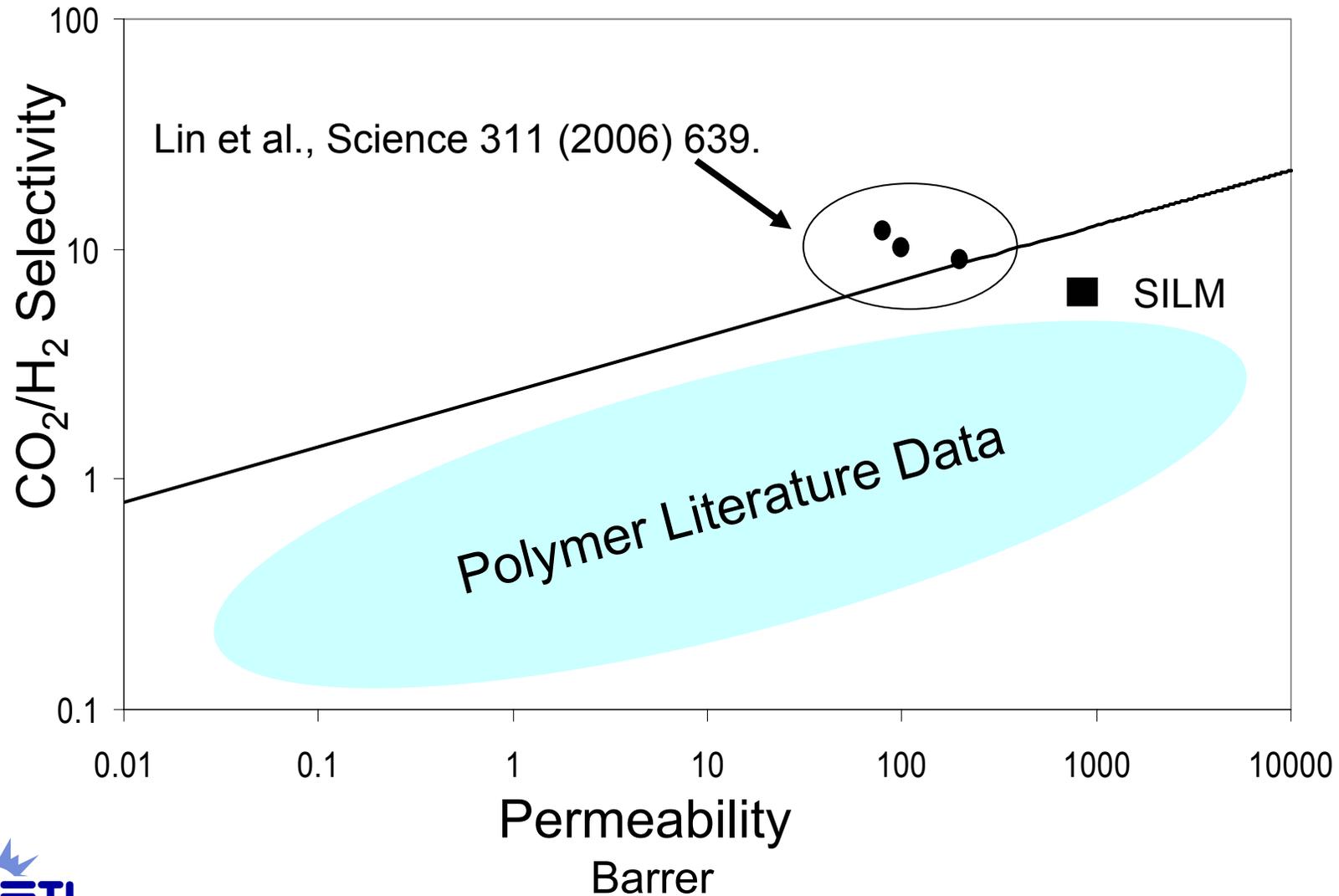


# H<sub>2</sub>O in Feed and Non-Ideality Insignificant

|  | Pure Gas |      | Dry Gas Mixture |      | Wet Gas Mixture |      |
|--|----------|------|-----------------|------|-----------------|------|
| Temperature (°C)                               | 37       | 100  | 37              | 100  | 37              | 100  |
| CO <sub>2</sub> Permeability (Barrer)          | 817      | 1170 | 840             | 1040 | 742             | 1060 |
| H <sub>2</sub> Permeability (Barrer)           | 136      | 359  | 121             | 350  | 109             | 367  |
| Selectivity (CO <sub>2</sub> /H <sub>2</sub> ) | 6.4      | 3.3  | 7.0             | 3.0  | 6.8             | 2.9  |



# SILM's versus Polymers



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# Summary

- **Support selection in SILM is nontrivial.**
- **Support performance is predictable by DSC analysis.**
- **Current performance limited by support failure and IL blowout.**
- **Ideal and non-ideal selectivities similar.**
- **Performance not significantly impacted by a small amount of water in the feed.**
- **Unoptimized SILM's are competitive with the best polymer membranes.**



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# Acknowledgements

The authors gratefully acknowledge the Brennecke and Maginn research groups at the University of Notre Dame. Their efforts in the synthesis and characterization of the ionic liquids along with their invaluable expertise in these areas have been very beneficial in the development of this exciting new technology. We look forward to continued fruitful collaboration.

