Analysis of CO₂ solubility and absorption heat into aqueous 1-Diethylamino-2-propanol

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Abstract

As the global warming becomes one of the issues of greatest concern, CO₂ was considered as a major greenhouse gas which make a most contribution to the global warming.[1] Therefore, the research on decrease of the emission of CO₂ is becoming more and more urgent. CO₂ capture is considered as one of most effective method to reduce the CO₂ emission. The absorption using the aqueous solutions of alkanolamines is the most widely used technology for capturing CO₂ from the gas streams in industrial processes due to its characteristics of mature technique, good economic effectiveness, and ability to deal with large scales of streams.[2] However, one of the most sticking point for this technique is using a high-performance absorbent, which should meet the basic requirements, such as large absorption capacity, fast reaction kinetics, good solvent stability, and energy efficiency for the regeneration[3]. As the previous study,[4] DEAB exhibited a high CO₂ absorption capacity, a fast reaction kinetics, and a fast mass transfer. A new tertiary amine, 1-diethylamino-2-propanol (1DEA2P), has the extremely similar structure as DEAB. Thus, 1DEA2P could show a good performance on CO₂ capture as 1DEA2P.

However, there are very few articles providing detailed information and no further research about the CO₂ capture performance of 1DEA2P, such as solubility, reacting kinetics, heats of reaction, mass transfer. Before being used for commercial application, those characteristics should be comprehensively figured out. Besides, the reliable vapor-liquid equilibrium (VLE) data is another essential considerable parameter, since it can provide quantitative information on the CO₂ absorption, kinetics behavior and mass transfer.
In this present work, the performances of CO2 absorption into aqueous 1DEA2P solution were comprehensively investigated in the terms of the CO2 equilibrium solubility, the reaction kinetics and the absorption heat. The CO2 equilibrium solubility in 2M 1DEA2P solution were studied, which was shown in Figure 1. In order to predict the CO2 solubility of 1DEA2P solution, several models (i.e. The Kent-Eisenbery, Austgen, Li-Shen and Hu-Chakma) were used to represent the equilibrium solubility of CO2 in 1DMA2P solution. The CO2 absorption heat for 1DEA2P was also determined on basis of the Gibbs Helmholtz equation as follow:

\[ \frac{d \left( \ln P_{CO2} \right)}{d \left( \frac{1}{T} \right)} = \frac{\Delta H_a}{R} \]  

(1)

In addition, ion (1DEA2P, 1DEA2PH+, HCO3−, CO32−) concentrations in 1DEA2P-H2O-CO2 system were obtained at the temperatures of 298K in order to develop the ion speciation plots. All the result were shown in Figure 2. As 1DEA2P is a novel amine, it was reasonable to compare its performance on CO2 capture with conventional amines (i.e. MEA, DEA and MDEA) and other alternative amines (i.e. 1DMA2P and DEAB). The CO2 equilibrium solubility of MEA, DEA, MDEA, AMP, 2M DEAB, 1DMA2P and 1DEA2P in 2M solution were presented in the Figure 3.

**Figure 1.** CO2 equilibrium solubility of in 2M aqueous 1DEA2P solution at 298, 313, and 333 K.

**Figure 2.** Ion speciation (concentration) plots in the system of 1DEA2P-H2O-CO2 at the temperature of 298K and 1DEA2P concentration of 1.0 mol/L.
Figure 3. CO₂ equilibrium solubility in aqueous solutions of 2M MEA, 2M DEA, 2M AMP, 2M MDEA, 2M DEAB, 2M 1DMA2P, and 2M 1DEA2P.

References


