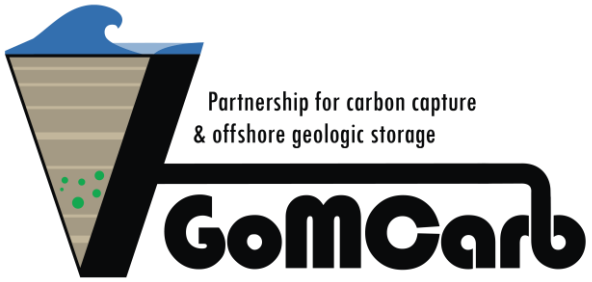
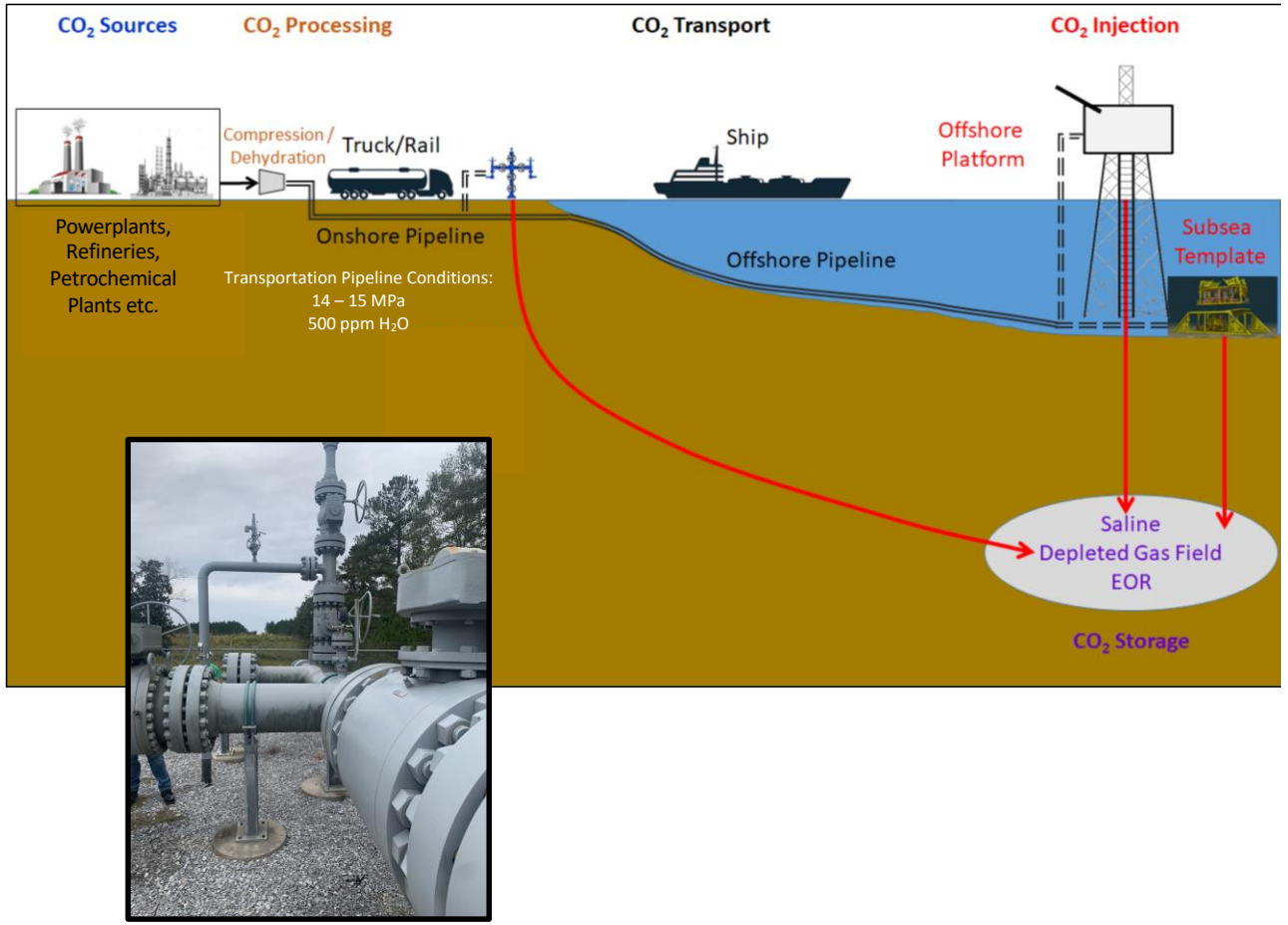


Effect of Monoethanolamine on the Viscosity and CO_2 Absorption of Aprotic Heterocyclic Anion Ionic Liquids

Adhish "Saketh" Madugula and Tracy J Benson, Ph.D.

College of Engineering
LAMAR UNIVERSITY
Dan F. Smith Department of Chemical
& Biomolecular Engineering

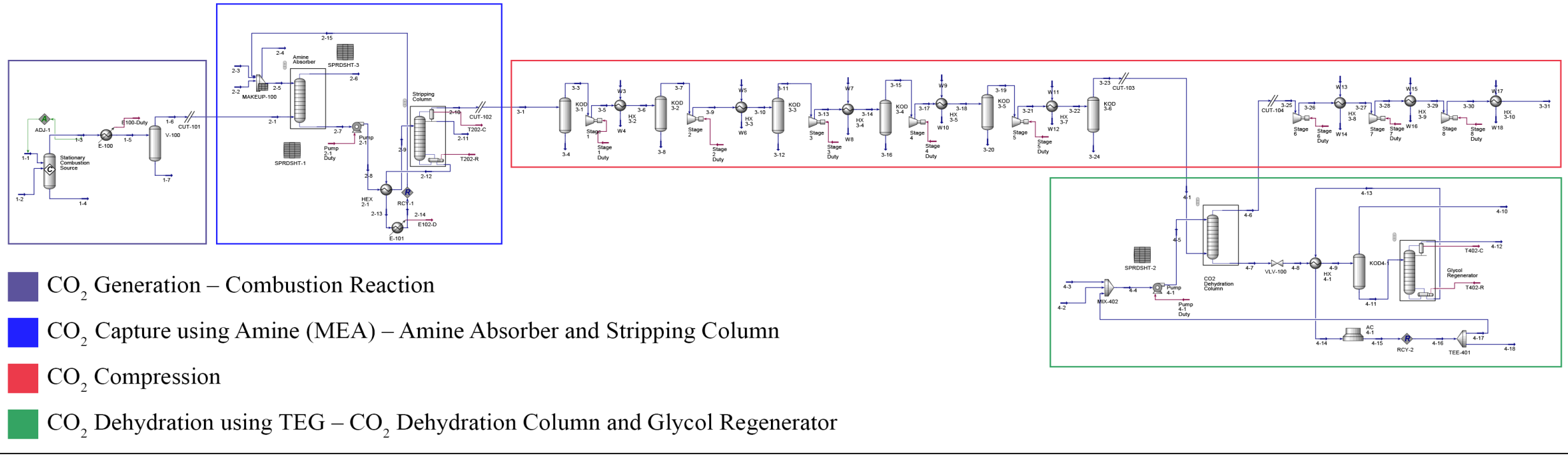
Carbon Capture and Storage



Carbon Capture and Storage (CCS)

(Process simulation from waste flue gas to pipeline quality)

