Aqueous Amine Absorption: Experimentation and Modeling

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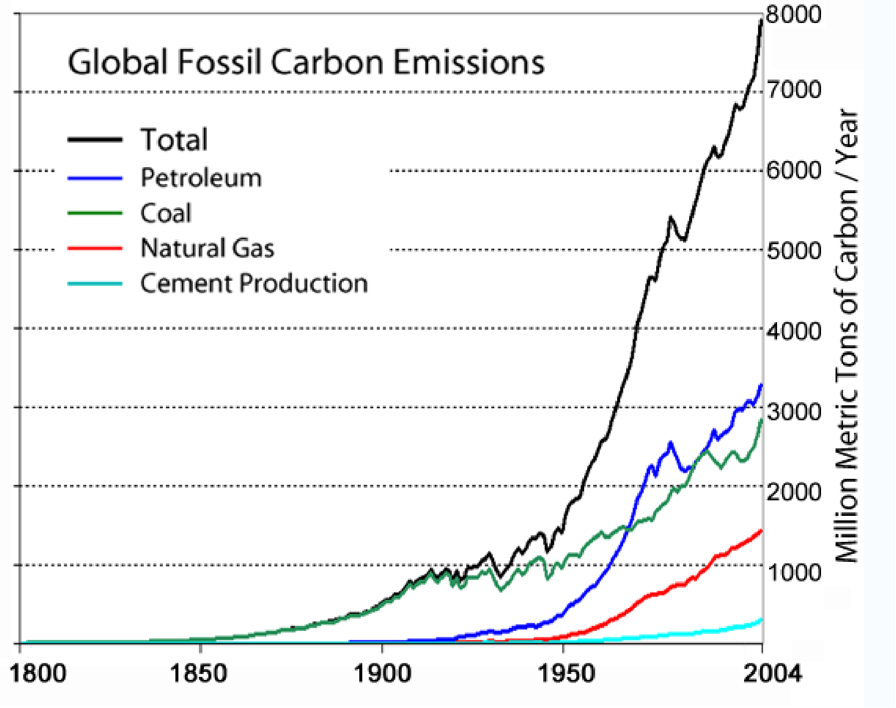
Motivation



Source: Energy Information Administration, 2005

- **Reduce CO_2 capture costs**
- **Flue gas units will dwarf acid gas treaters**
- **Precise sizing requires accurate mass transfer data**
- **No existing data for aged solvents**
- **Packing requires rate-based modeling**
- **Significant energy savings in the regenerator**

