

NETL-RUA's Carbon Capture Solutions

David Luebke

Carbon Capture Technical Coordinator

David.Luebke@netl.doe.gov

NETL-RUA: Strength in Collaboration



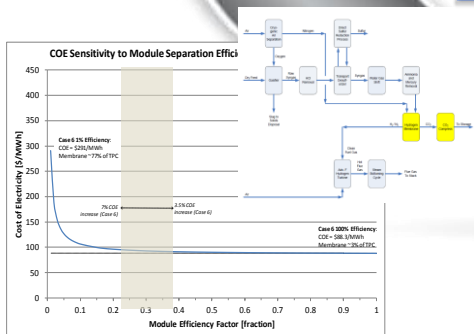
Integrated Technology Development

Material Synthesis & Fabrication

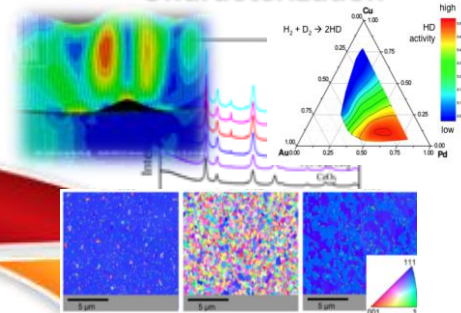
Molecular Design & Optimization

Characterization

Accelerating Discovery,
Development & Deployment



Process Synthesis &
Techno-economic
assessment



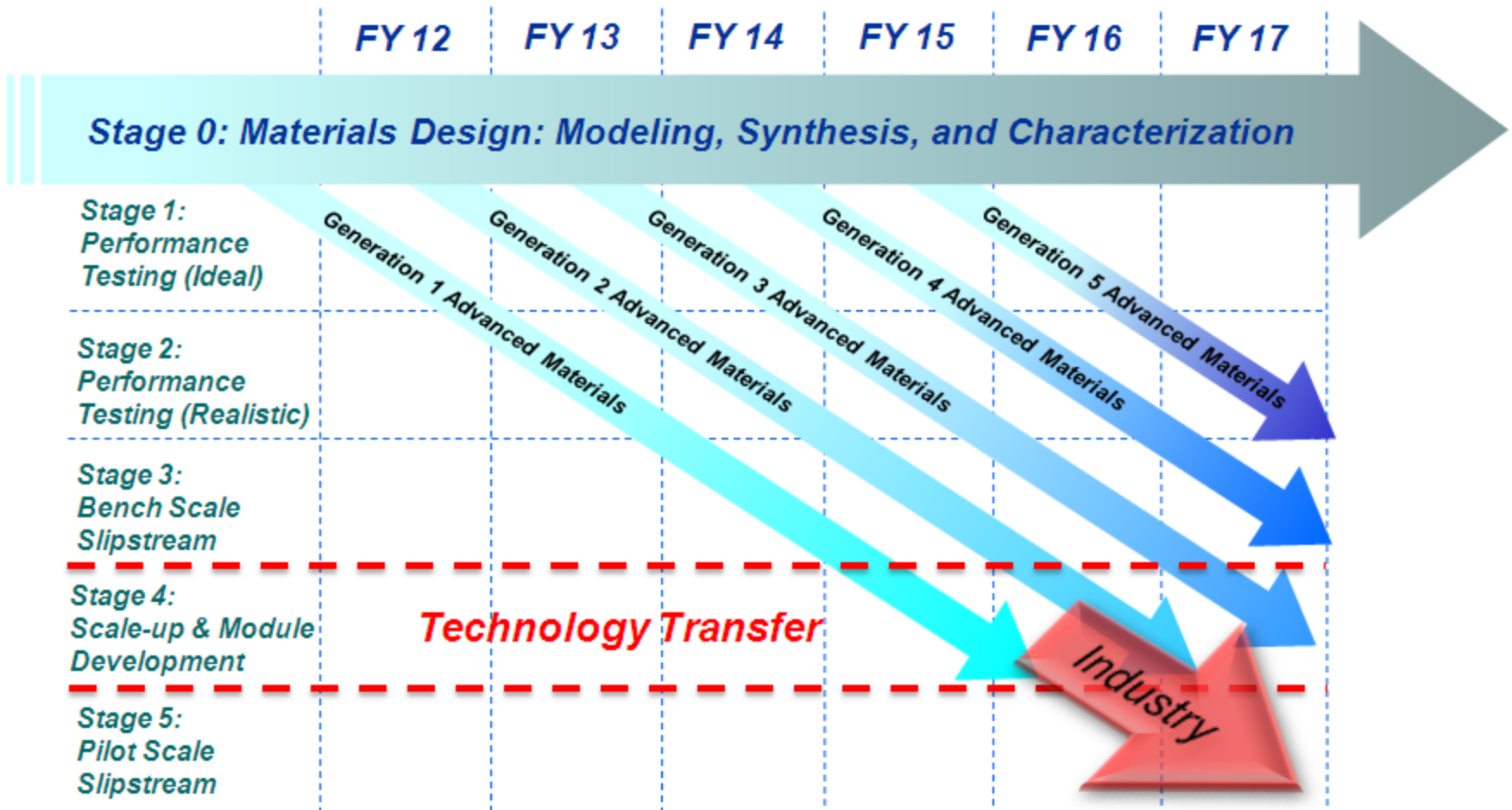
Performance Assessment
In Real Environments