10 – 15 mol% CO_2 and 1 atm → **CO_2 w/ 500 ppm water and 130 atm**



CO_2 Generation – Combustion Reaction

CO_2 Capture using Amine (MEA) – Amine Absorber and Stripping Column

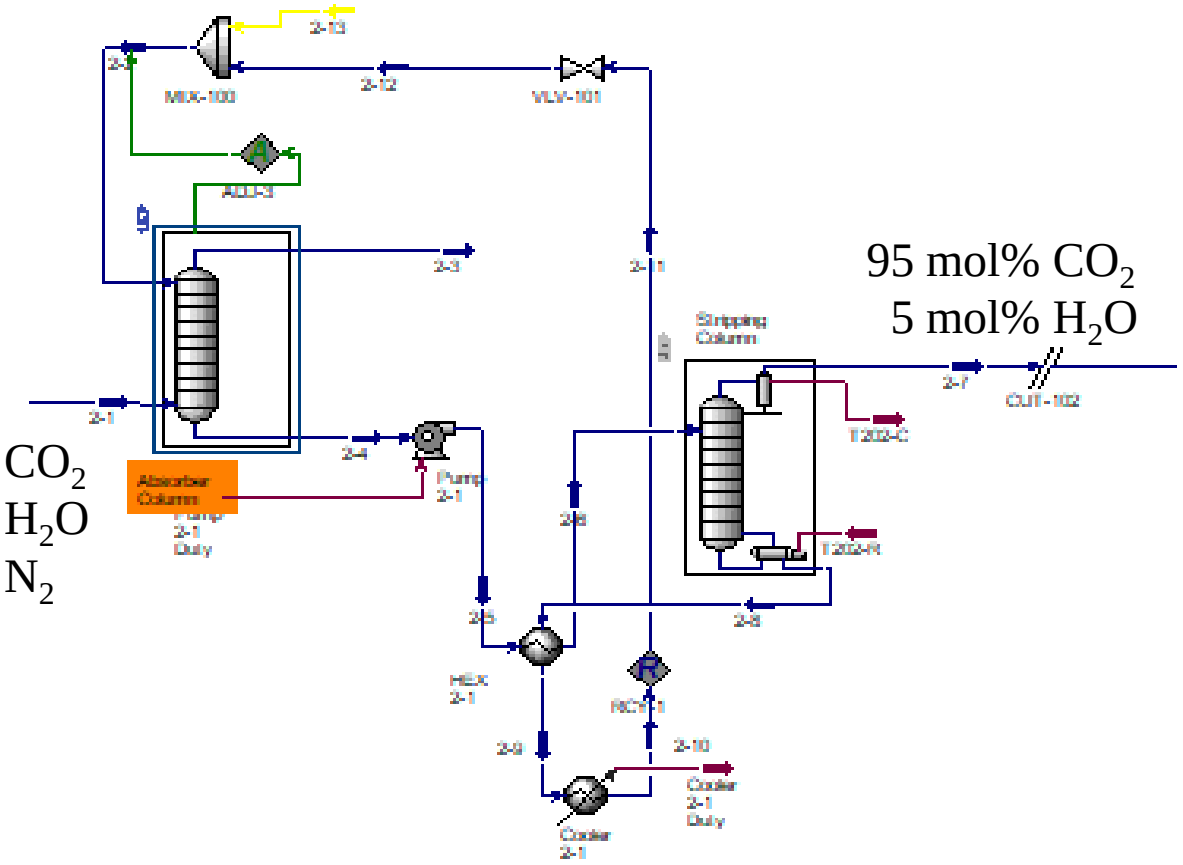
CO_2 Compression

CO_2 Dehydration using TEG – CO_2 Dehydration Column and Glycol Regenerator

Madugula et al. (2021) Chem Eng J Advances, 8, 100162

Carbon Capture Using Cyclic Absorption/Stripping

10 – 15 mol% CO_2
8 – 10 mol% H_2O
75 – 85 mol% N_2

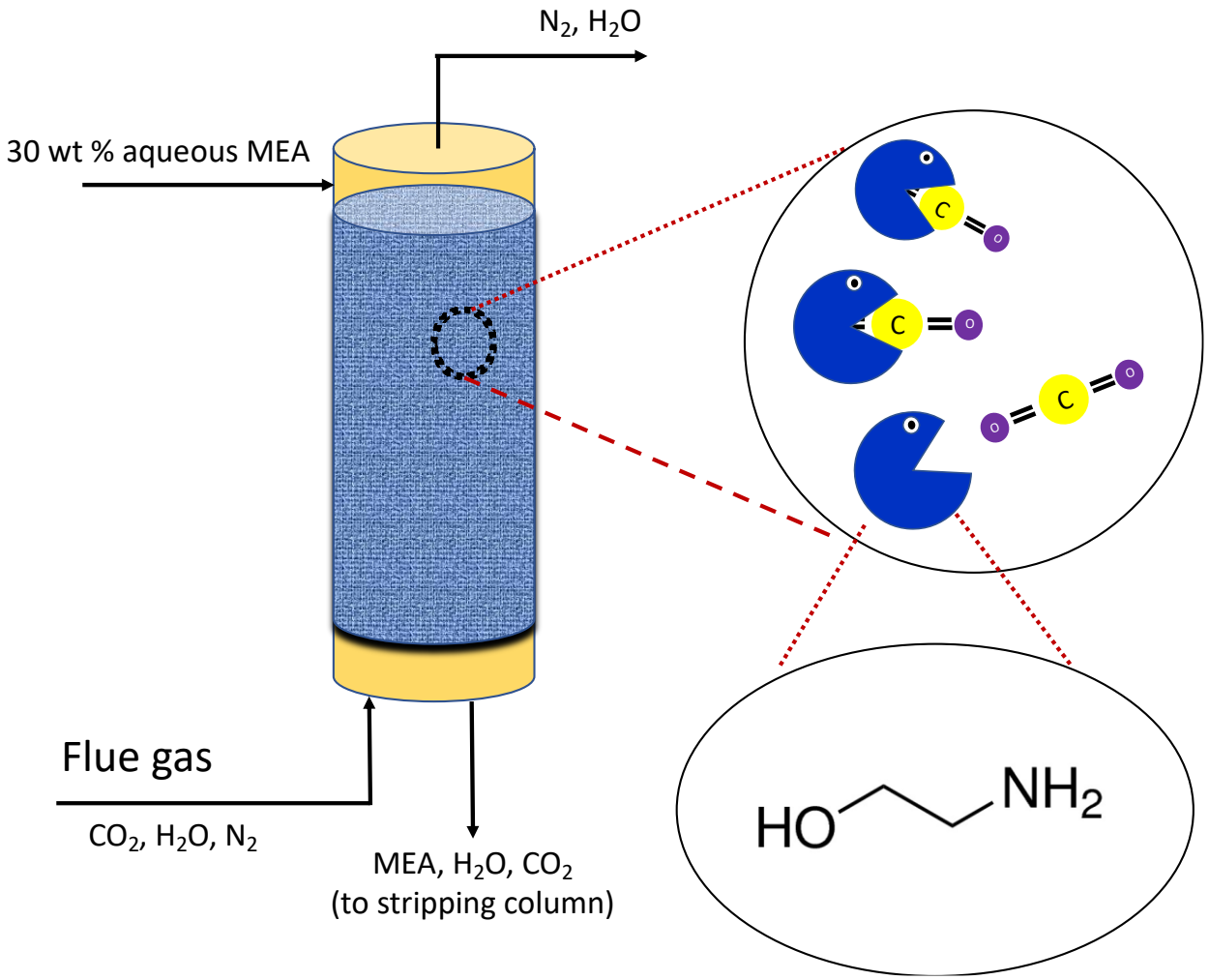


Amine Absorbents

+ **Established chemistry**
+ **Established technology**
+ **Industry ready**

- **High energy demand**
- **Amine degradation**
  - **Temperature**
  - **O_2, SOx, NOx**