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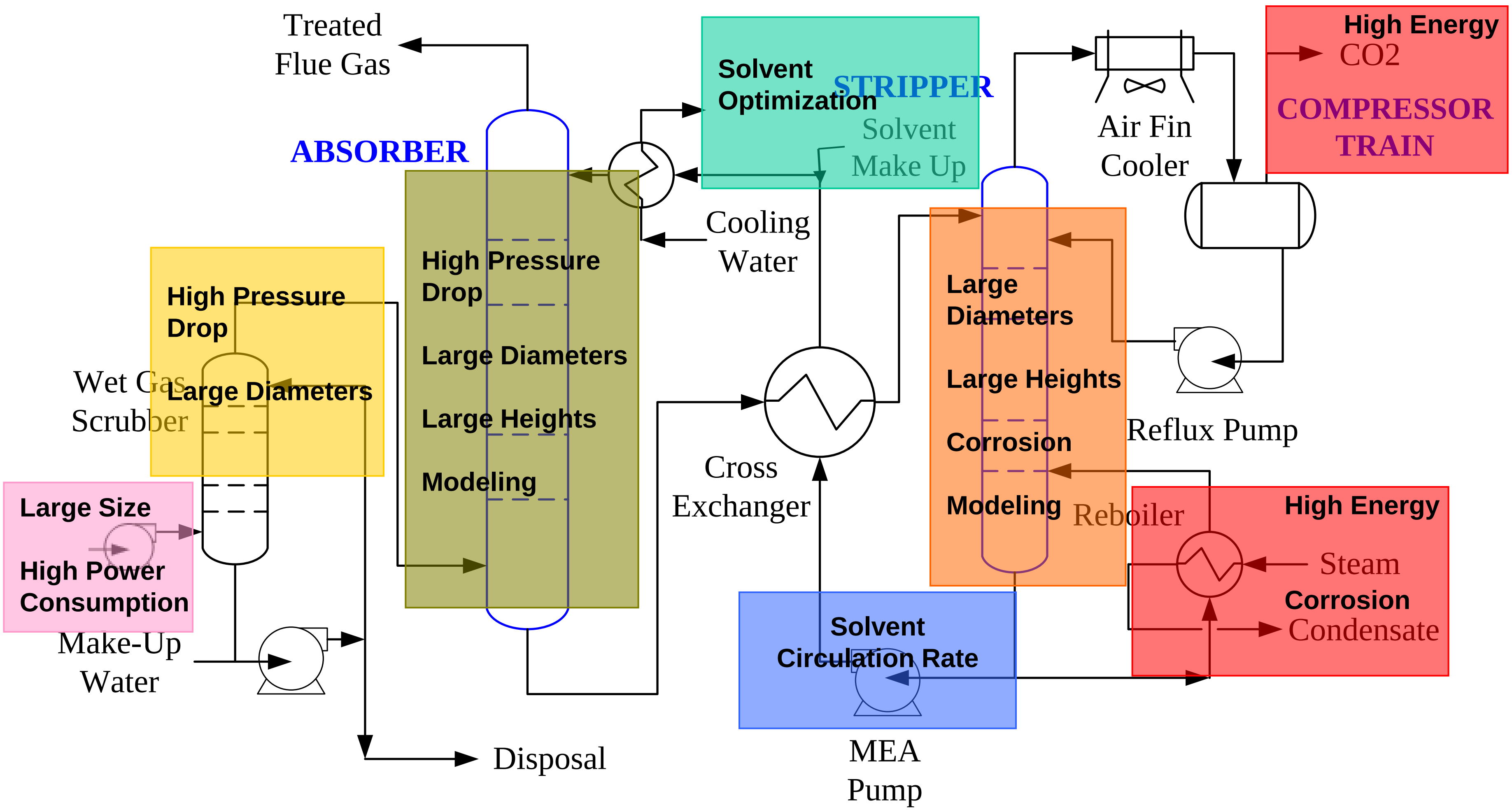
Aqueous Amine Absorption



