1st Post Combustion Capture Conference

Amino Acid Solvents for CO_2 Absorption

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Abstract

Amino acid solvents were tested for CO_2 capture performance 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 alk, 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.

*Key words:*Amino acid; Solvent screening; Natural gas; Absorption/desorption rates; Cyclic capacity; Heat of CO_2 absorption

1. Introduction

Amino acid solvents are attractive for post combustion CO_2 absorption because of their low environmental impact, with characteristics such as zero volatility, low ecotoxicity, and high biodegradability [1]. To absorb CO_2, amino acids must be activated in water with the addition of an equi-molar amount of base. In the presence of added base, the amino group on the amino acid reacts with CO_2 like amines [2,3]. Potassium (K^+) was used as the base in four tested solvents: 6 m SarK, 6.5 β-AlaK, 6 m GlyK, and 3 m/5 m TauK/HtauK; sodium (Na^+) was used for 4.5 m SarNa. Many amino acid solvents precipitate with CO_2 loadings [4,5]. As aqueous solvents, this physical property limits solvent cyclic capacity and the potential for flexible operation at rich loadings.

Typical coal fired power plants generate flue gas with 12% CO_2 and 5-8% O_2. GTCC plants with similar power capacity generate flue gas with 3% CO_2, 15% O_2, and twice the molar flow rate of coal flue gas. These differences in flue gas properties results in changes in solvent performance. When used for GTCC, desirable solvent properties include: stability towards oxidative degradation, good absorption performance at lean CO_2 loadings, and low volatility.

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2. Experimental Method and Data Analysis

Experimental data were collected using a WWC, the same as the apparatus and method used by Chen [6] and Dugas [7]. 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).

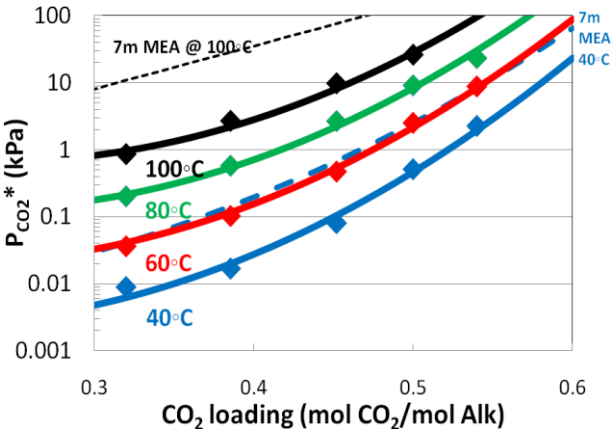

Figure 1: CO_2 solubility in 6.5 m β-alaK. Filled points: measured data. Solid lines: model prediction (Eq.1). Dashed lines: 7 m MEA model, Ref [6]

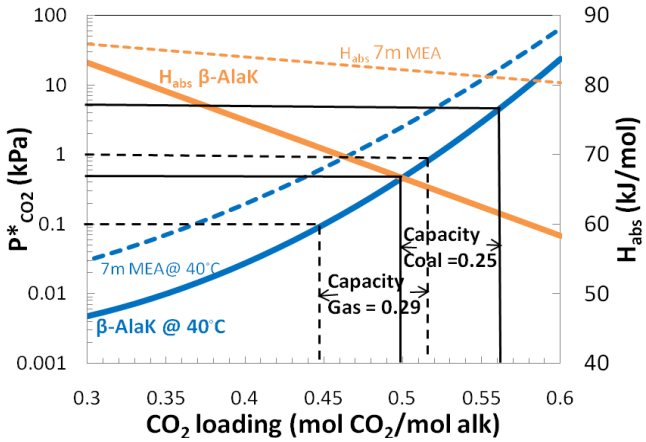

Figure 2: Cyclic capacity and heat of CO_2 absorption anlaysis for 6.5 m β-alaK

3. Results

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

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

4. References

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