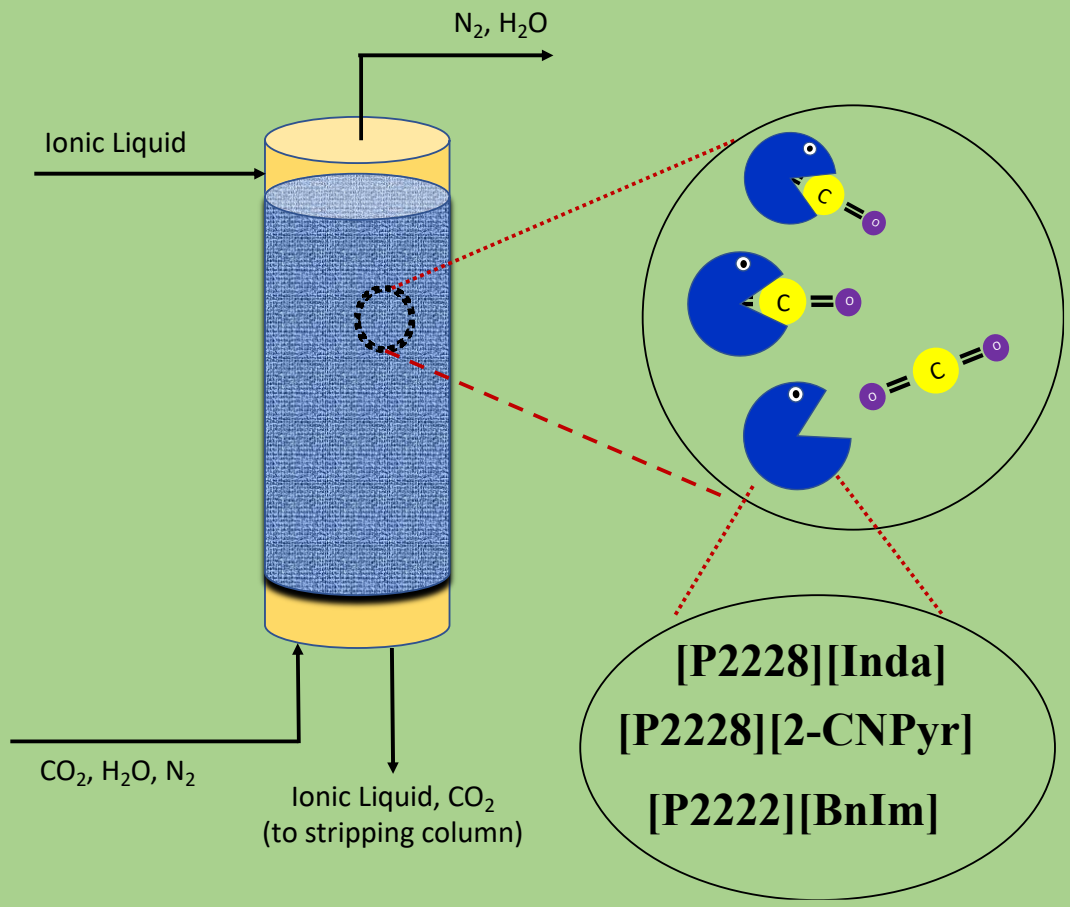
Carbon Capture: Absorption Using MEA

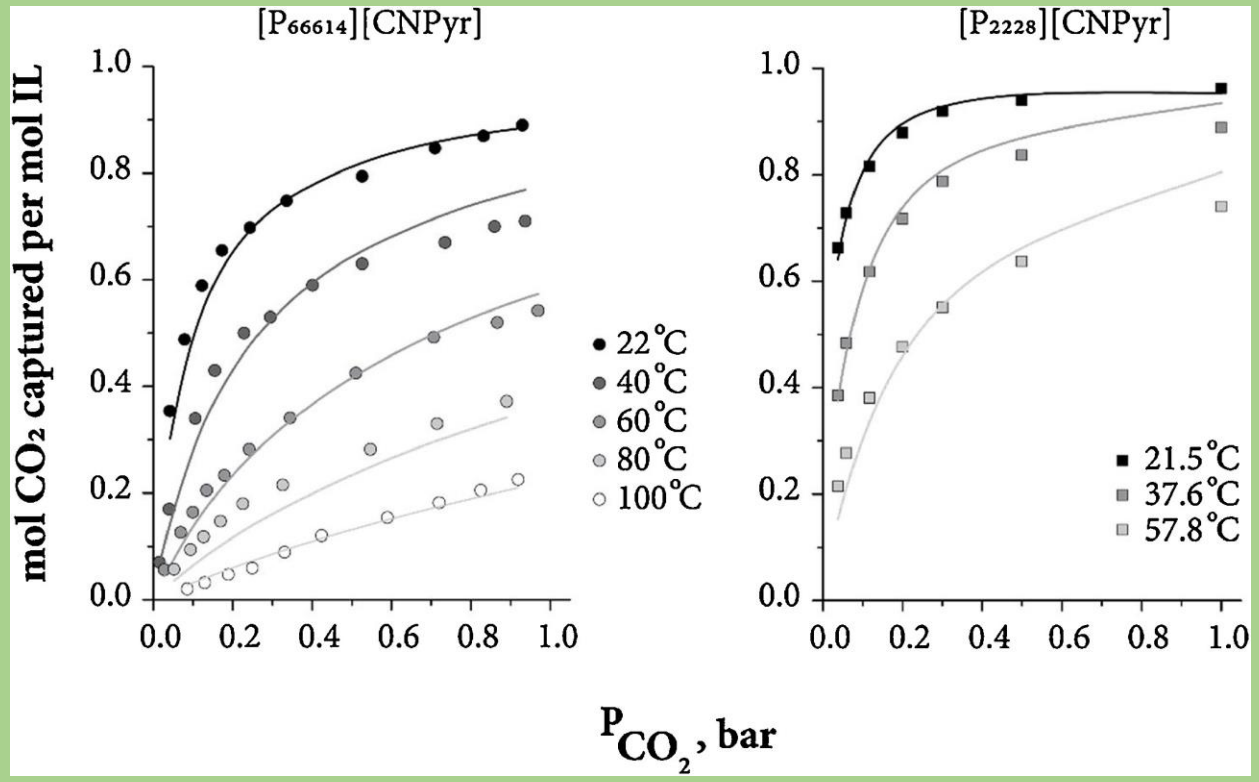


Monoethanolamine (MEA)

MW = 61.1
Density = 1.012 g/mL
T_{melt} = 50.5 °F (10.3 °C)
T_{boil} = 338 °F (170 °C)
$T_{degrade}$ = 248 °F (120 °C)
VP = 64 Pa (20 °C)

Carbon Capture: Using Ionic Liquids





de Riva et al. (2018) Int. J. Greenhouse Gas Contrl

Parameters to Consider

$$D_{ij} = 1.173 \times 10^{-16} \left(\frac{T \times \sqrt{\varphi_j \times MW_j}}{\mu_j \times (V_{bi})^{0.6}} \right)$$

