

# Polymer Membranes Overview

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# Background – Group

- **14 Current PhD Students**
- **2 Postdoctoral Fellows**
- **2 Staff Members**
- **48 Previous MS/PhD students**
- **29 Previous postdocs and visiting scholars**

# Research Group Focus

**Develop fundamental structure/function rules to guide the preparation of high performance polymers or polymer-based materials for gas and liquid separations as well as barrier packaging applications.**

# General Focus Areas

- **Materials design to control small molecule transport in polymers**
- **Energy-efficient separations**
- **Clean water**
- **Clean energy**

# Current Gas Separation Projects

- **Thermally rearranged (TR) polymers for natural gas purification.**
- **Novel, high performance polybenzimidazoles (PBIs) for hydrogen separations.**
- **Crosslinked poly(arylene ether ketones) for air separation.**
- **Olefin/paraffin separation using membranes.**
- **Membranes for carbon capture, including graphene oxide membranes.**

# Current Water Purification Projects

- **Chlorine-tolerant desalination membranes based on sulfonated polymers.**
- **Fouling resistant ultrafiltration and microfiltration membranes.**
- **Fundamentals of fouling of porous membranes.**
- **Fundamentals of water and ion transport in polymers.**
- **Influence of multiphase block copolymer morphology on water and ion transport.**

# Funding



**CBET, PFI**



**James R. Fair Process  
Science and Technology  
Center**



**Center for Layered Polymeric Systems**  
NSF Science and Technology Center

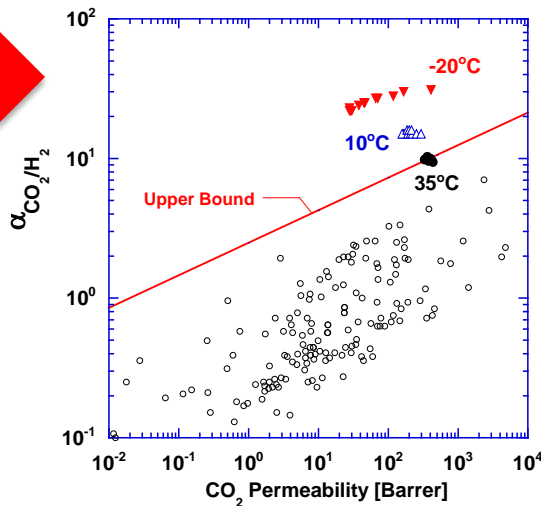
**Membrane Technology and  
Research, Inc.**



**Air Liquide**



# Reduction to Practice: Gas Separations



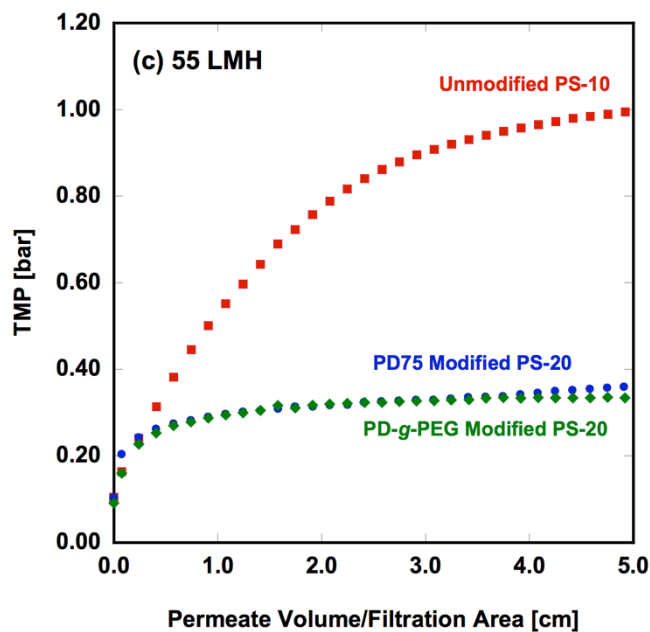
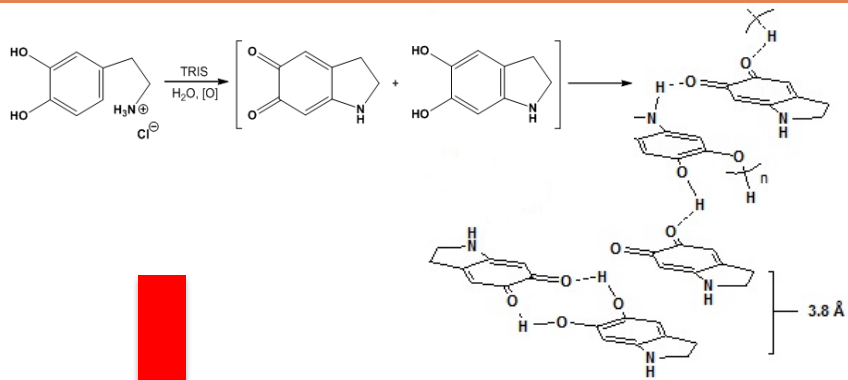
H. Lin, E. van Wagner, B.D. Freeman, L.G. Toy, and R.P. Gupta, *Science*, 311, 639-642 (2006).