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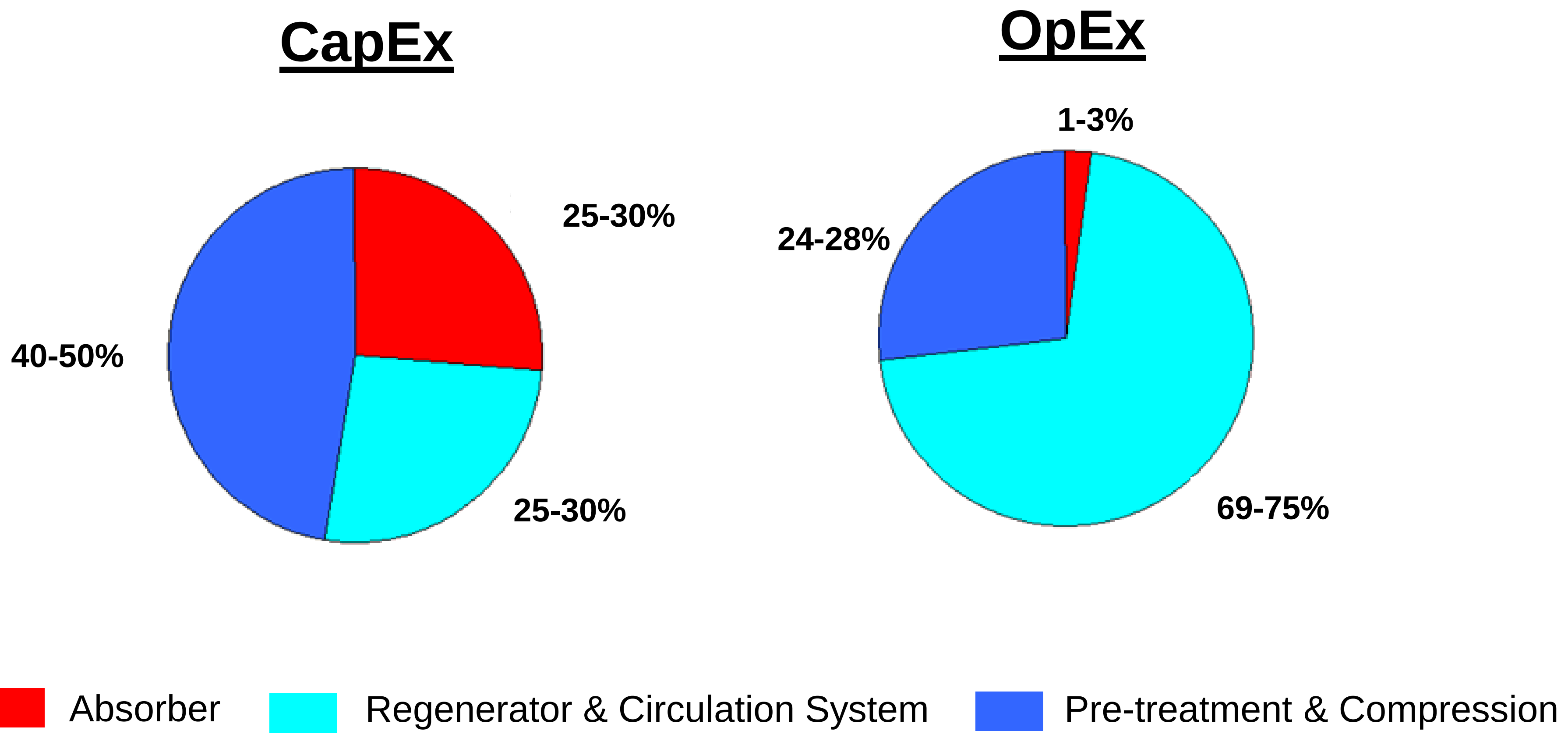
Capture Costs



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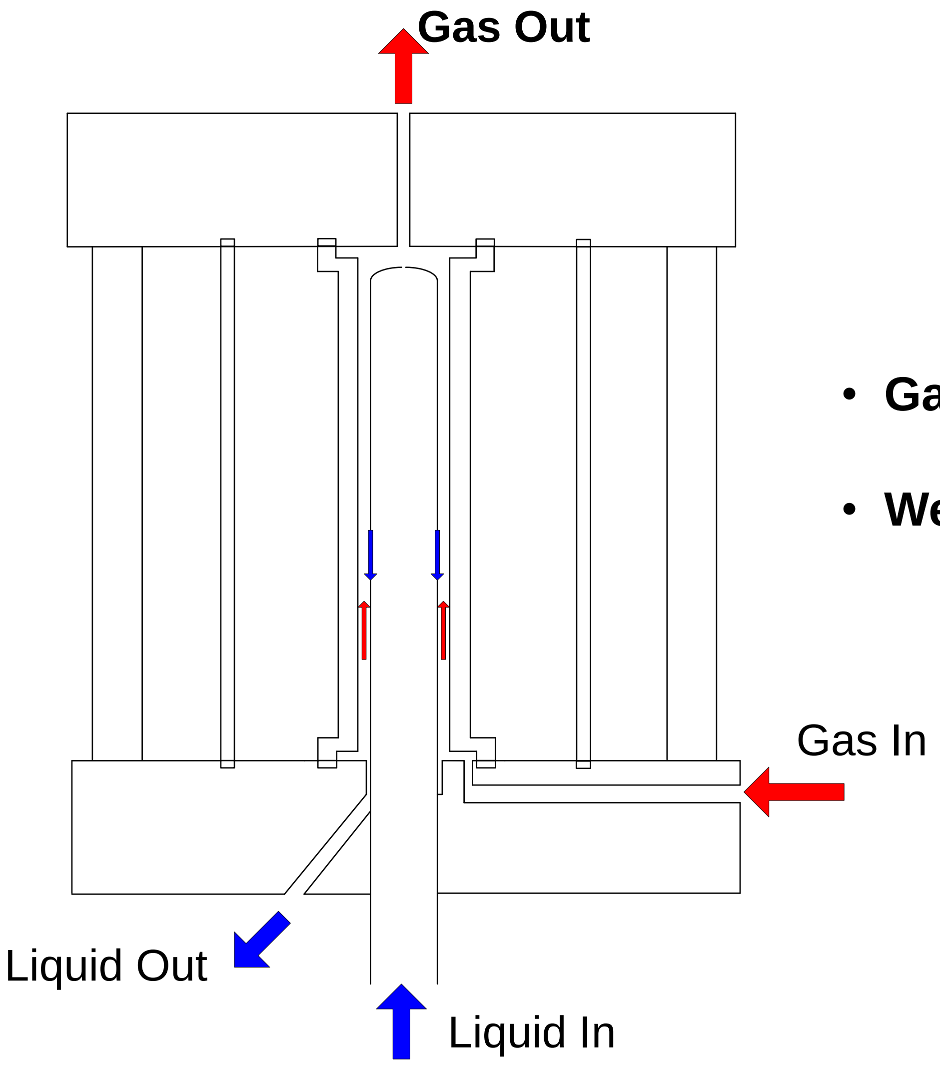
Wetted-Wall Column