Viscosity ↑, Diffusivity ↓

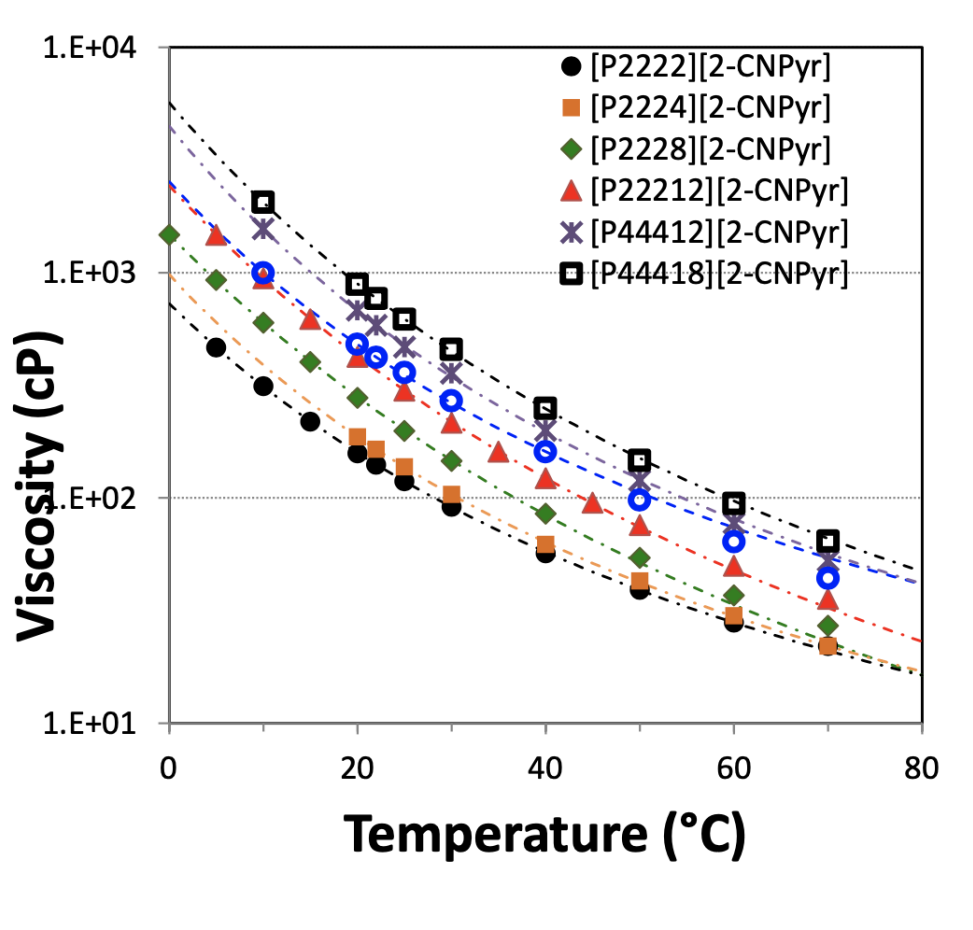
Temperature ↑, Viscosity ↓

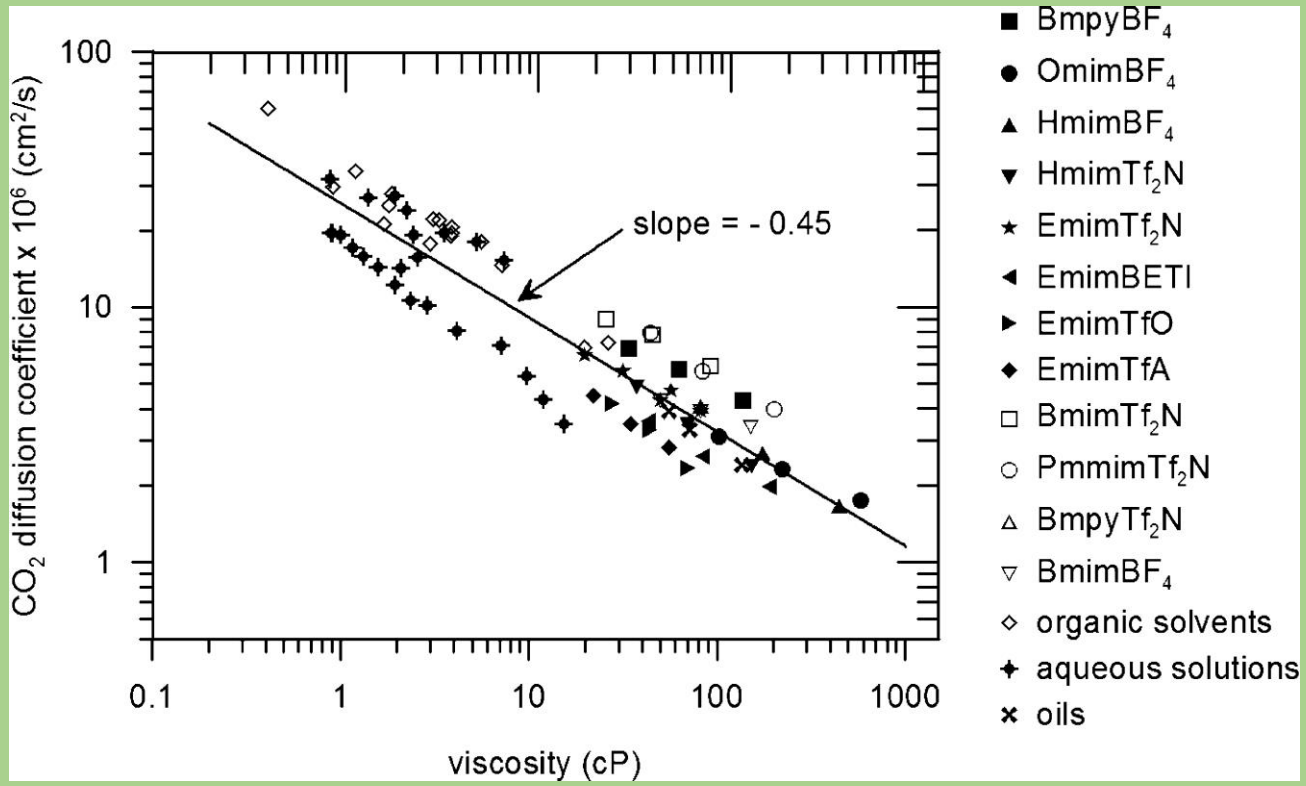
Henry's Law:

