Heat of reaction for CO_2 absorption using aqueous K_2CO_3 solution with homopiperazine

Sungjun Moon, Sungyoul Pak, Sungchan Nam and Yeoil Yoon*

Korea Institute of Energy Research, Daejeon 305-343, Korea
*(21yoon@kier.re.kr)

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Abstract

Carbon dioxide (CO_2) is emitted from the consumption of fossil fuels and CO_2 emission is directly caused by the phenomenon of global warming. Coal-fired power plant is considered as a major source of CO_2 emission and it takes about 32~40 % of the total emission. The separation and capture of CO_2 from power plant is gaining interest as a method to reduce greenhouse gas emissions. Various methods for CO_2 separation and capture are having been developed, and some commercialized technologies for post-combustion having been applied to natural gas industry for 60 years. However, the technical improvements, such as high CO_2 loading and low generation energy should be achieved. Reaction heat can be explained by the summation of sensible heat, evaporation heat and heat of CO_2 absorption reaction. Since the heat of absorption reaction is considered as the energy needed to desorb CO_2 from rich absorbent. The CO_2 desorption energy and binding energy of each solvent have almost the same value. As for the heat of reaction, the enthalpy of the standard state($\Delta H°$, heat of reaction) was obtained by calculating the heat of reaction generated per one mole of CO_2.

In this work, the heat of reaction between absorbent and CO_2 was measured using differential reaction calorimeter (DRC, SETARAM Co. Ltd.) for comparing with generation efficiency of absorbent at higher than atmospheric pressure and refers to the entire quantity of heat generated from reactions between solvents and CO_2. In order to

measure the total amount of CO_2 dissolved in solution, CO_2 consumption were analyzed by gas chromatography (GC). Aqueous absorbents were tested with more commonly used material, such as Monoethanolamine (MEA) and Potassium carbonate (K_2CO_3). Homopiperazine is used as a promoter of K_2CO_3 solution to prevent crystalline formation and increase absorption capacity of K_2CO_3 absorbent. The experimental results are compared with heat of reaction and values derived from solubility measurements. In solubility of CO_2, the CO_2 loading capacity (mol-CO_2/mol-solvent) of MEA and K_2CO_3 + homopiperazine are shown approximately 0.5 and 0.73 at 313K. Also, in our experiment the reaction heat of K_2CO_3 + homopiperazine was shown to be lower than MEA solution. On the other hand, homopiperazine was shown to have the highest loading capacity and heat of reaction. Therefore, K_2CO_3 + homopiperazine is to be more favorable in the case of MEA. The results will be presented to comparison with MEA and an interpretation of the behavior of the K_2CO_3 + homopiperazine. The experimental results are compared with respect to heat of reaction and values derived from CO_2 loading capacity.

Table 1. Overall heat of reaction of various absorbents at 313K.

Absorbent	Loading (mol CO_2/mol solvent)	-Δh (kJ / mol CO2)	-Δh (kJ / g $_{CO2}$)
MEA 30 wt%	0.54	82.38	1.87
MDEA 30 wt%	0.59	44.65	1.01
K_2CO_3 15 wt%	0.79	27.81	0.63
HomoPZ 10 wt%	1.04	94.58	2.15
K_2CO_3 15 wt% + HomoPZ 10 wt%	0.73	70.77	1.61