- **Gas-liquid contactor**
- **Well defined surface area**

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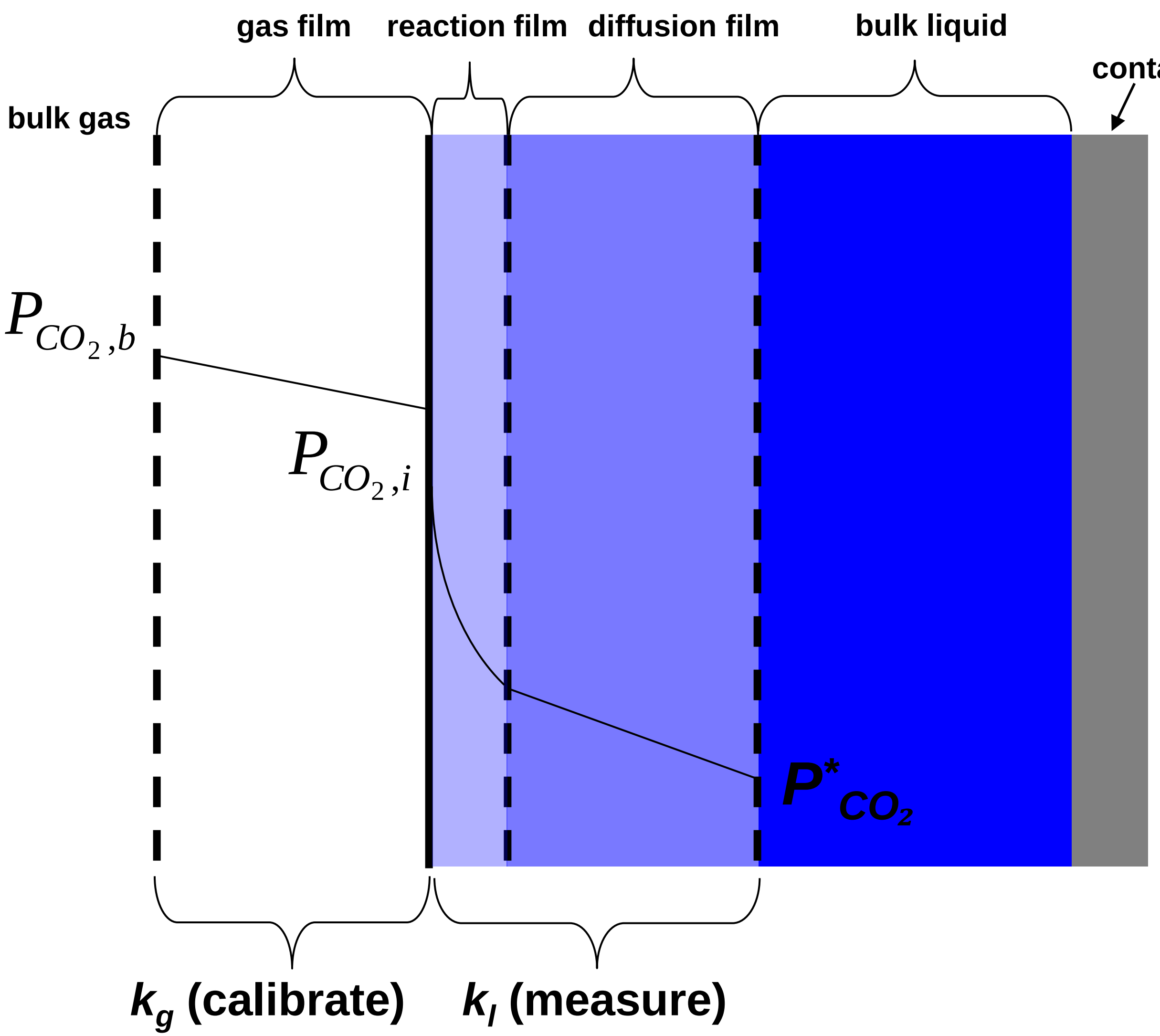
Mass Transfer with Chemical Reaction