Material Processing & Device
Development

Integrated Technology Development

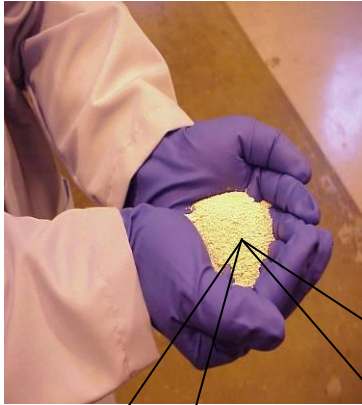
Technology Pathway



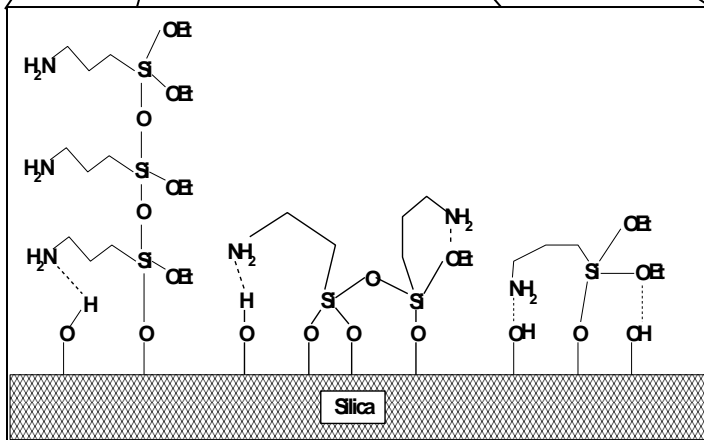
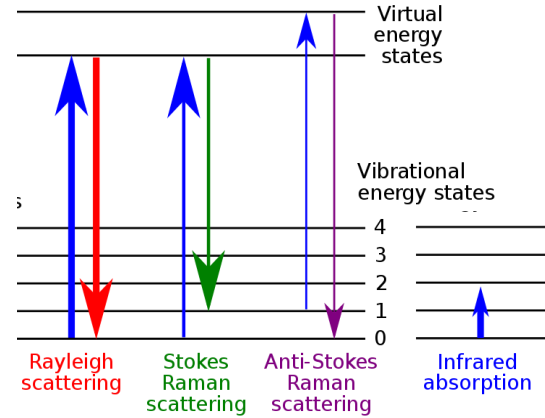
Technologies

Supported Amine Sorbents

Miller/Fisher: 10:30 a.m. Monday



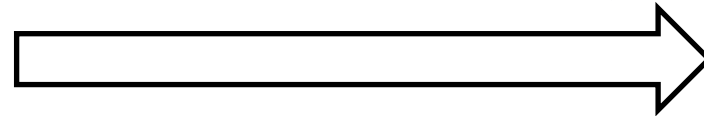
Characterization



John Kitchin, CMU

Angela Goodman, DOE

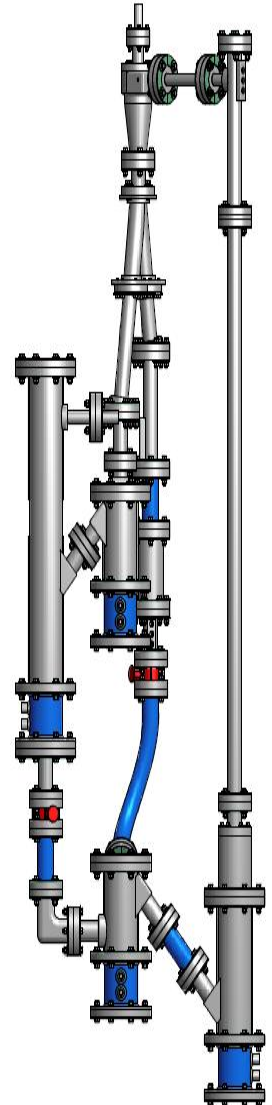
Damodaran Krishnan, Pitt



Scale-up

Larry Shadle, DOE

David Miller, DOE (CCSI)



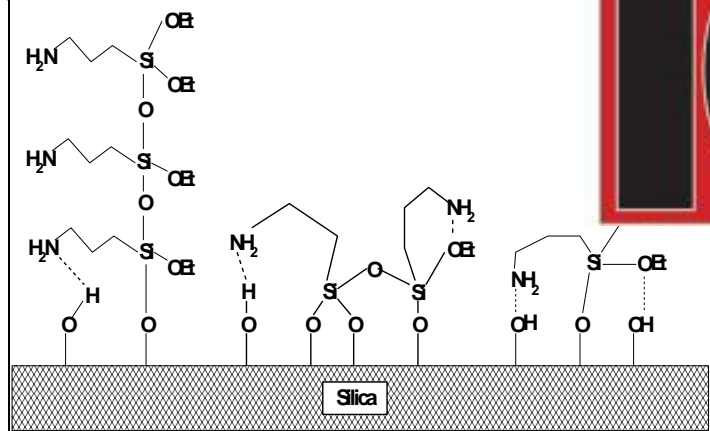
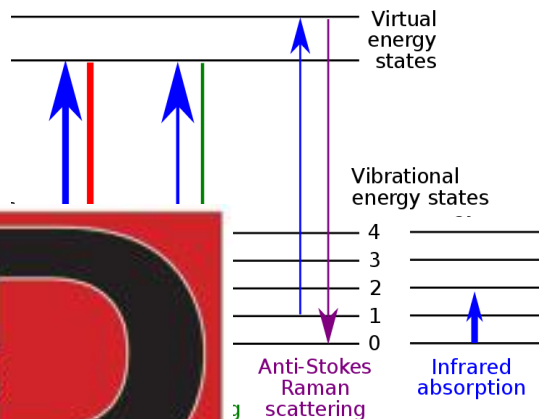
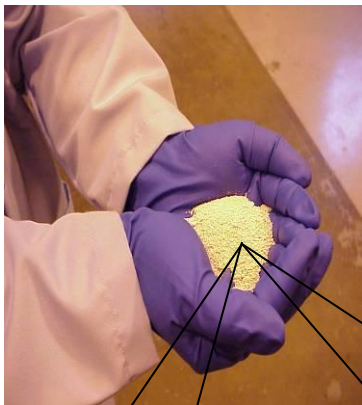
McMahan Gray, DOE

Bingyun Li, WVU



Supported Amine Sorbents

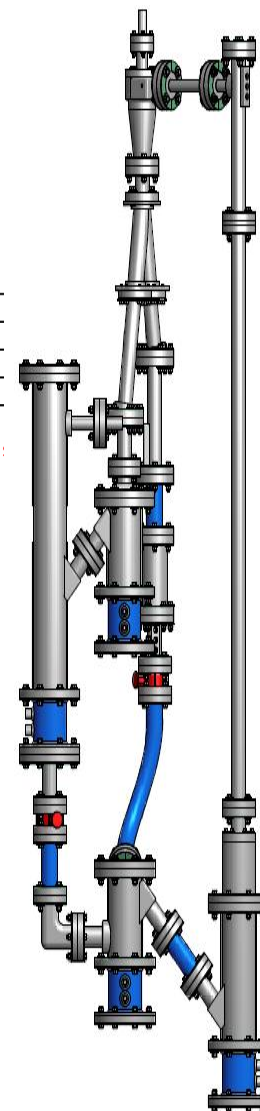
Miller/Fisher: 10:30 a.m. Monday



Lin, CMU
Iman, DOE
Prishnan, Pitt

Scale-up

Larry Shadle, DOE
David Miller, DOE (CCSI)

