Absorption capacity for CO_2 capture process using DEAE-AMP aqueous solution

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Abstract: The absorption capacity of CO_2 in DEAE –AMP aqueous solution was investigated at temperatures ranging from 303.2K to 323.2K. The mass fraction of DEAE and AMP respectively ranged from 0.3 to 0.4 and 0 to 0.15. On the basis of experimental measurement, the mass fraction and temperature dependences of the absorption capacity are illustrated.

1. Introduction

In the past decades, the level of carbon dioxide in atmosphere has become higher and higher due to the extensive use of fossil fuels. The environmental problems caused by CO_2 have become more and more serious. The reduction of CO_2 has become a hot issue[1,2]. The amine-based chemical absorption technologies are considered to be the most robust and promising methods for post-combustion CO_2 capture[3-5]. Traditional alkanolamines including monoethanolamine(MEA), diethanolamine(DEA), N-methyldiethanolamine(MDEA) and diisopropanolamine(DIPA) have been widely used in CO_2 capture process[6]. However, traditional alkanolamine aqueous solutions have some disadvantages like high corrosion and high energy cost of regeneration[7,8]. Blending amine solvents can preserve the good potentials of individual solvent. They have attracted more and more attention.

DEAE has good potential for the removal of CO_2 from gaseous streams and can be prepared from renewable resources. Many studies have been focused on the absorption capacity of CO_2 in DEAE. Maneeintr K et al. [9] measured the solubility of CO_2 in DEAE aqueous solution and the corresponding physical properties. Their results showed that DEAE provides better performance for CO_2 absorption than MEA. Fu et al. [10] studied the solubility and viscosity of MEA promoted DEAE aqueous solution at temperatures ranging from 303.2 to 323.2K. Adak S et al. [11] investigated the vapor-liquid equilibrium and physicochemical properties of novel aqueous blends of (2-Diethylaminoethanol + Piperazine) (DEAE-PZ) for CO_2 appropriation.

AMP is a space hindrance amine. It takes the advantage of fast kinetics, high mass transfer and low corrosion[12,13]. Dey A et al [14] studied the CO_2 absorption in MEA-AMP blends. Wai S K et al [15] investigated the solubility, absorption and desorption rates of CO_2 in AMP–DETA aqueous solution. AMP-DEAE aqueous solution is expected to be a new solvent for removing CO_2. However, experimental work concerning the solubility of CO_2 in DEAE-AMP aqueous solutions is relatively rare.

The main purpose of this work is to experimentally determine the solubility of CO_2 in DEAE-AMP aqueous solution and demonstrates the effect of temperature and mass fractions on the solubility. This work was studied at the temperatures from 303.2K to 323.2K. The mass fraction of DEAE and AMP respectively ranged from 0.30 to 0.40 and 0.00 to 0.15.

2. Experiment

2.1 Materials

Chemicals used in this work are detailed in Table 1. They were used without further purification. Aqueous solutions of DEAE-AMP were prepared by adding deionized water (Electrical resistivity >15 MΩ·cm at 298 K) obtained from the Heal Force ROE -100 apparatus. An analytical balance (Jingtian FA1604A) with an accuracy of 0.1 mg was used to weigh all required chemicals.

Table 1 sample description.

Chemical name	CAS No.	Purity (mole fraction, as stated by the supplier)	source
DEAE	110-37-8	≥99%	Shanghai Aladdin reagent company
AMP	124-68-5	≥95%	Shanghai Aladdin reagent company

2.2 Apparatus and Procedure

The experiment is carried out in a thermostat water bath. The equipment is composed of one high-pressure CO_2 tank, one mass flow controller (MFC), one mass flow meter (MFM), one absorption bottle, one constant temperature water bath, one desiccator and one CO_2 analyzer (Advanced Gasmitter by Germany Sensors Europe GmbH, the accuracy is ±2%). The absorption bottle was immersed into the thermostatic bath and the temperature of the solution can be regulated within 0.1 K. The equipment was designed to operate at atmospheric pressure.

CO_2 was inlet into the MFC to maintain a constant flow rate and then into the absorption bottle and absorbed by the solution. The residual and unabsorbed gas firstly flowed into the CO_2 analyzer and then into the mass MFM. The CO_2 concentration was measured by the CO_2 analyzer, and the flow rate was measured by the MFM. The data was recorded by a computer.

