Amino Acid Solvents for CO_2 Absorption

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Abstract

Amino acid solvents were tested for CO_2 capture performances at optimized absorber conditions. The solvents are: 6 m potassium glycine (GlyK), 6.5 m potassium β-alanine (β-AlaK), 3 m / 5 m potassium taurine / homotaurine (TauK/HtauK), 6 m potassium sarcosine (SarK), and 4.5 m sodium sarcosine (SarNa). A Wetted Wall Column (WWC) was used to measured the absorption/desorption rates and CO_2 solubility of each solvent at variable CO_2 loadings and temperatures (40°C, 60°C, 80°C, 100°C). Solvents are analyzed at coal fired power plant flue gas conditions and gas turbine combined cycle (GTCC) plant conditions. The operation lean/rich CO_2 loading is assumed to correspond to CO_2 equilibrium partial pressures of 500 Pa/ 5000 Pa for coal, and 100 Pa / 1000 Pa for GTCC. The absorption/desorption rates, cyclic capacity, and heat of CO_2 absorption are reported for each solvent at both conditions and compared against 7 m monoethanolamine (MEA). All amino acid solvents have low capacities at 0.2-0.3 mol CO_2/mol alkalinity, which is 50% of 7 m MEA. The absorption rate of 6 m SarK is competitive against 7 m MEA. 3 m / 5 m TauK /HtauK has an attractive high heat of absorption at 80 kJ/mol. The performances of amino acids are not competitive against amines for CO_2 capture from coal power plants. However, amino acids have physical properties and absorption characteristics which are advantageous at GTCC flue gas conditions.

Experimental Methods and Results

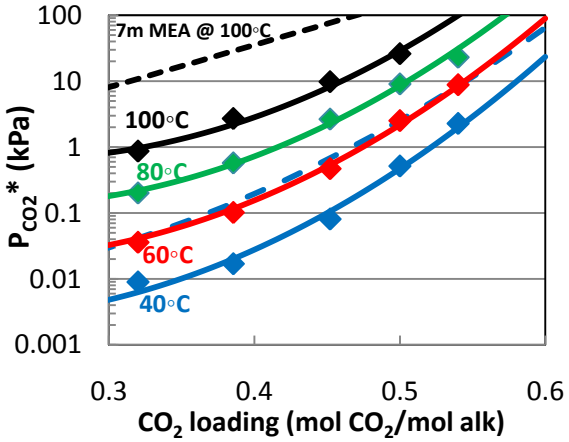

Figure 1: CO_2 solubility in 6.5 m β-alaK. Filled points: measured data. Solid lines: model prediction (Eq.1). Dashed lines: 7 m MEA model, Ref [2].

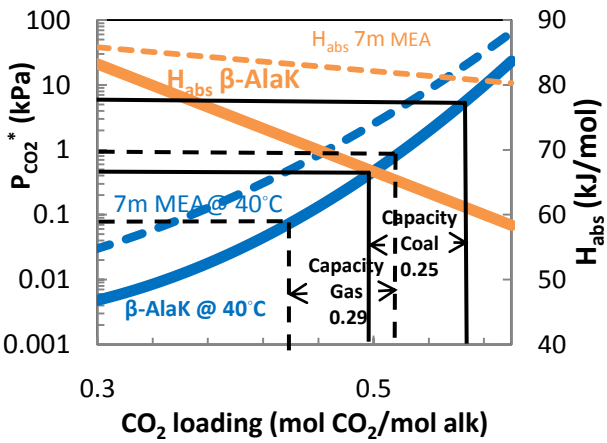

Figure 2: Cyclic capacity and heat of CO_2 absorption anlaysis for 6.5 m β-alaK. Dashed lines: 7 m MEA model. Ref [2].

