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Calorimetric Studies of Precipitating Solvent System

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Abstract

Calorimetric study of a precipitating solvent system of Potassium-Taurate (KTAU) was performed in the CPA202 calorimeter. Two different experiments were conducted, i.e. heat of absorption of CO₂ in KTAU solvent at different conditions (concentration = 1.5 M and 3.0 M), loading up to ~ 0.8 mol CO₂/ mol Taurine and temperature = 25°C, 40°C, 80°C). Moreover, dissolution heats of Taurine/solid were also measured. The result agrees well with the reported data. The procedure developed for the heat of dissolution measurements was verified by measuring heat of dissolution of solid Taurine in water and comparing results with data in literature. The solid formation occurs during the absorption of CO₂ in 3.0M KTAU at low temperatures (25°C and 40°C) and at loadings (~ 0.3 mol CO₂/ mol Taurine). The heat of dissolution of the formed solid in pure water is slightly higher than that of Taurine in pure water but less heat is required to dissolve the same solids in unloaded 3.0 M KTAU solution.

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1. Introduction

Neutralized amino acid salts could be an attractive alternative to alkanolamines as solvents for CO₂ absorption, due to comparable reactivity and absorption capacity [1-3], better resistance to degradation, negligible volatility and higher surface tension [1] and also a favorable pK_a value [4].

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An amino acid molecule can contain primary or secondary amino-groups, which react with CO₂ similarly to alkanolamines. The main products are carbamate (R1) and bicarbonate (R2).



Solid formations might be observed during the CO₂ absorption with amino-acid salts solutions under certain range of concentrations, temperatures and pH of solutions [1]. Depending on amino acid and process conditions, the solid product may be a neutralized salt of amino acid, amino acid itself, bicarbonate of amino acid or metal bicarbonate. In a standard absorption-desorption process, the solid formation could be a big challenge in the operation but under specific circumstances can turn as advantages to the process, for instance leading to higher CO₂ capacity.

Fernandez et al. [5, 6] have made a conceptual process development by comparing non-precipitating and precipitating systems and reported that the precipitating solvent gave significant reductions in the energy consumption, - 35% compared to a conventional process based on 5M MEA. The energy consumption was estimated based on experimental VLE data. The Van Hoff equation was used to derive the heat absorption of CO₂ into solutions from the VLE correlation. An additional heating source in the form of low quality steam to re-dissolve the solid was also reported to account for about 10 % of the energy requirement. Neither heat of absorption nor heat of dissolution of the solid was measured.

This work aims to provide the experimental data on a calorimetric measurement for both the heat of absorptions of CO₂ into a neutralized amino acid salt solution and the heat of dissolution of formed solid in the solution. Provided experimental data could be used to improve the existing thermodynamic model and to provide a better estimate of energy requirement.

Nomenclature

| | |
|------------------|---|
| Am | Alkanolamine |
| FS | Full Scale |
| M | Molarity (mol/L) |
| MEA | Monoethanolamine |
| R | Reaction |
| SS | Stainless Steel |
| VLE | Vapour Liquid Equilibrium |
| H _{Abs} | Heat of Absorption |
| H _s | Heat of Dissolution |
| α | Loading (mol CO ₂ / mol Amine) |

2. Experimental and Methods

2.1. Chemicals

The purchased chemicals were used as received without further purification. Aqueous solutions were prepared by dissolving the chemicals (Table 1) in the distilled de-ionized water until 1 L of final solution is obtained. The purity of KOH was taken into account during the solvent preparation and assuming the rest is water.

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