$$N_{CO_2} = K_G\left(\Delta P\right)$$

$$\frac{1}{K_G} = \frac{1}{k_g} + \frac{1}{k_l}$$

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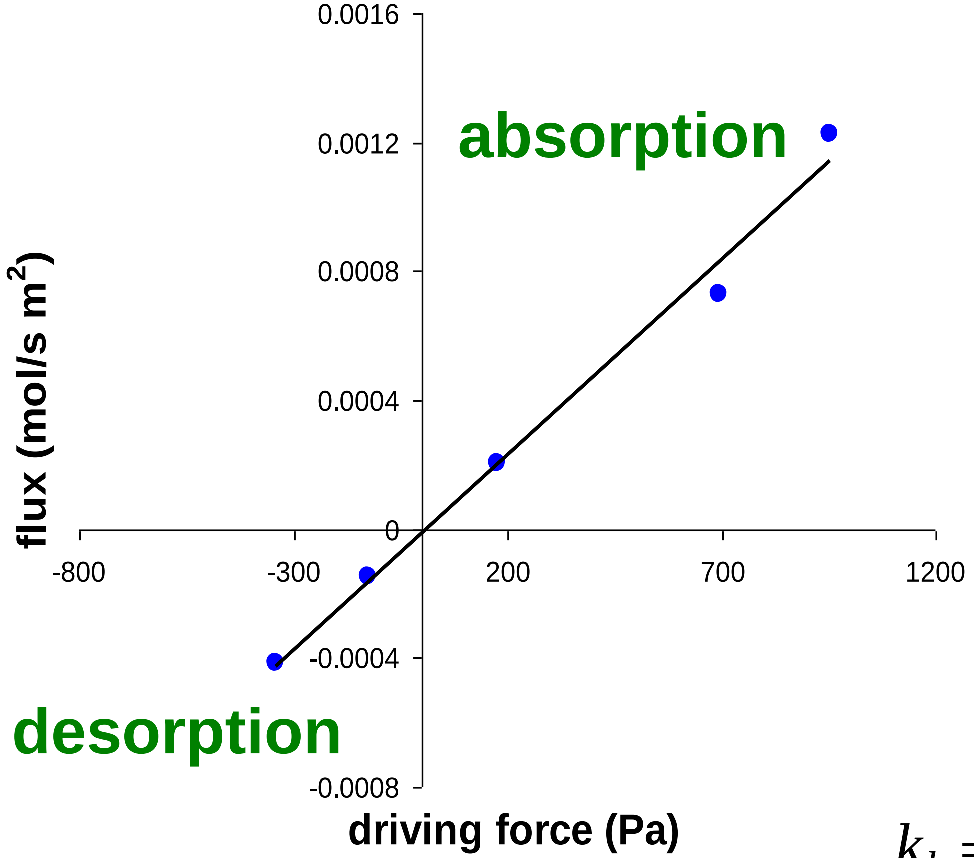
Experimental Technique