$$P_{CO2} = y_{CO2}P = x_{CO2}H(T)$$

Temperature ↑, Absorption Capacity ↓

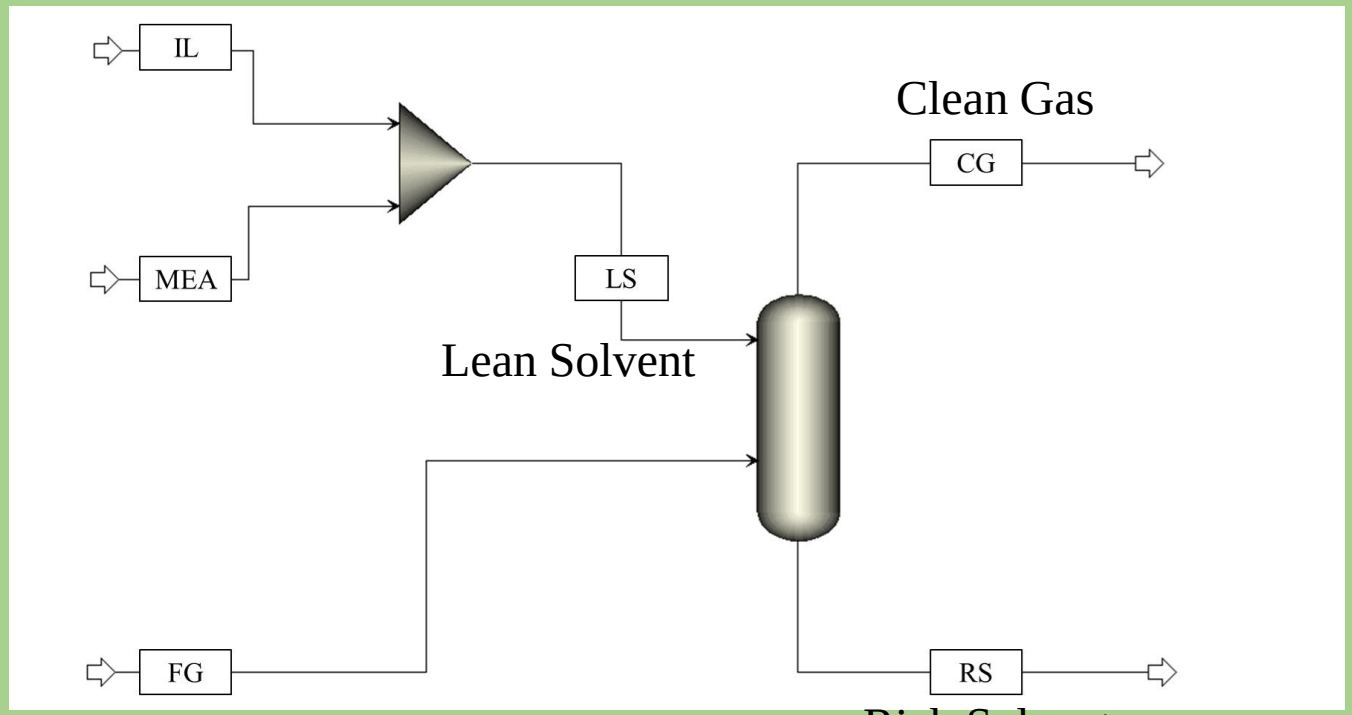
Properties of Ionic Liquids

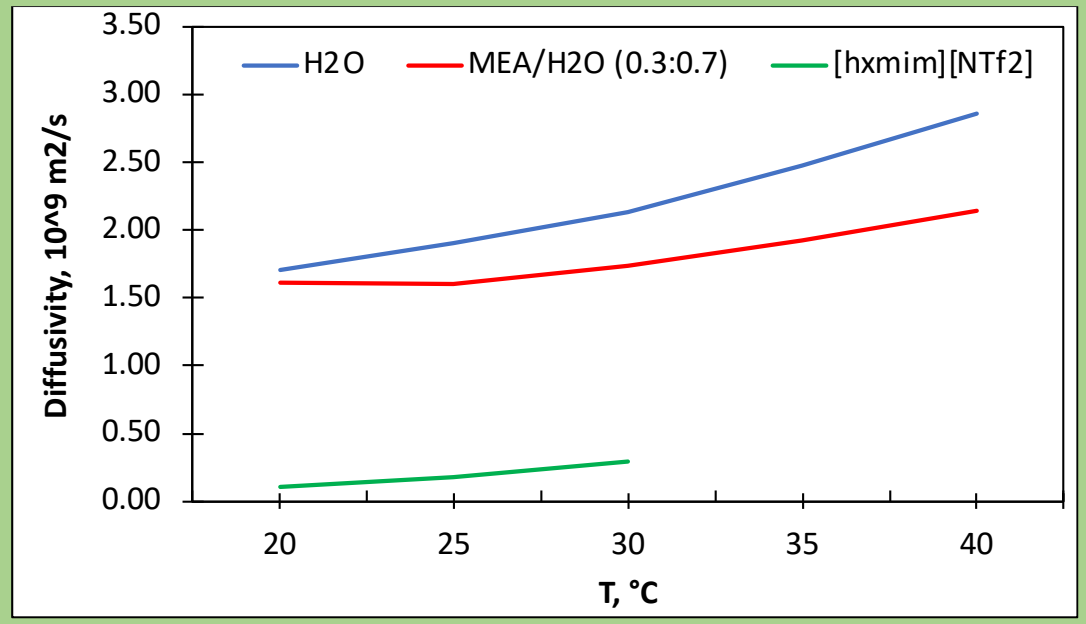




Moganty and Baltus (2010) Ind. Eng. Chem. Res., 49, 9370

Can We Find a Compromise?

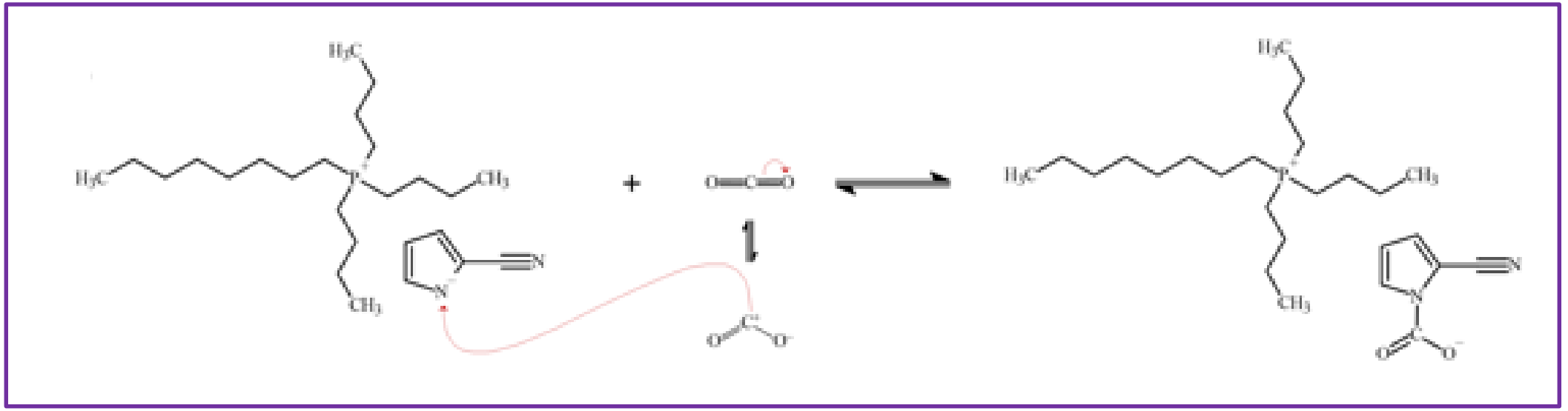




- Electrolytic Non-Random Two Liquid
- Redlich – Kwong Equation of State

Mandal, et al. (2005) J. Chem. Eng. Data, 50, 352
Gonzalez-Miquel, et al. (2014) J. Chem. Eng. Data, 59, 212

Chemisorption Mechanism

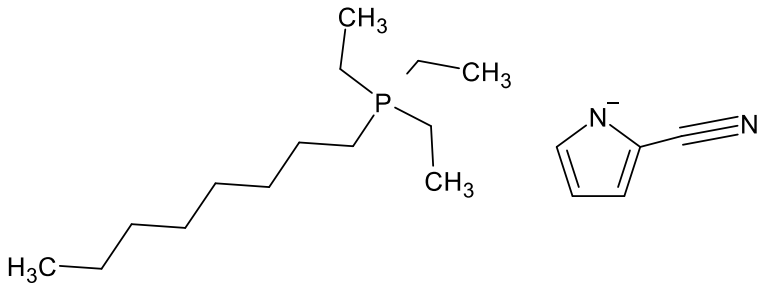


$$\ln(K_H) = A_{H,i} + \frac{B_{H,i}}{T}$$

$$\ln(K_{eq}) = A_{K,i} + \frac{B_{K,i}}{T}$$

$$\ln(K_{eq}) = \frac{\Delta S}{R} + \left(\frac{-\Delta H^0_{chem}}{RT}\right)$$

