Achieving a 10,000 GPU Permeance for Post-Combustion Carbon Capture with Gelled Ionic Liquid-Based Membranes

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Motivation
- Current technologies fall substantially short of DOE targets
- 2020 DOE NETL Sequestration Program post-combustion capture goal 90% capture with less than a 3% increase in COE
- Industry/DOE benchmark technology for capture of CO2
- Amino Absorption
- Paracitic low: 90% CO2 capture from gas will require approximately 22-30% of the produced plant power
- Estimated CO2 capture cost using membranes* is substantially
- Industry/DOE benchmark technology for capture of CO2

Membrane Selective Layer Design Synthesis & Evaluation
- Room-Temperature Ionic Liquids (RTILs)
- Compounds entirely consisting of ions resembling the ionic melts of metallic salts
- Liquids at ambient temperature and over a broad temperature range from -96 to 300 °C
- Negligible vapor pressure
- Beneficial properties: high solubility/perm selectivity for CO2, low flammability, excellent chemical stability
- Easily tailored for specific properties by manipulating salting functional groups
- Lack mechanical stability necessary for industrial utilization as thin film gas separation membranes

- Gel-RTILs
- Formed by incorporating low molecular weight organic gelators (LMOGs) into RTILs
- Physical gelation: H-bonding, van der Waals interactions, π-π stacking between LMOG and RTIL
- Gel-RTIL maintains CO2 affinity and permeability characteristics of RTILs
- Low fraction of LMOG required, typically 1-5 mol%
- Free RTIL provides for fast liquid-like diffusion and enhanced flux
- Increase in mechanical and thermal properties of RTIL upon gelation
- Demonstrated high perm-selectivity for CO2 over other components (coal-fired power plant exhaust gas

Objectives & Approach
- Design mechanically and chemically robust room temperature ionic liquid (RTIL)-based selective layers (SLs)
- Evaluate tailored gel-RTILs, RTIL-Poly(RTIL) composites, incorporation of task-specific CO2 complexation chemistry
- CO2 permeability exceeding 1000 barrer
- CO2/N2 selectivity of at least 20
- Develop ultrasonic spray coating technology (USCT)
- Commercially viable development of USCT which enables
- Achieving a 10,000 GPU Permeance for Post-Combustion Carbon Capture with

Membrane Opportunities
- Estimated CO2 capture using membrane** is substantially
- Advantages of membrane-based separations over other separations technologies
- Smaller footprints, smarter operation, better scalability & modularity
- Membrane performance scales linearly with permeance
- Less than $10/t CO2 captured at 10,000 GPU (extrapolated)

- Existing membrane materials have limited selectivity, productivity, chemical resistance, & mechanical durability
- Compelling need for new materials and processing methods to enhance productivity and selectivity

Program Goal Achievement: Improved Materials/Processes
- Development of RTIL-based selective layer materials with:
  - improved CO2 permeability (P > 1000 barrer),
  - improved selectivity in flue gas environments; &

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