$$K_g = \frac{\text{flux}}{\text{driving force}}$$

$$k_l = \left(\frac{1}{K_g} - \frac{1}{k_g} \right)^{-1}$$

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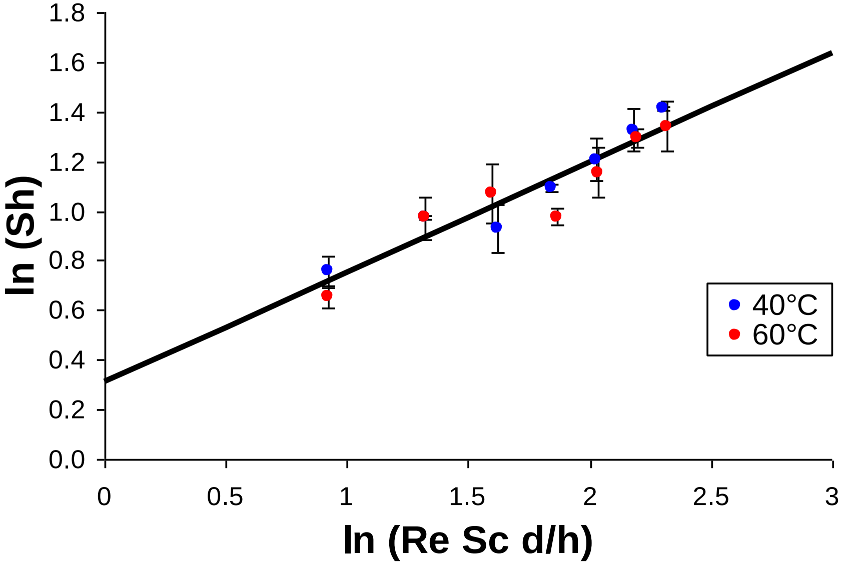
Gas Film Calibration and Benchmark



$$Sh = C\left(Re\ Sc\ \frac{d}{h}\right)^{\alpha}$$

$$k_g = 1.4\left[\frac{D_{CO_2}}{R\,T\,d}\right]\left[\frac{d^2\,u}{D_{CO_2}\,h}\right]^{0.44}$$

k_l (mol/sm^{2}Pa)

	30 wt% MEA, 0.351 loading	30 wt% MEA, 0.496 loading	14 wt% PZ, 0.352 loading
COP	$1.8 \times 10^{-6} \pm 6.6 \times 10^{-8}$	$4.1 \times 10^{-7} \pm 7.6 \times 10^{-8}$	$1.2 \times 10^{-6} \pm 1.1 \times 10^{-6}$
Published*	1.7×10^{-6}	3.8×10^{-7}	1.4×10^{-6}

*Dugas, R., G. Rochelle, "Absorption and desorption rates of carbon dioxide with monoethanolamine and piperazine," *Energy Procedia*, 1163-1169, 2009.

Aged Solvents

- Most designs based on fresh solvents

- Effect of degradation components unknown

k_l fresh (mol/s m^2 Pa)	k_l aged (mol/s m^2 Pa)
3.7×10^{-6}	3.1×10^{-6}

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Modeling Results

- Non-equilibrium, Aspen Hysys model
- Model compares favorably to literature (30 wt.% MEA)

	COP	Published*
CO_2 Capture (%)	90.1	90.1
Regen. Energy (MJ/kg CO_2)	13.8	15.9
Solvent Circulation (L/s)	2638.9	2639.4
Absorber Packing Height (m)	15.0	15.0
Regenerator Packing Height (m)	10.0	10.0
Lean CO_2 Loading (mol CO_2/mol alk.)	0.28	0.25
Rich CO_2 Loading (mol CO_2/mol alk.)	0.48	0.46

*Fisher, K.S., G. Rochelle, "Integrating MEA Regeneration with CO_2 Compression and Peaking to Reduce CO_2 Capture Costs," DOE/NETL report, 2005.

Conclusions and Future Work

- Accurate experimental data required for proper design of CO_2 capture systems
- Kinetic information of aged systems needed to predict real performance
- Incorporate kinetic data into rate-based models

Acknowledgements

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Questions?