Ionic Liquids Suited for Aqueous CO_2

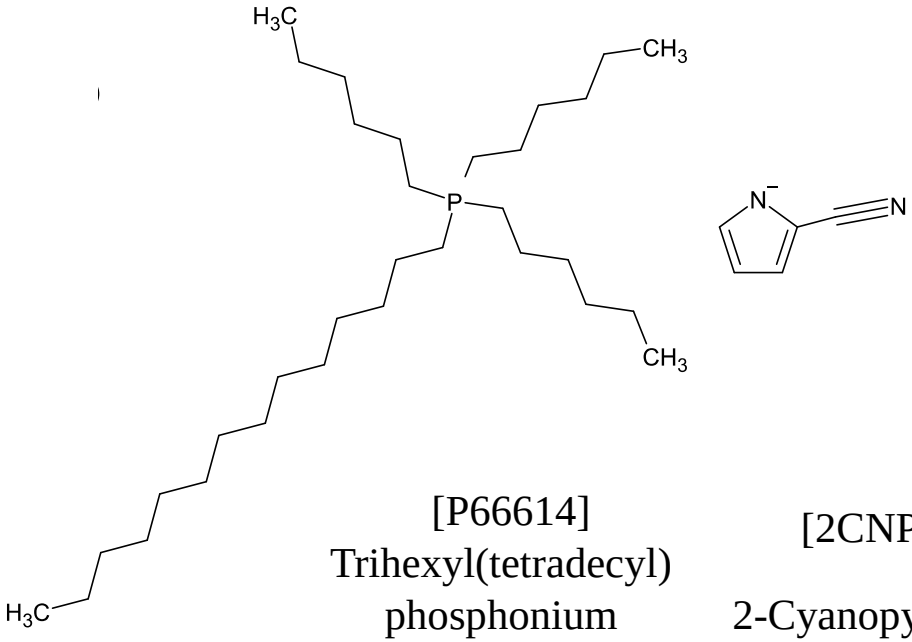


[P2228]

Triethyl(octyl) phosphonium

[2CNPyr]

2-Cyanopyrrolide



[P66614]
Trihexyl(tetradecyl) phosphonium

[2CNPyr]

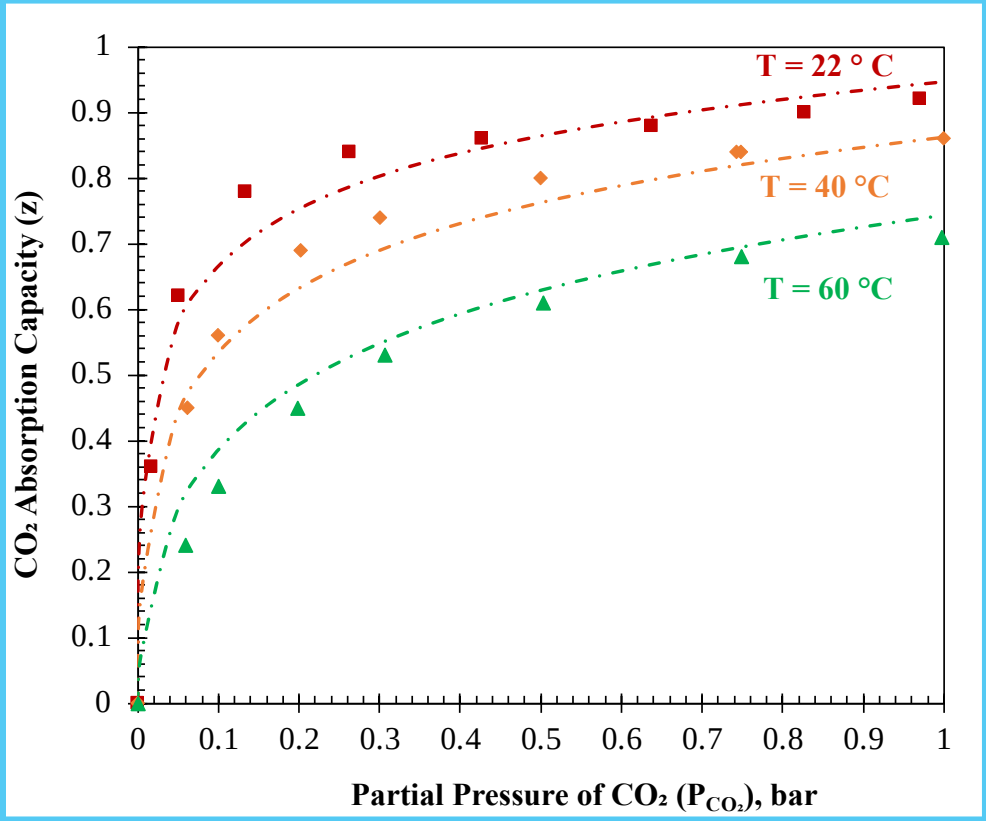
2-Cyanopyrrolide

Aprotic Heterocyclic Anion (AHA) – Small changes in viscosity with absorbed CO_2

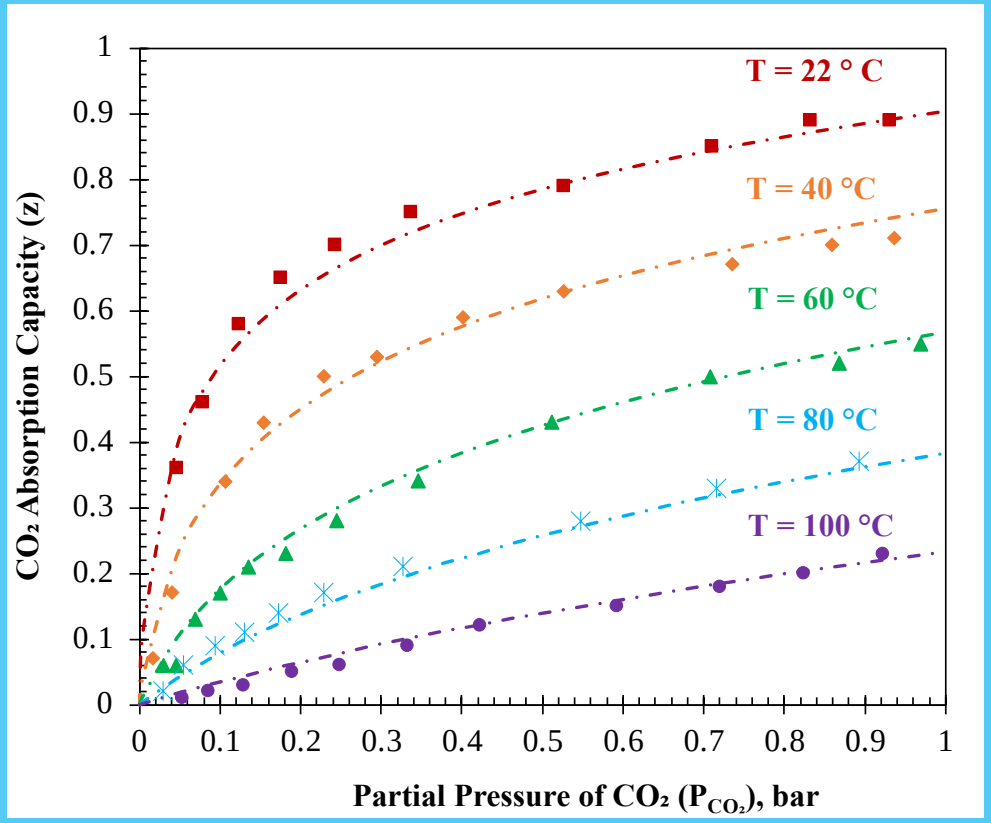
Phosphorous – Good for high water concentrations