## 20 TPD System at NCCC/PC4

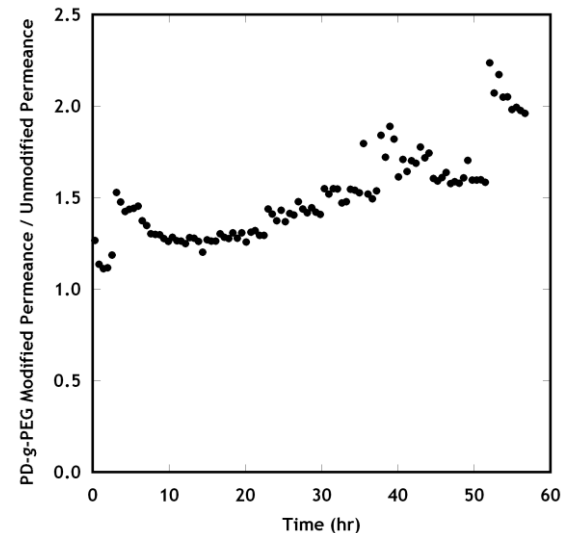




# Reduction to Practice: Water Purification



Dreyer, Miller, Freeman, Paul, and Bielawski, *Langmuir* 28, 6428-6435 (2012).  
Miller, Paul, and Freeman, *Polymer*, 55(6), 1375-1383 (2014).



# Example Career Paths – University/Government

<b>Student</b>	<b>Employer</b>	<b>Area (Ph.D./Work)</b>
Prof. Bryan McCloskey	IBM (postdoc) University of California, Berkeley	Fouling-resistant membranes/Batteries
Prof. Haiqing Lin	Membrane Technology and Research – 7 years SUNY-Buffalo	Gas separation membranes/Gas separation membranes
Prof. Ho Bum Park (postdoc)	Hanyang Univ. (Seoul)	Gas and water purification membranes/Gas and water purification membranes
Dr. Lauren Greenlee	NIST, Boulder, CO	High recovery desalination membranes/Nanoparticles in water treatment
Prof. Geoff Geise	Penn State (postdoc) University of Virginia	Water and ion transport in polymers/fuel cell membrane materials
Dr. Dan Miller	UC, Berkeley (postdoc)	Fouling resistant membranes/polymeric solar cells
Dr. Zach Smth	UC, Berkeley (postdoc)	Gas separation membranes/Metal organic framework adsorbents