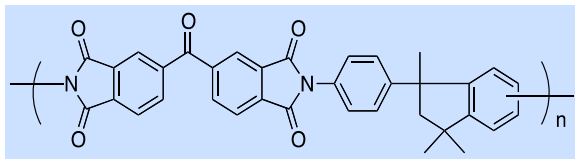


McMahan Gray, DOE
Bingyun Li, WVU



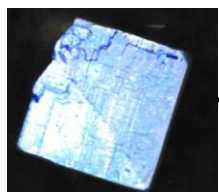
MOF-based Mixed Matrix Membranes

Albenze: 11:15 a.m. Wednesday

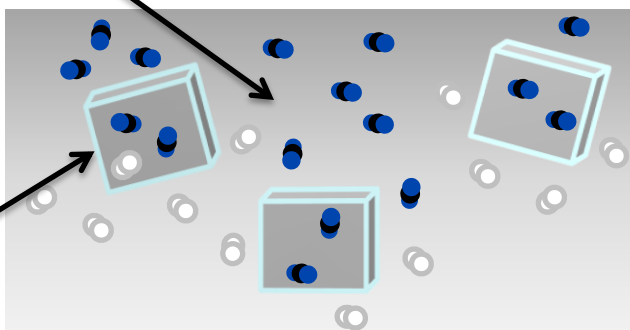


Polymer Membrane

**Brian Adzima, ORISE
Hunaid Nulwala, CMU**



MOF

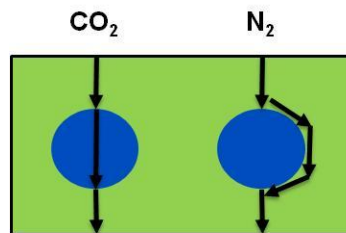


MMM

**David Hopkinson, DOE
Surendar Venna, ORISE**

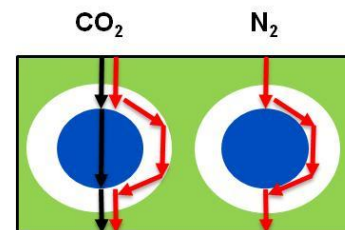
Brian Kail, URS

Nathaniel Rosi, Pitt

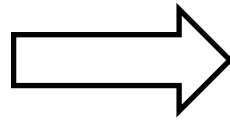
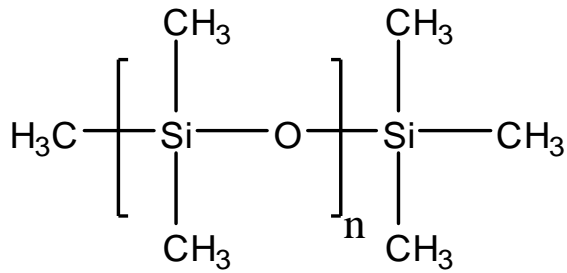


"True" MMM Transport

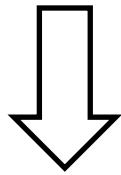
Particle Bypass



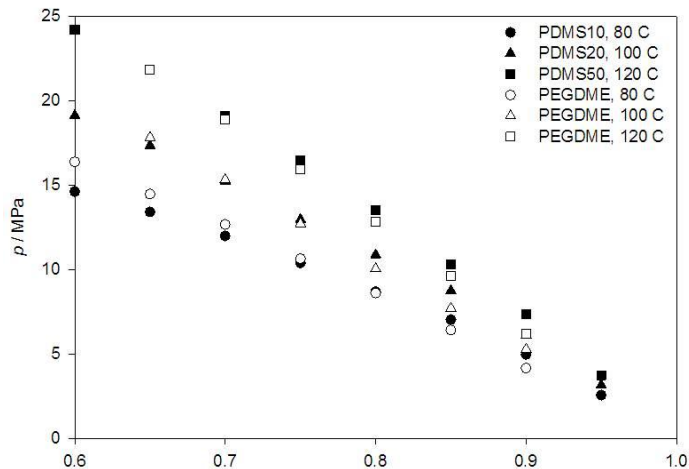
PDMS



Chemical Modification

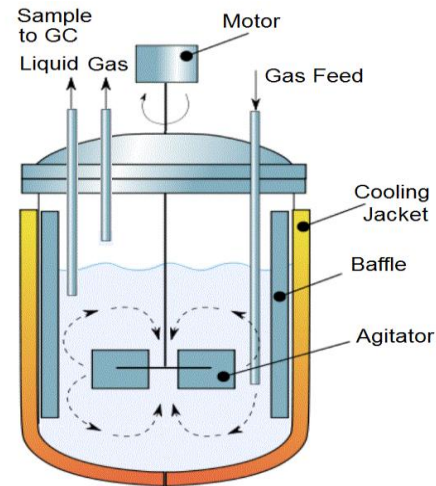
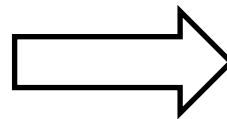


Phase Behavior



Bob Enick, Pitt

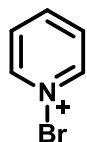
Hunaid Nulwala, CMU
Robert Thompson, URS



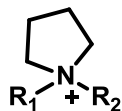
CSTR
Scale-up

Fan Shi, URS
Dave Luebke, DOE

Ionic Liquids



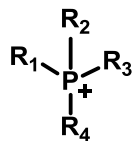
Pyridinium



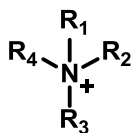
Pyrrolidinium

Estimated 10^{18} possible ionic liquids

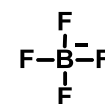
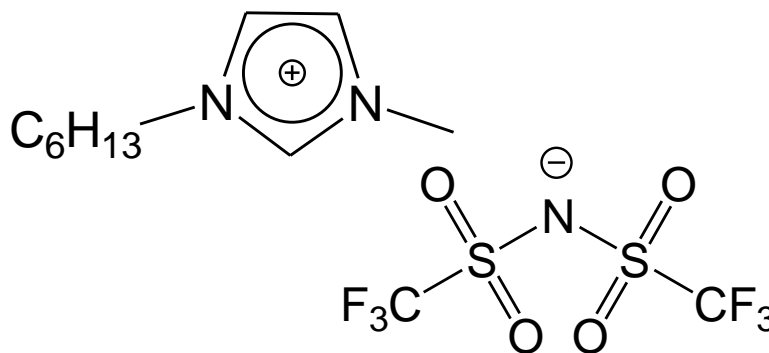
I^- Iodide Br^- Bromide Cl^- Chloride