Absorption Profiles from Literature Data

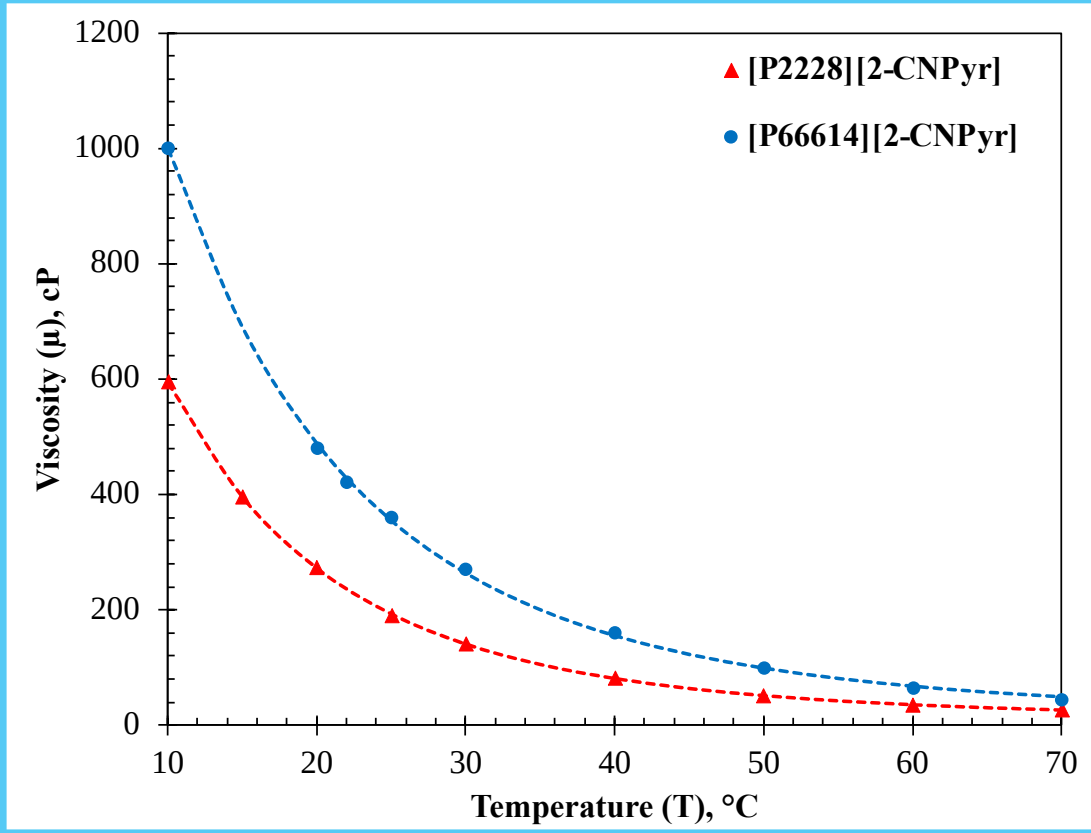
[P2228][2-CNPyr]

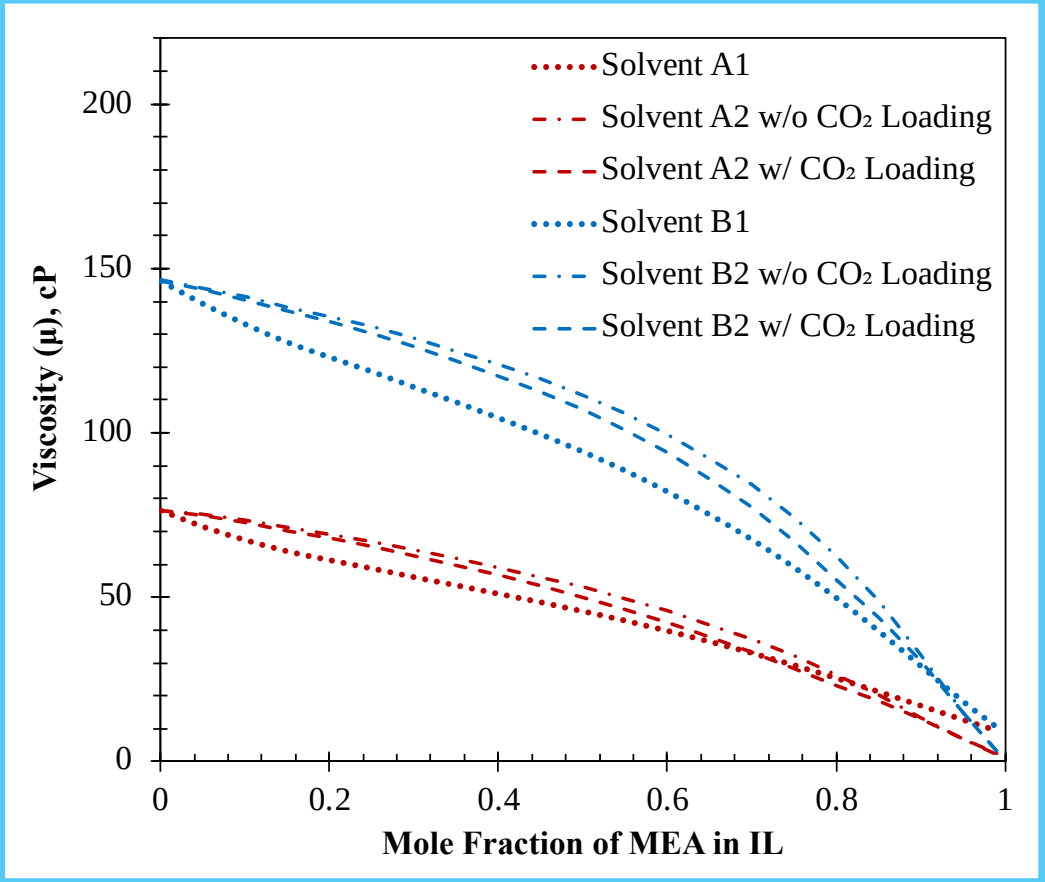


[P66614][2-CNPyr]