# Example Career Paths - Industry

<b>Student</b>	<b>Employer</b>	<b>Area (Ph.D./Work)</b>
Dr. Liz van Wagner	GE Global Research, Niskayuna, NY	Fouling-resistant membranes/Membranes
Dr. Grant Offord	Eastman Chemical, Longview, TX	Gas separation membranes/Olefin manufacture
Dr. Tom Murphy	Dow Chemical, Freeport, TX	Physical aging in gas separation membranes/polymer manufacturing
Dr. David Sanders	Exxon Mobil, Houston, TX	Gas separation membranes/catalysis
Dr. Hao Ju	Dow Water & Process Solutions, Edina, MN	Fouling-resistant membranes/Water purification membranes
Dr. Alyson Sagle	Air Products, St. Louis, MO	Fouling resistant membranes/Gas separation membranes
Dr. Wei Xie	United Technologies, Hartford, CT	Desalination membranes/Flow batteries

# What you can expect

- **Learn to systematically apply the scientific method to research problems.**
- **Perform experimental research addressing some of the most important, fundamental problems in the field today.**
- **Work on problems addressing grand challenges of our time (clean water, clean energy, energy-efficient separations, water/energy nexus).**
- **Learn to write effectively and persuasively.**
- **Learn to deliver influential oral technical presentations.**
- **Become a member of a worldwide community and family of excellent former group members and colleagues sharing common interests.**
- **Go places you've never been before.**
- **Have fun 😊.**

# New Projects/Funding

- **Our group is hoping to add 2 to 3 new students in the following areas:**
  - **Water purification membranes (either fundamentals of water/ion transport in polymers or surface modification of membranes to improve fouling resistance)**
  - **Gas separation membranes (polymer membranes for carbon capture)**
- **Support:**
  - **Proposal pending at National Science Foundation (NSF) (water purification)**
  - **Ongoing project with Korea Carbon Capture and Sequestration R&D Center**
  - **NSF Science and Technology Center (water or gas purification)**
  - **Discretionary support (either gas or water purification)**

# Life at/near Pickle Research Campus



Pinthouse offers craft brews and creative pizzas in a welcoming beer hall atmosphere.

## SAVEUR SEEKING: Everything's Coming Up Burnet

Tired of hitting up the Drag and South Congress every time you're hungry? Travel a tiny bit north to Burnet, a street bursting at the seams with great Tex-Mex, wine and beer, plus a few exciting new additions coming up in the near future.