Phosphonium



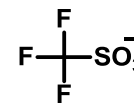
Ammonium



Tetrafluoroborate



Hexafluorophosphate



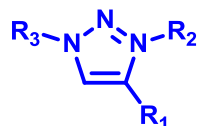
Trifluoromethylsulfonate



Acetate

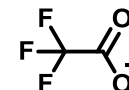


Imidazolium

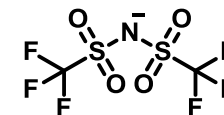


Triazolium

~1000 ionic liquids commercially available



Trifluoroacetate

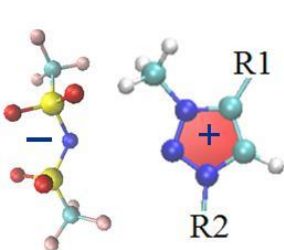


TF₂N

- Highly Tailorable Liquid Salts
 - Negligible Vapor Pressure
 - Good Thermal Stability
 - High CO₂ solubility relative to CH₄, N₂, and H₂

Ionic Liquids

Chemical Informatics



Initial
IL

Guide and
Validate
Simulation

Provide Force
Field,
Structure and
Solubility

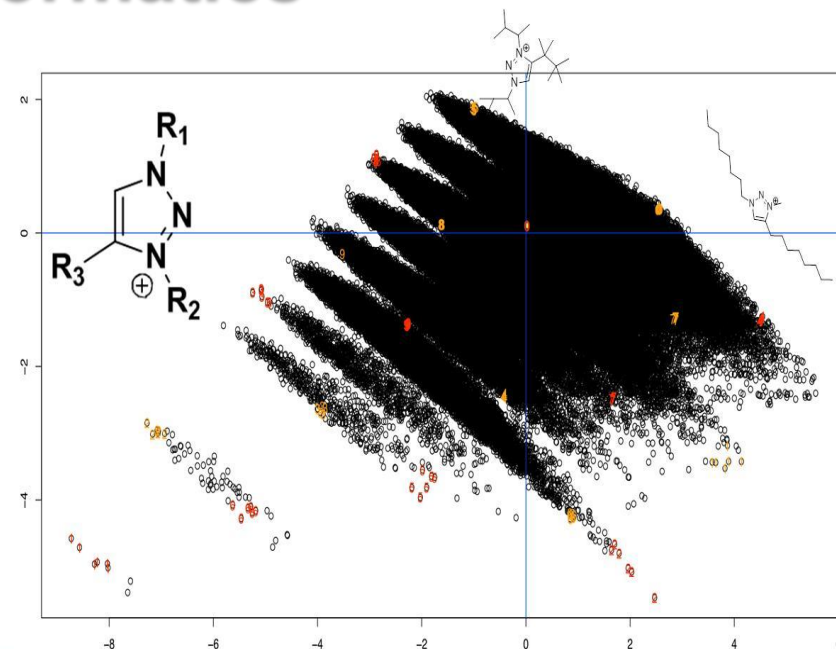
Experiment

Molecular
