The chemical reaction kinetics study for the absorption of carbon dioxide into the aqueous diethylethanolamine/diethylenetriamine solutions

Jaan Jeng Hsu and Meng-Hui Li

R&D Center for Membrane Technology and Department of Chemical Engineering Chung Yuan Christian University Chung Li 32023, Taiwan, ROC mhli@cycu.edu.tw (M.-H. Li)

1. Introduction –Alkanolamines and their blends are most widely used in the natural gas industry, oil refineries, petroleum chemical plants, and synthetic ammonia plants for the removal of acidic components, such as CO2 and H2S, from gas streams[1]. Different solvent systems are still undergoing development as the search for better performance in high CO2 loading, the fast absorption rate and the less environmental impact [24]. The diethylethanolamine (DEEA) has been shown to has a higher carbon dioxide solubility and a lower absorption heat than those of monoethanolamine (MEA) and N-methyldiethanolamine MDEA[5]. Also polyamines have more than one amine functionalities which allow high absorption capacity and fast reaction kinetics compared to solvents with a single amine group [2, 6]. In this study, blended amines containing the tertiary alkanolamines DEEA and a polyamine DETA are considered as an potential CO2 absorbent. Thus, the reaction kinetics of absorption of CO2 into the aqueous diethylethanolamine (DEEA) + diethylenetriamine (DETA) solutions was studied using a wetted wall column apparatus. The density, viscosity, Henry's constant and diffusivity coefficient of CO2 in the aqueous amine solutions at different temperature were also measured. The reaction rate constants were determined from the measured specific absorption rate data. The results of the present study are in general with the accuracy in the carbon dioxide absorption process design calculations using aqueous DEEA + DETA solutions as the CO2 absorbents. 2. Experimental - A short wetted-wall column was used to measure the measure the CO2 absorption rate. Figure 1 shows the wetted-wall column for measuring the CO2 absorption specific rate. 3. Results and Discussion - The reaction rate constants were determined from the measured specific absorption rate data using the pseudo-first order reaction mechanism for the reaction of CO2 with DEEA and the zwitterion mechanism for CO2 with DETA. 4. Conclusions - The results of this study can be used for CO2 absorption process design calculatons using aqueous DEEA + DETA solutions as the CO2 absorbent. 5. References [1] A. L. Kohl, and R. B. Neilsen, Gas purification, 5th ed., Houston, USA: Gulf Publishing Co., 1997. [2] S. Ma'mun, H. F. Svendsen, K. A. Hoff, and O. Juliussen, "Selection of new absorbents for carbon dioxide capture," Energy Convers. Manage, vol. 48, no. 1, pp. 251–258, 2007. [3] S.-H. Wu, A. R. Caparanga, R. B. Leron, and M.-H. LI, "Vapor pressures of aqueous blendedamine solutions containing (TEA/AMP/MDEA) + (DEA/MEA/PZ) at temperatures (313.15343.15) K," Experimental Thermal and Fluid Science, vol. 48, pp. 1-7, 2013. [4] Y.-H. Hsu, R. B. Leron, and M.-H. Li, "Solubility of carbon dioxide in aqueous mixtures of (reline + monoethanolamine) at T = (313.2 to 352,2) K," J. Chem. Thermodynamics, vol. 72, pp. 94-99, 2014. [5] J. G. M. S. Monteiro, H. Knuutila, N. J. M. C. P.-v. Elk, G. Versteeg, and H. F. Svendsen, " Kinetics of CO2 absorption by aqueous N,N-diethylethanolamine solutions: Literature review, experimental results and modelling," Chem. Eng. Sci., vol. 127, pp. 1-12, 2015. [6] A. Hartono, E. F. da Silva, H. Grasdalen, and H. F. Svendsen, "Qualitative determination of species in DETA-H2O-CO2 system using. 13C NMR spectra," Industrial & engineering chemistry research, vol. 46, no. 1, pp. 249–254, 2007.