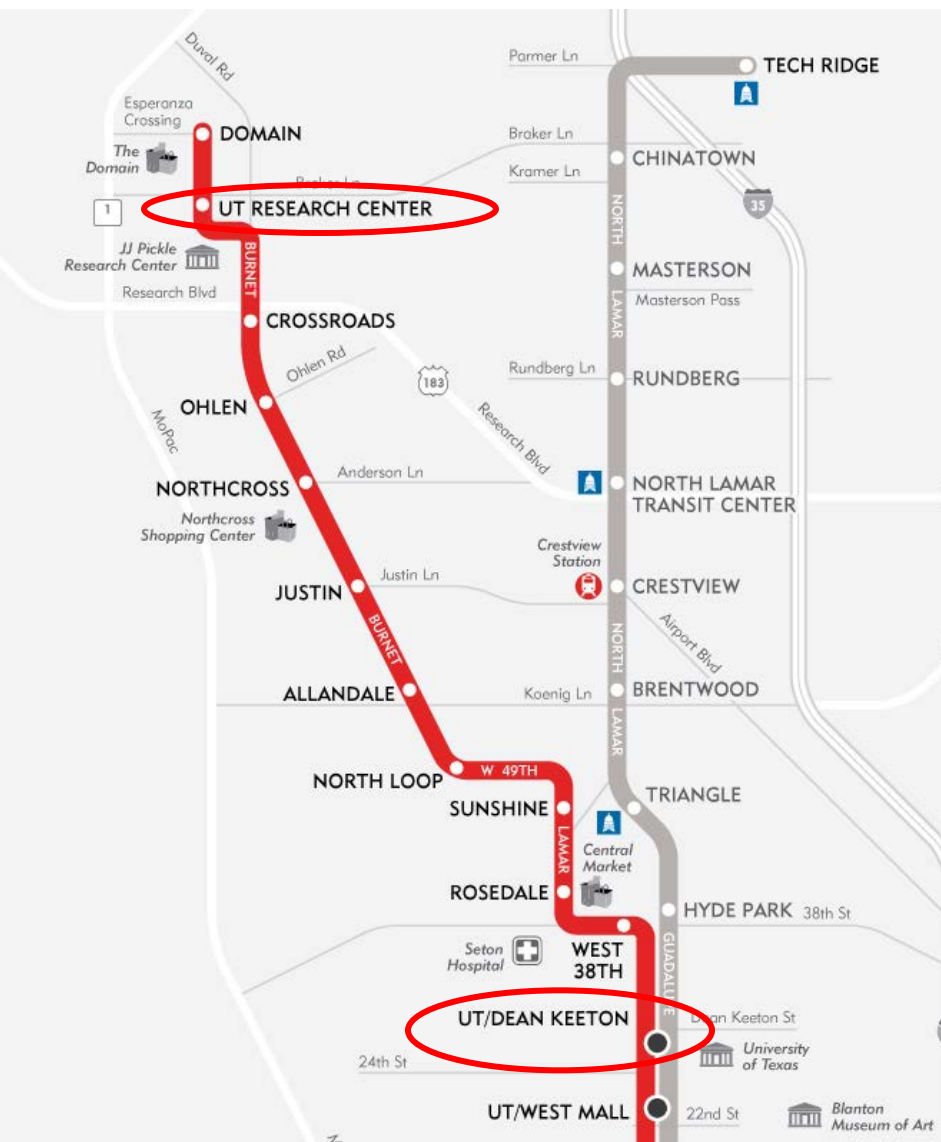
[http://www.readthehorn.com/lifestyle/saveur\\_seeking/82281/everythings\\_coming\\_up\\_burnet](http://www.readthehorn.com/lifestyle/saveur_seeking/82281/everythings_coming_up_burnet)



# The Domain is Becoming North Austin's Downtown



# New Bus Service (MetroRapid 803) Between PRC and Main Campus



## WEEKDAYS

Hours: 5 a.m. – 12:30 a.m.

5 AM - 7 AM	15 MIN
7 AM - 9 AM	12 - 15 MIN
9 AM - 2 PM	15 MIN
2 PM - 5 PM	12 - 15 MIN
5 PM - 7 PM	12 - 15 MIN
7 PM - 12:30 AM	20 MIN

## SATURDAY / SÁBADO

Hours: 6 a.m. – 12:30 a.m.

6 AM - 11 AM	30 MIN
11 AM - 7 PM	20 MIN
7 PM - 12:30 AM	30 MIN





# THE UNIVERSITY OF TEXAS AT AUSTIN



**THANK YOU!**

# Background – Prof. Freeman

- **Attended NC State Univ. for BS, ChE (1983)**
  - Worked as undergraduate researcher in gas separation membranes
- **Attended UC Berkeley for PhD, ChE (1988)**
  - Used light scattering to study diffusion of polymers in solution
- **Studied at ESPCI in Paris as postdoc (1988-89)**
  - School directed by Pierre Gilles de Gennes, 1991 Nobel Laureate in Physics
  - Studied molecular dynamics in polymers via spectroscopy
- **Started faculty appointment at NC State in 1989**
- **Moved to UT Austin in January 2002**

# Selected Accomplishments

- **371 publications (including 4 in Science since 2002)**
- **21 patents/patent applications**
- **5 edited books**
- **1 startup company – Advanced Hydro (2009)**
- **Membranes for hydrogen purification commercialized by Membrane Technology and Research as Polaris membranes**
- **Many student awards**
  - **7 current or former NSF Fellows**
  - **1 DOE fellow**
  - **Numerous student research & travel awards**