Simulation

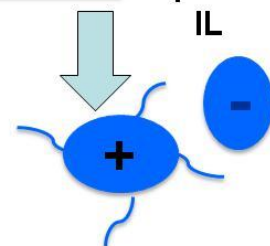
Chemical
Informatics

Select Best Candidates
for Experimental
Validation

Screen Huge
Library of ILs/
Suggest Candidates



Optimal
IL

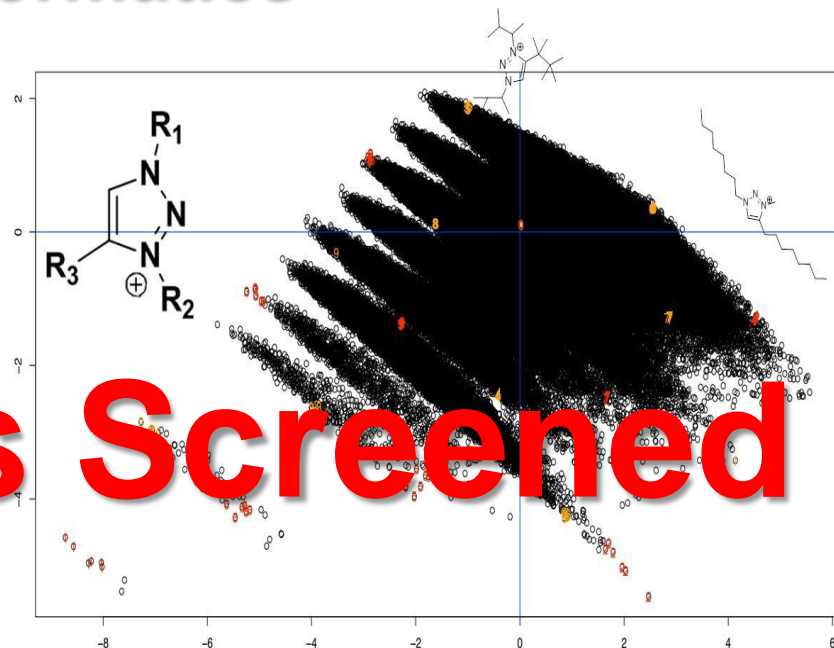


Berkeley
EFRC

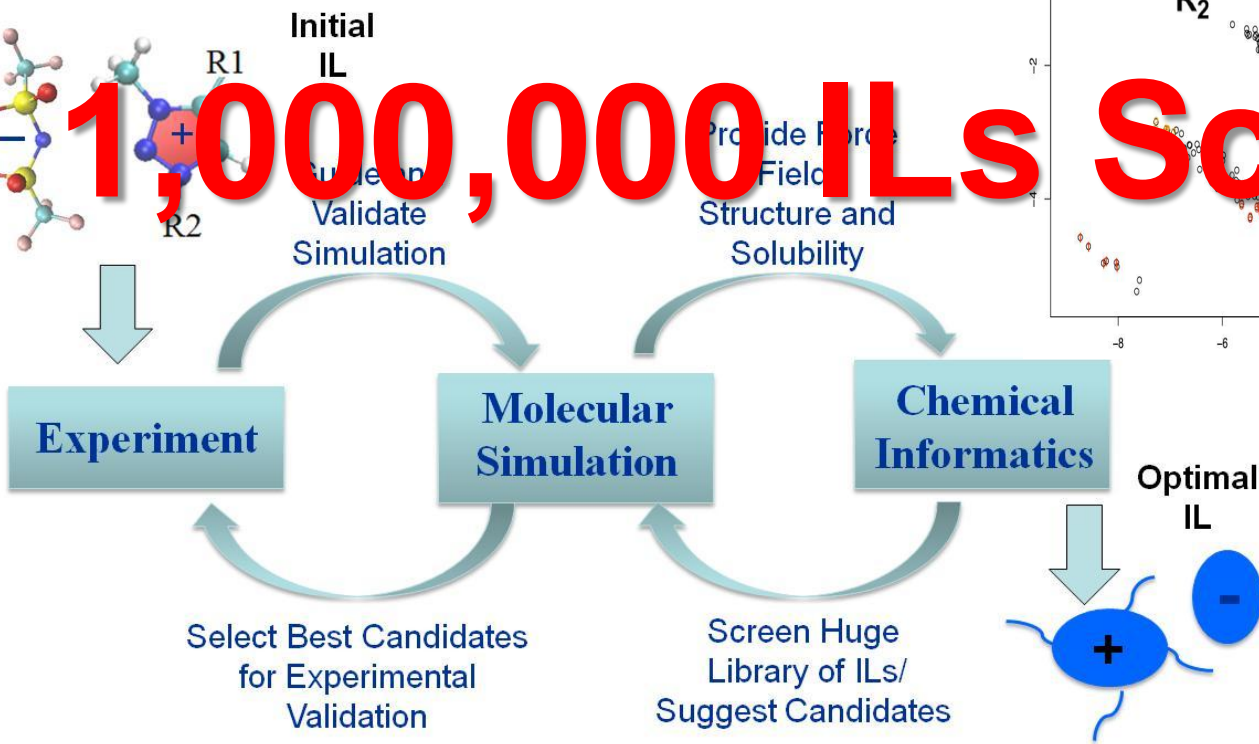
Ionic Liquids

Chemical Informatics

Hunaid Nulwala, CMU
Robert Thompson, URS
Michael Lartey, ORISE

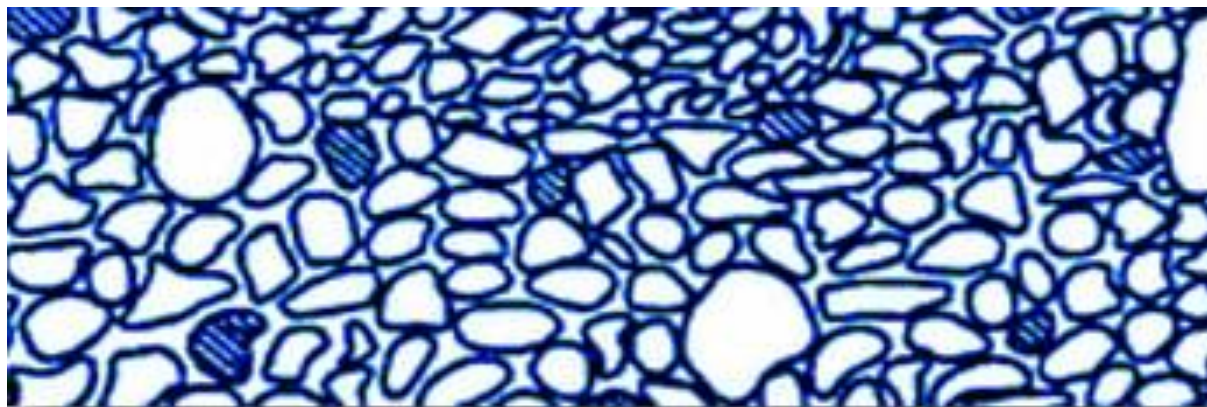


1,000,000 ILs Screened

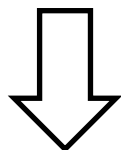


Berend Smit, Berkeley
Maciej Haranczyk, Berkeley
Jeff Kortright, LBNL

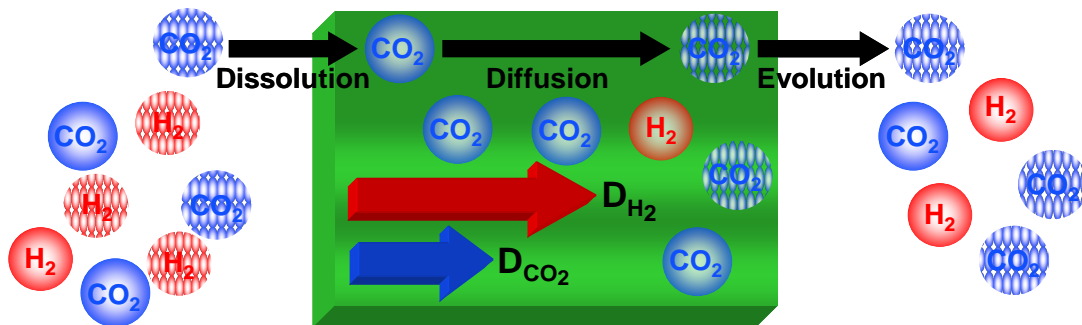
Supported Ionic Liquid Membranes



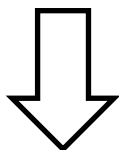
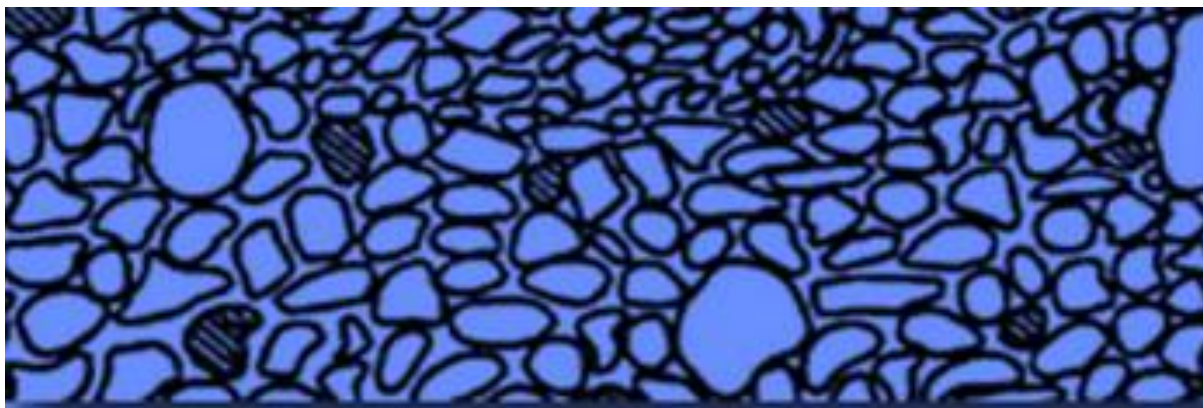
+ IL