3. Results and discussion

The experimental results for the solubility of CO_2 in DEAE-AMP aqueous solutions are shown in Table 2.

Table 2. Solubility (m) of CO2 in DEAE-AMP aqueous solutions. Pressure (p) = 101 kPa.

ωDEAE	ωAMP	m/ (g CO_2/100g aqueous solution)		
		303.2K	313.2K	323.2K
0.30	0.00	9.98	9.77	9.21
	0.05	11.98	11.12	10.57
	0.10	13.12	12.41	12.18
	0.15	14.64	14.12	13.56
0.40	0.00	12.99	12.27	12.08
	0.05	14.58	14.19	12.99
	0.10	15.93	15.45	14.05
	0.15	17.04	16.42	15.18

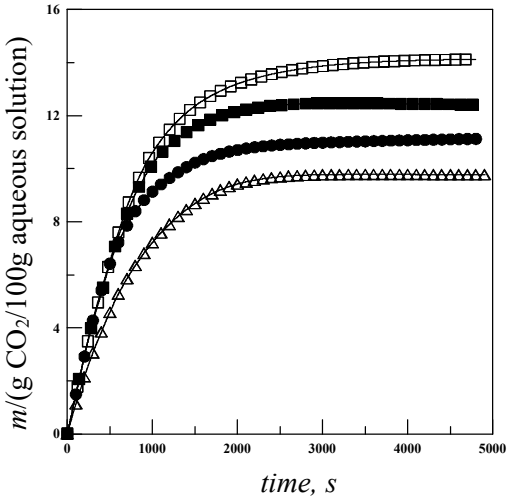

Figure 1. Effect of the mass fraction of AMP on the absorption capacity of CO2 in DEAE-AMP aqueous solutions. ω_{DEAE}=0.30. T=313.2K. Symbols: △ω_{AMP}=0; ●ω_{AMP}=0.05; ■ω_{AMP}=0.10; □ω_{AMP}=0.15. Lines: trend lines.

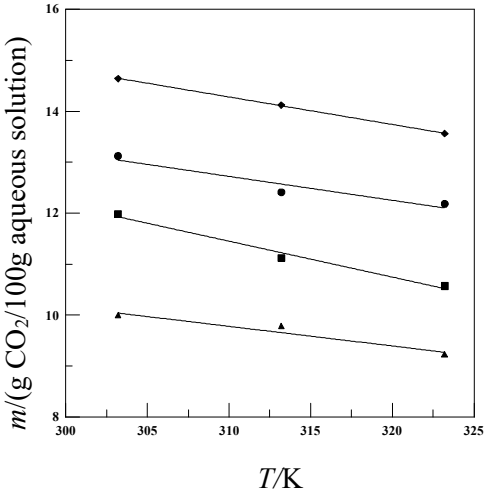

Figure 2. Effect of the temperature on the absorption capacity of CO2 in DEAE-AMP aqueous solutions. ω_{DEAE}=0.30. Symbols: ▲ω_{AMP}=0; ■ω_{AMP}=0.05; ●ω_{AMP}=0.10; ◆ω_{AMP}=0.15. Lines: trend lines.

Figure 1. shows the influence of ω_{AMP} on the absorption capacity of CO_2 in DEAE-AMP aqueous solutions. From this figure, one may find that at given temperature and given ω_{DEAE}, the absorption capacity increases with the increase of ω_{AMP}.

Figure 2. shows the influence of temperature on the absorption capacity of CO_2 in DEAE-AMP aqueous solutions. From this figure, one may find that at given ω_{DEAE} and given ω_{AMP}, the absorption capacity decreases with the increase of temperature.

4. Conclusions

In this work, the absorption of CO_2 in AMP promoted DEAE aqueous solutions was investigated at temperatures ranging from 303.2K to 323.2K. The effects of temperature and mass fractions of AMP on the absorption capacity were demonstrated. Our results show that:

(1) At given temperature and given ω_{DEAE}, the increase of ω_{AMP} tends to increase the absorption capacity of CO_2 in DEAE-AMP aqueous solution.

(2) The absorption capacity of CO_2 decreases with the increase of temperature at given ω_{AMP} and given ω_{DEAE} in DEAE-AMP aqueous solution.

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