Motivation

• The primary disadvantage of concentrated aqueous ammonium solvents is ammonia volatility
  – One route to minimize scrubber ammonia loss is to operate with dilute NH3 solutions at the cost of increasing more power for solvent regeneration
  – A solvent based membrane solution makes dilute solvent operation more feasible since higher heat of regeneration is negated

• To reduce the energy penalty associated with solvent-based post-combustion CO2 capture system by incorporation of dual-function membrane prior to the regenerator
  – To increase carbon loading
  – Water reduced in the solvent by physical separation
  – Catalytic reaction increases the concentration of bicarbonate over carbonate
  – To regenerate solvent catalytically
  – Regenerated by ammonium protons on the surface of membrane

Project Goals and Milestones

1. Year 1
   - Optimize membrane synthesis for optimal flux and rejection rate.
   - Scale support and membrane synthesis to permit testing at pilot facility
   - Work is ongoing to explore novel methods to grow membranes on existing equipment
   - Commercial supports obtained as alternates to current pall
   - Other solvents (later on)

2. Year 2
   - Determine best support and membrane structure for scale up
   - Work has started on hollow fiber separation option

3. Year 3
   - Work continues with membrane growth on existing Ceramic extruder and ancillary equipment ordered to synthesize porous supports
   - Test process using the CAER’s 0.1 MWp pilot CO2 capture facility including use of coal flue gas

Project Progress

1. Commercial supports obtained as alternates to current pall.
   - Pall Membralox® ceramic coated asymmetric supports have adequate flux but lack cost effectiveness

2. Ceramic extruder and ancillary equipment ordered to synthesize porous supports

3. Work has started on hollow fiber separation option
   - A polysulfone based commercial product was sourced

   - Promising flow and catalytic activity obtained using existing pall products
   - Work is ongoing to explore novel methods to grow zeolite on various test supports

Table 2. Performances for 0.55 m total-carbon-loading solutions for A and B type membranes vs. time.

<table>
<thead>
<tr>
<th>Membrane Type and ID</th>
<th>Testing time (min)</th>
<th>Temp. (°C)</th>
<th>pH</th>
<th>Flux (kg/m²·h)</th>
<th>Total CO2 Rejection (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1</td>
<td>107</td>
<td>30</td>
<td>0.02</td>
<td>19.3</td>
<td>-23.4</td>
</tr>
<tr>
<td>A-2</td>
<td>74</td>
<td>30</td>
<td>0.01</td>
<td>24.4</td>
<td>-20.6</td>
</tr>
<tr>
<td>A-3</td>
<td>105</td>
<td>30</td>
<td>0.01</td>
<td>22.6</td>
<td>-3.64</td>
</tr>
<tr>
<td>B-1</td>
<td>156</td>
<td>98</td>
<td>0.24</td>
<td>1.08</td>
<td>-69.7</td>
</tr>
<tr>
<td>B-2</td>
<td>241</td>
<td>98</td>
<td>0.00</td>
<td>0.91</td>
<td>-42.4</td>
</tr>
<tr>
<td>B-3</td>
<td>418</td>
<td>98</td>
<td>0.00</td>
<td>1.47</td>
<td>-22.1</td>
</tr>
</tbody>
</table>

Experimental Setup

• Isomeric support with zeolite membrane coating
• Ammonium carbonate solvent (currently)
• Other solvents (later on)
  - \( \Delta (pH) = pH_{\text{solution}} - pH_{\text{membrane}} \)
  - Total flux = \( \frac{\text{mass flux}}{A \times t} \), A: membrane area; t: permeation time; m: mass of permeate.
  - Rejection rate \( R_{j} = \frac{C_{j,f} - C_{j,p}}{C_{j,f}} \), i.e., permeate concentration; \( C_{j,f} \): i feed concentration.

Figure 1. Schematic representation of proposed catalysis.

Figure 2. System integration.

Figure 3. The Impact of Proposed Research on Incremental Cost of Electricity with Carbon Capture and Storage.

Figure 4. Membrane evaluation apparatus and CAER pilot scrubber/stripder.

Figure 5. SEM pictures of A-type membranes.

CO2 Capture Costs with 5 Active CAER Research Areas Highlighted

A1: New Solvent Development
A2: Solid/Liquid Catalyst Development
A3: Post-scrubbing Dewatering
A4: Enhance Stripping Investigation
A5-a: Material Development for Corrosion
A5-b: Fluid dynamic with Presence of Solid