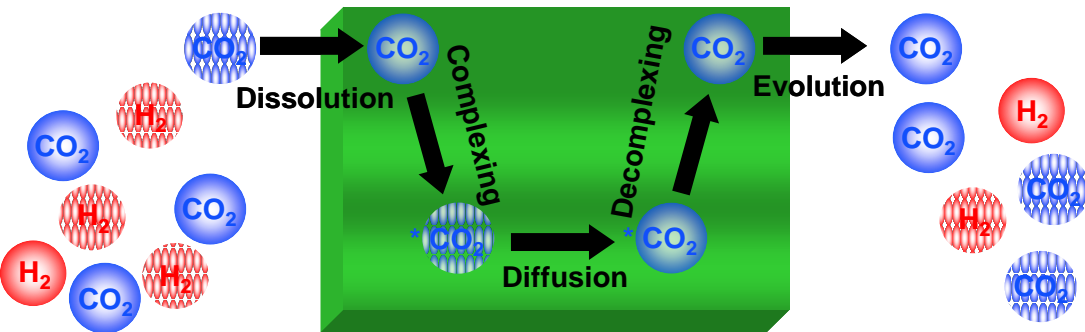
IL Development



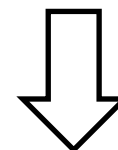
Supported Ionic Liquid Membranes



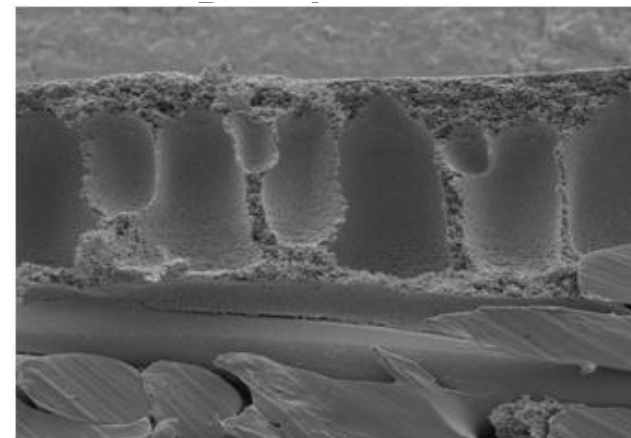
IL Development



Michael Lartey, ORISE



Polymer Support

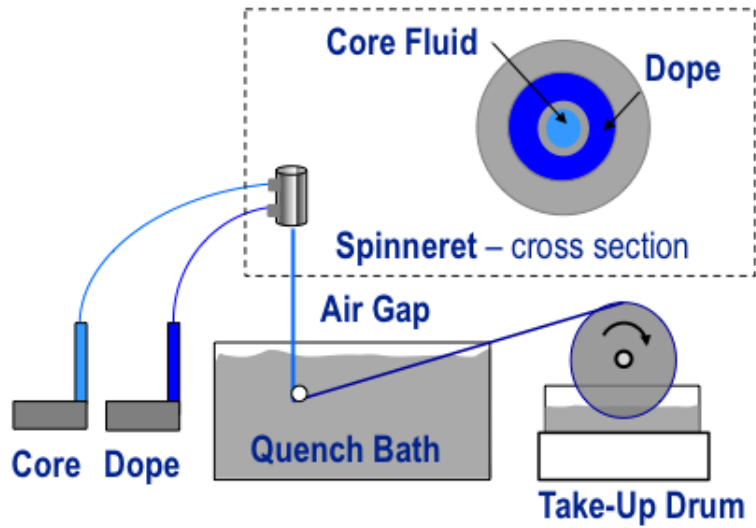


Victor Kusuma, ORISE

Membrane Development

Fiber Modules and High Throughput Testing

Fiber Fabrication

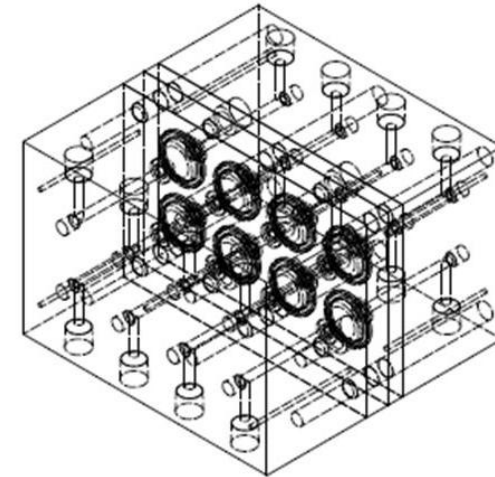
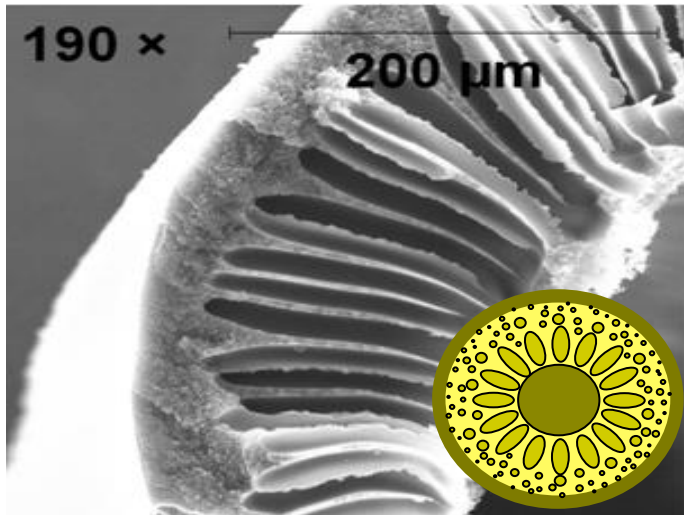


Membrane Development

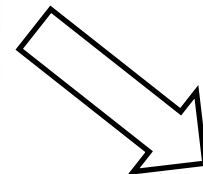
Fiber Modules and High Throughput Testing

