Direct Synthesis of Dimethyl Carbonate (DMC) from Methanol and CO$_2$
**CO₂ Utilization Routes**

DMC synthesis by CO₂:

\[2\text{CH}_3\text{OH}(l) + \text{CO}_2(g) \leftrightarrow \text{CO}((\text{OCH}_3)_2(l) + 2\text{H}_2\text{O}(l))\]

Main uses of DMC:
- DMC is a versatile non toxic solvent
- Used as solvent in polycarbonate and PU industry
- Used as fuel additive for gasoline/diesel
- DMC can boost density and RON of the GTL fuels

<table>
<thead>
<tr>
<th>name</th>
<th>abbrev</th>
<th>MW</th>
<th>mp</th>
<th>bp</th>
<th>d(20°C)</th>
<th>vapor pressure</th>
<th>lower heating value</th>
<th>wt %</th>
</tr>
</thead>
<tbody>
<tr>
<td>dimethyl carbonate</td>
<td>DMC</td>
<td>90</td>
<td>1</td>
<td>90</td>
<td>1.069</td>
<td>81</td>
<td>55.6</td>
<td>53.3</td>
</tr>
</tbody>
</table>

**Table 6. Range of Alkyl Carbonate Gasoline Blending Values at 3–5 vol %**

<table>
<thead>
<tr>
<th>RON</th>
<th>MON</th>
<th>approx R + M/2</th>
</tr>
</thead>
<tbody>
<tr>
<td>125–131</td>
<td>100–109</td>
<td>116</td>
</tr>
</tbody>
</table>

**Table 4. Range of Alkyl Carbonate Gasoline Blending Values at 10 vol %**

<table>
<thead>
<tr>
<th>RON</th>
<th>DMC</th>
<th>DEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>106–111</td>
<td></td>
<td>111</td>
</tr>
</tbody>
</table>
Challenges with DMC synthesis

- Pressure has a positive effect on conversion
- Temperature has negative effect on conversion
- Reaction temperature more than 120 °C decreases MeOH conversion
- Water scavengers can help increase the conversion
- 2,2-dimethoxypropane (DMP) and dicyclohexylcarbodiimide (DCC) are reported (water scavengers)
- Reusability of scavengers and catalyst regeneration is a big concern and expensive
- Max MeOH conversion is 17% and DMC selectivity of 7%
Objectives

New process can be designed with:

- Cheap alternatives to 2-cyanopyradine for a sustainable option
- Use ion exchange resins as catalyst instead of metal oxide
  - Ion exchange resins can be operated in low temp range and high pressure
- Catalyst regeneration is very economic and simple
- Optimized separation sequence developed in Hysys/Aspen Plus
- Incorporating new design by retrofitting a DMC plant in existing infrastructure in Qatar
- Utilizing MeOH and CO$_2$ to minimize C-footprint of Qatar
- Blending DMC with GTL Gasoline and Naphtha for a sustainable fuel mix for Qatar
Projected Project Flow

- Synthesizing/identifying new catalysts
  - CeO$_2$, ZrO$_2$, Ion exchange resins

- New Scavengers design
  - MOFs, Dimethyl ketals, Nitriles

- Performance in batch reactor and flow reactor for scale up
  - Selectivity and Conversion

- Techno economic analysis
  - ROI, CAPEX, CO$_2$ equivalence
  - Energy requirement
Thank you