Objective

To develop a bio-mimetic hollow fiber membrane contactor (HFMC) process that can produce \( \text{O}_2 \) from air with greater than 95% \( \text{O}_2 \) purity at a cost substantially below the benchmark technology, cryogenic distillation.

State-of-the-art mature air separation technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>( \text{O}_2 ) purity limit (vol.%)</th>
<th>Largest ( \text{O}_2 ) flow rate (Ton ( \text{O}_2 )/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cryogenic distillation</td>
<td>99+</td>
<td>&gt;3,000</td>
</tr>
<tr>
<td>Pressure swing adsorption (PSA)</td>
<td>95</td>
<td>&lt;350</td>
</tr>
<tr>
<td>Conventional gas separation membranes</td>
<td>40</td>
<td>&lt;20</td>
</tr>
</tbody>
</table>

- **Cryogenic distillation**
  - The most mature technology for large scale and high purity (>99%) \( \text{O}_2 \) production
  - Cost estimate with Integrated Environmental Control Model: $35.80/ton \( \text{O}_2 \) for an IGCC plant producing 500 MW, net with Illinois 6 coal and shift/Selexol for \( \text{CO}_2 \) capture

Our inspiration: ...Red Blood Cell

We use membrane contactor to realize our concept...

What is a membrane contactor?

- High surface area membrane device that facilitates mass transfer
- Gas on one side, liquid on other side
- Membrane does not wet out in contact with liquid
- **Separation mechanism**: \( \text{O}_2 \) permeates through membrane, reacts with the solvent; \( \text{N}_2 \) does not react and has low solubility in solvent

Our innovative Technology

A membrane contactor process with hollow fibers and \( \text{O}_2 \) carrier solution mimics “blood vessels” and “blood” to produce > 95% purity of \( \text{O}_2 \)

Membrane in hollow fiber configuration
- High packing density
- Small equipment size

Accomplishments

- Oxygen carrier solvent (Co-PEI aqueous solution) developed and showed high \( \text{O}_2 \) loading capacity and low viscosity

<table>
<thead>
<tr>
<th>Composition</th>
<th>Kinematic viscosity ((10^4 \text{ m}^2/\text{s}))</th>
<th>( \text{O}_2 ) capacity per volume of solution ((\text{L(STP)/L of solution}))</th>
<th>Kinematic viscosity after ( \text{O}_2 ) absorption ((10^4 \text{ m}^2/\text{s}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.0</td>
<td>0.59</td>
<td>2.8</td>
</tr>
<tr>
<td>2</td>
<td>2.2</td>
<td>0.78</td>
<td>2.8</td>
</tr>
<tr>
<td>3</td>
<td>2.3</td>
<td>1.1</td>
<td>3.0</td>
</tr>
</tbody>
</table>

- Oxygen absorption rate measured

  - The production of concentrated \( \text{O}_2 \) validated experimentally in the bio-mimetic process: using a polypropylene membrane and with argon sweep approach, \( \text{O}_2 \) concentration greater than 98.1% was observed in desorbed gas stream on an argon free basis.

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