Erik Albenze, URS

Fiber
Fabrication



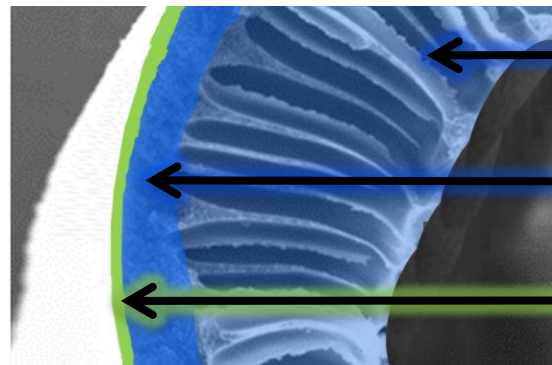
Shan Wickramanayake, URS
Dave Hopkinson, DOE



SILM Fiber Development



Lie Hong, URS
Dave Luebke, DOE

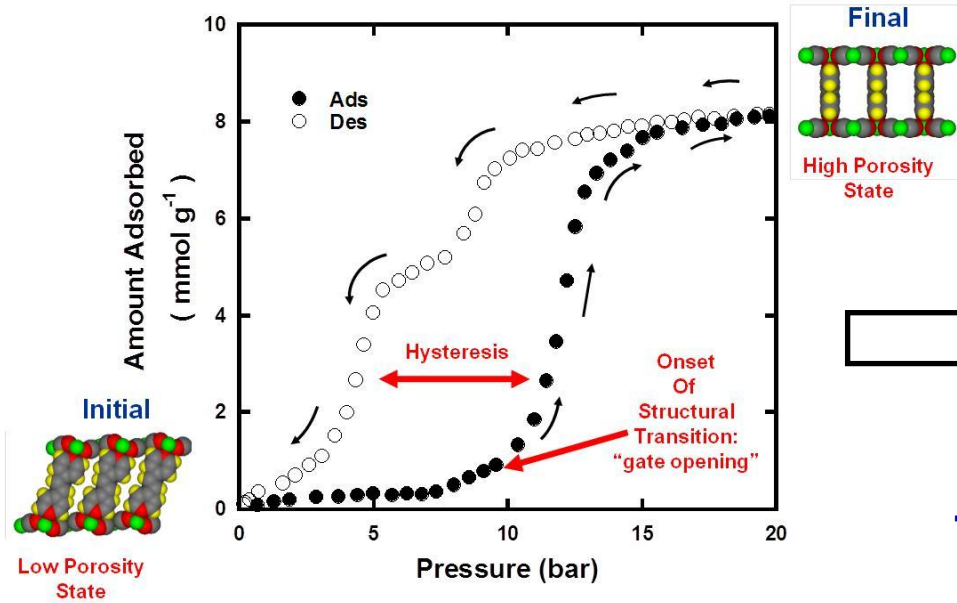


Much Too Thick (~200 micron)

Still Too Thick (~20 micron)

Practical Membrane
Thickness (~1 micron)

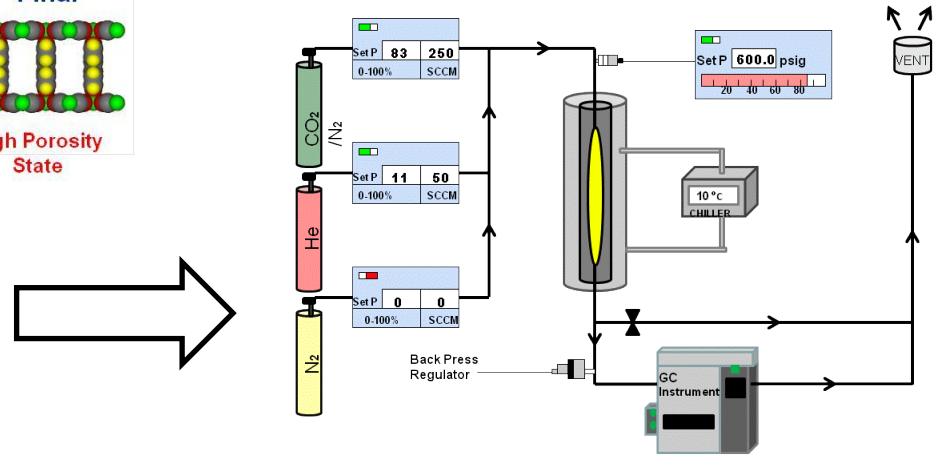
Structurally Dynamic MOFs



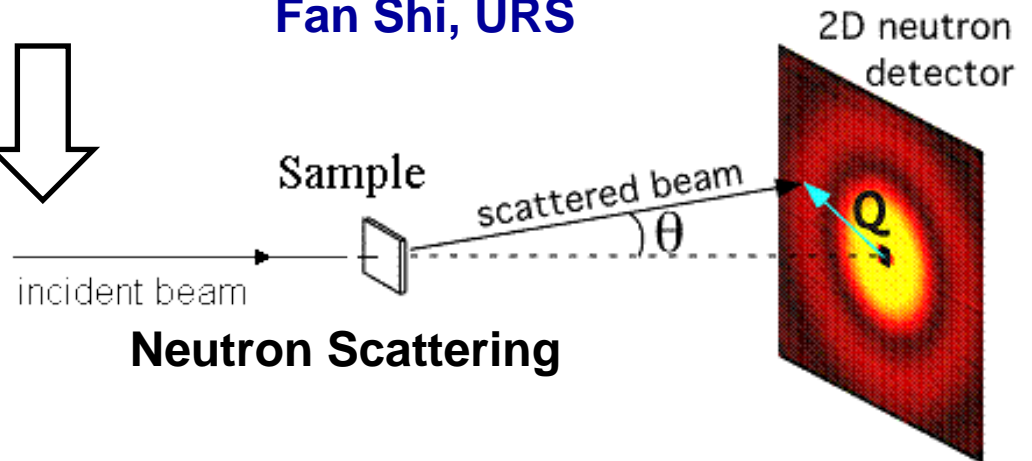
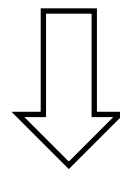
Christopher Matranga, DOE
Jeff Culp, URS