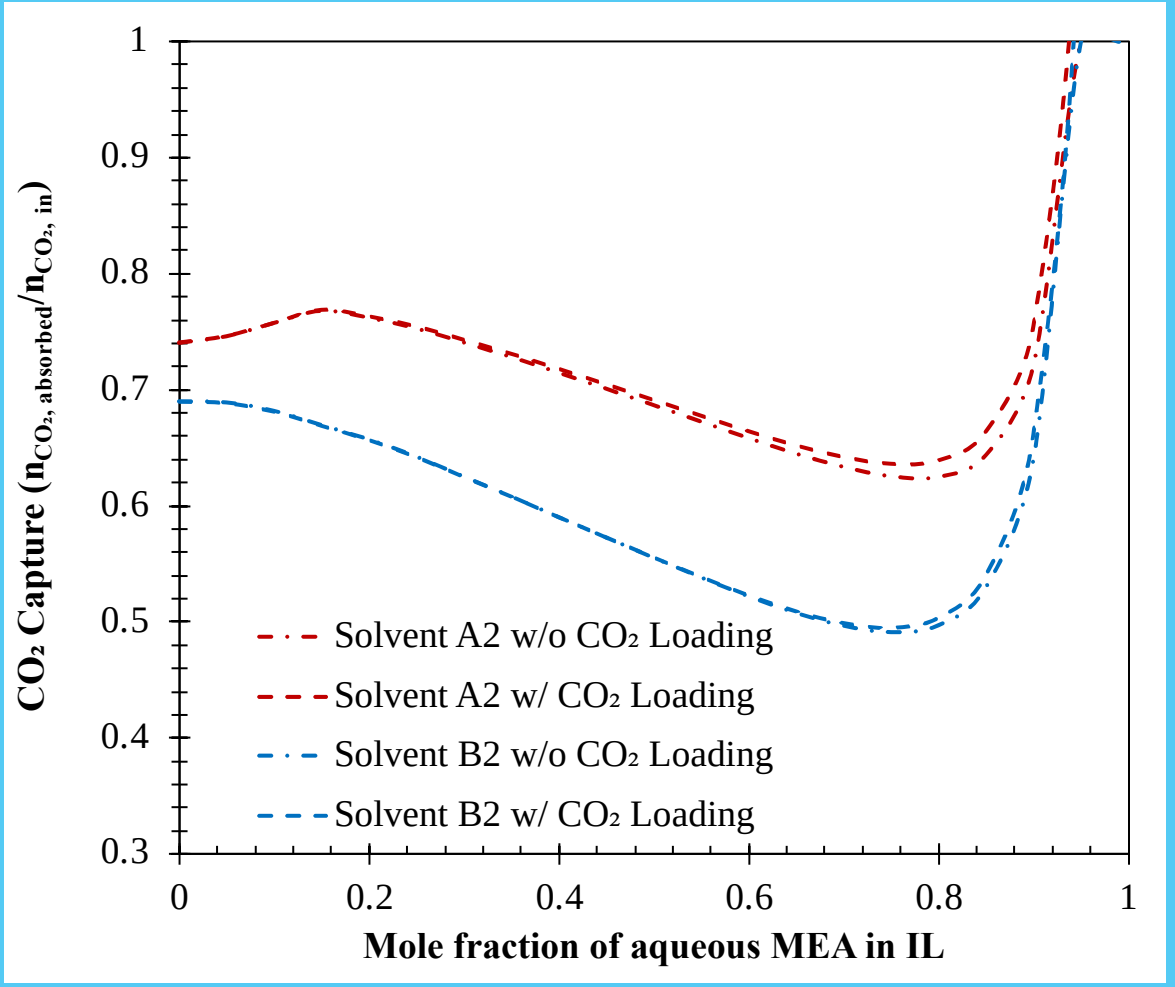
Viscosity Profiles



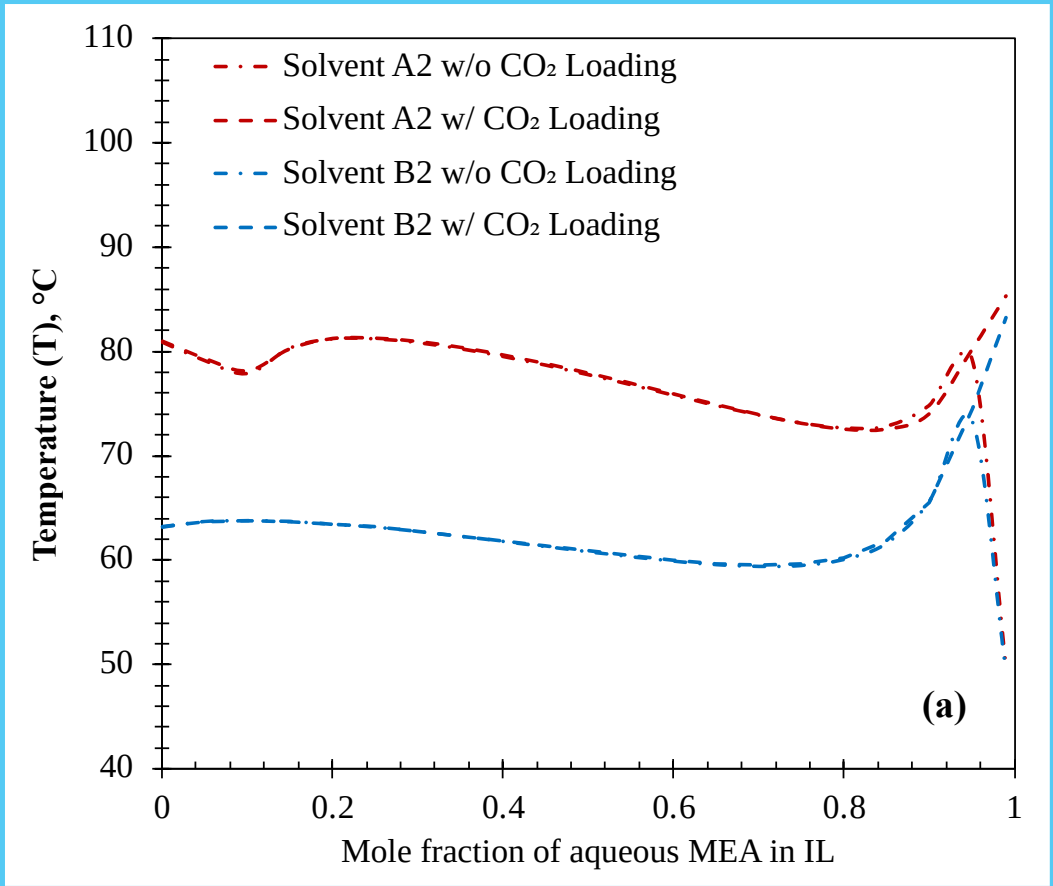


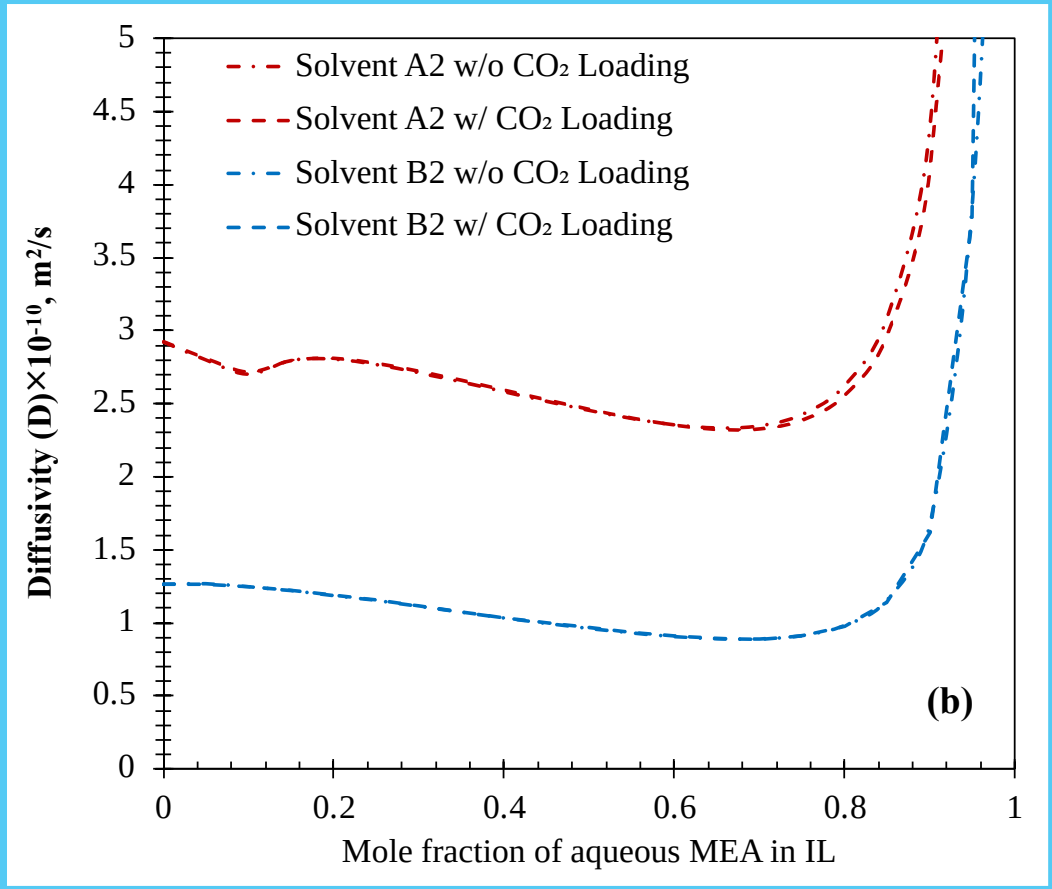
Solvent A: [P2228][2-CNPyr]
Solvent B: [P66614][2-CNPyr]

Carbon Capture per mole MEA



Absorber Temperature and Diffusivity





Next Steps

- **Complete Optimization**
- **Perform Lifecycle Assessment**