Experimental data were collected using a WWC, the same as the apparatus and method used by Chen [1] and Dugas [2]. The absorption/desorption rates are reported using liquid film mass transfer coefficients (k_g'). A semi-empirical VLE model (Equation 1) is used to model experimental data and represent solvent CO_2 solubility (Figure 1).

$$P^*_{CO_2} = a + b/T + c \cdot \alpha + d \cdot \alpha / T + e \cdot \alpha^2 \quad (1)$$

This model is used to calculate solvent capacity and heat of CO_2 absorption (Figure 2). The measured absorption rates are compared against 7 m MEA and 8 m PZ (Figure 3). The heat of CO2 absorptions are predicted for both coal and GTCC conditions (Figure 4).

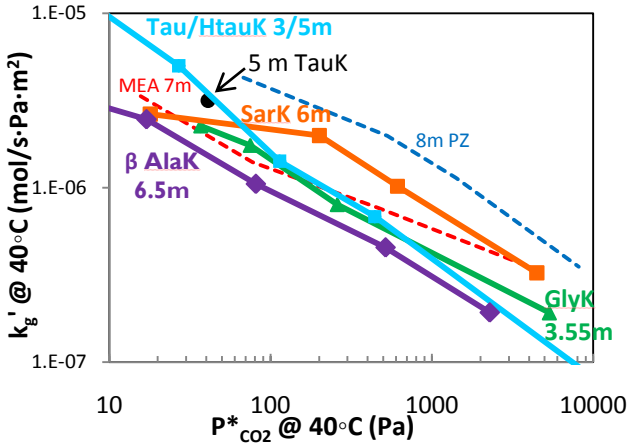

Figure 3: Measured absorption rates of amino acid solvents. Filled points: measured data. Dashed lines: 7 m MEA (red) and 8 m PZ (blue) results, Ref [2].

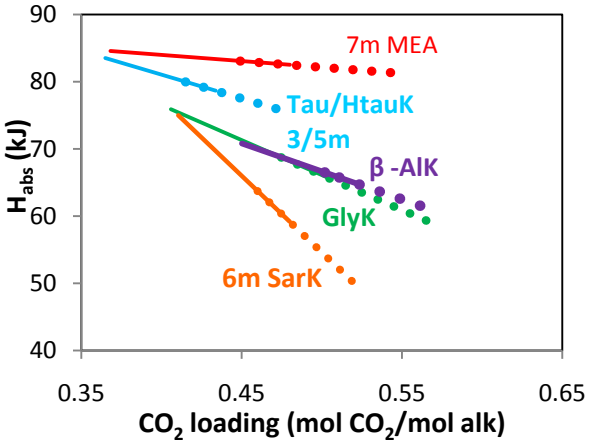

Figure 4: Heat of CO_2 absorption predicted using regressed VLE model (Eq.1). Solid lines: coal operation range. Dotted lines: GTCC range. Red: 7 m MEA model, Ref [2].

Table 1: Absorption properties of tested amino acid solvents, compared against 7 m MEA [2].

Amino acid (m)	CO_2 Capacity (mol CO_2/kg Solution)		$k_g'_{avg}$ (@40°C) (x 10^{-7} mol CO_2/s Pa m^2)		Mid ΔH_{abs} (kJ/mol)	
					P^*_{CO2} =1.5kPa	P^*_{CO2} =0.5kPa
	Coal	Gas	Coal	Gas	Coal	Gas
GlyK (3.55)	0.25	0.25	3	10.2	64	69
GlyK (6)	0.35*	0.35	0.2*	3.2	64*	
SarK (6)	0.22	0.236	5	18.9	56.5	64
Tau/Htau (3/5)	0.195*	0.23	2.2*	10.3	74.5*	80
β AlaK (6.5)	0.25*	0.29	2*	7.4	64*	67
MEA (7)	0.47	0.55	4.3	11.7	82	83

* Calculated theoretical values, since solid precipitation was observed in the operation range

References

[1] Chen X, Closmann F, Rochelle GT. "Accurate screening of amines by the wetted wall column". *GHGT 10*. Amsterdam, Netherlands. 18-21 September, 2010.

[2] Dugas R, Rochelle G. Absorption and desorption rates of carbon dioxide with monoethanolamine and piperazine. Energy Procedia 2009; 1(1): 1163-1169.