Andrew Allen, NIST

Mixed Gas Testing



Tom Brown, DOE
Fan Shi, URS



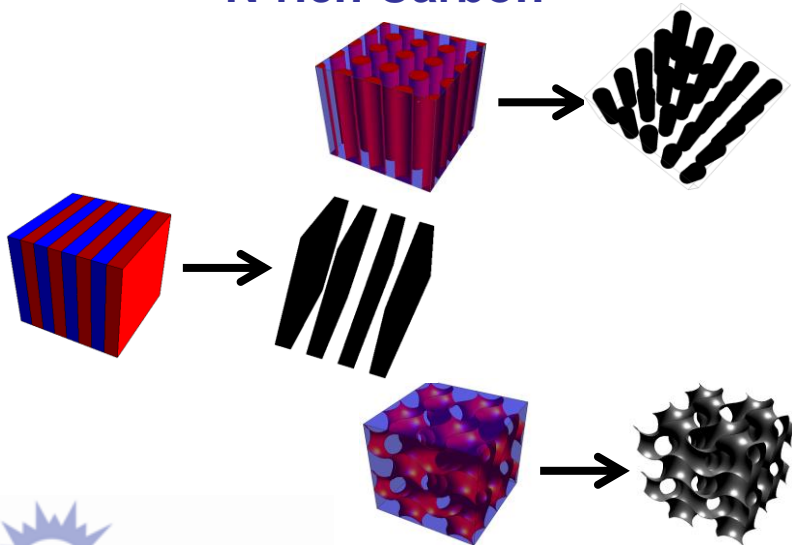
Neutron Scattering

Advanced Research Projects

Bingyun Li, WVU

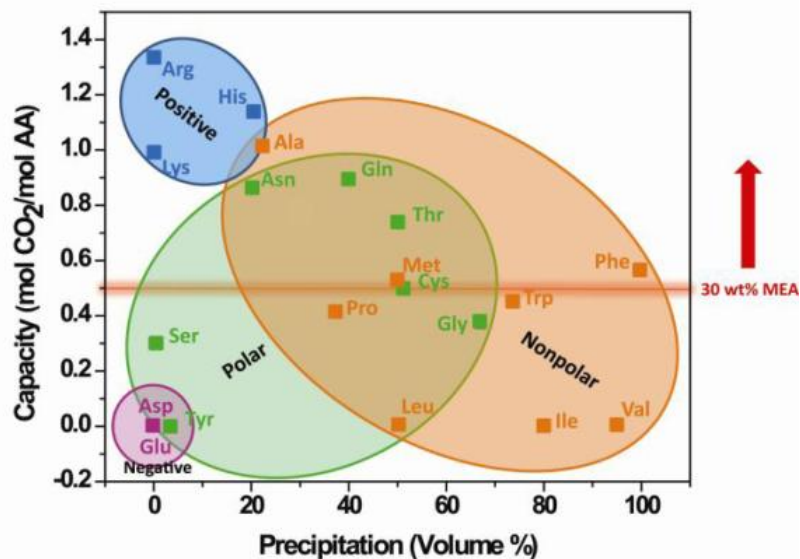
Fan Shi, URS

N-rich Carbon



Phase Change Amino Acids

Comparison between 30 wt% MEA and 20 AA-K⁺ salts



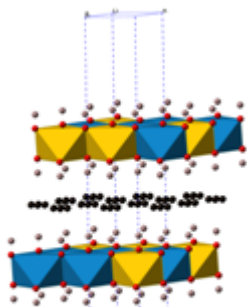
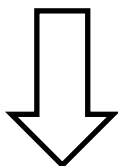
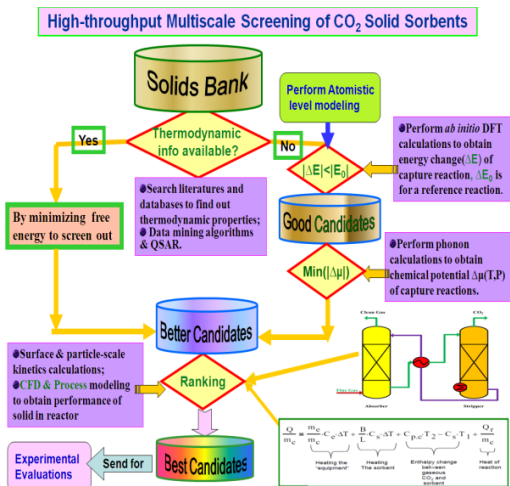
Hunaid Nulwala, CMU

Tomasz Kowalewski, CMU

Sittichai Natesakhawat, Pitt

Advanced Research Projects

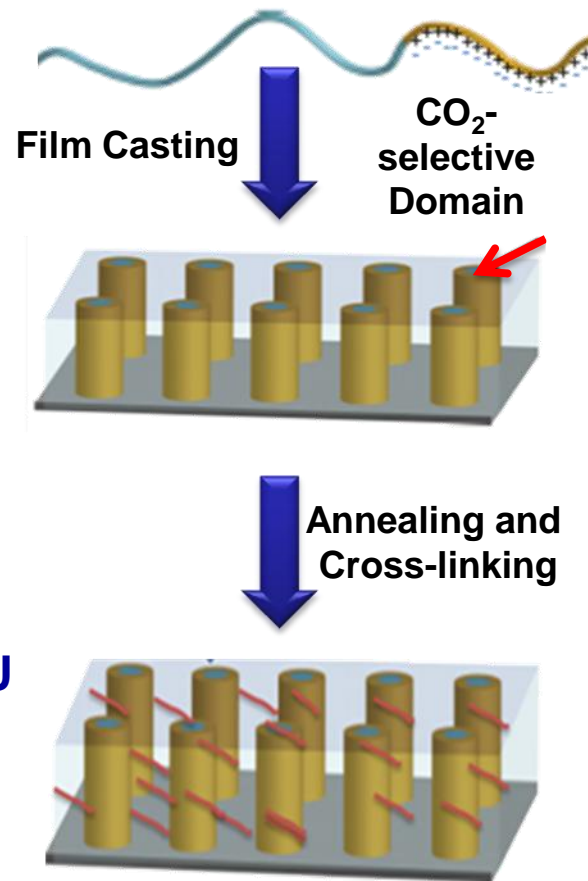
Layered Double Hydroxides



Jonathan Lekse, URS
Yuhua Duan, DOE

Brian Adzima, ORISE
Krzysztof Matyjaszewski, CMU

Structured Polymer Membranes



NETL-RUA:

Creating Technology Solutions

- **Unrivaled Understanding of Energy Applications**
- **Results-based Technology Development Approach**
- **Vast Array of Expertise and Facilities within NETL-RUA**
- **Collaborations with World Class Research Organizations**
- **Proven Record of Achieving Technology Solutions**