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Solubility of Carbon Dioxide in Monoethanolamine + Ethylene Glycol + Water and Monoethanolamine + Poly(ethylene glycol) + Water at 333.2 K

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The solubility of carbon dioxide in monoethanolamine (MEA) + ethylene glycol (EG) + water and monoethanolamine (MEA) + poly(ethylene glycol) (PEG) + water has been measured at 333.2 K and at partial pressure ranges of carbon dioxide up to 2300 kPa. The concentrations of aqueous mixtures are 15.3 mass % MEA + 15.3 mass % EG, 15.3 mass % MEA + 42.3 mass % EG, 15.3 mass % MEA + 15.3 mass % PEG, and 15.3 mass % MEA + 42.3 mass % PEG. In each case, the solubility was represented as functions of partial pressures of carbon dioxide. At the same mass ratio, the carbon dioxide solubilities in the aqueous solutions at 333.2 K decreased when compared with those at 313.2 K.

Introduction

Aqueous alkanolamine solutions have been extensively used for the removal of acid gases in gas mixtures. Particularly, the removal of carbon dioxide by using chemical absorbents has been of great interest, since it was found that the global warming effect is primarily due to excessive discharge of carbon dioxide and methane. Aqueous monoethanolamine (MEA) solutions are the most frequently used chemical absorbents because of high reactivity to such chemicals as carbon dioxide. However, it is known that these solutions can also react with materials in reactor vessels, tubing lines, and several process compartments. For this reason, highly MEA-concentrated aqueous solutions should be avoided for the carbon dioxide removal process.

The use of mixed solutions of chemical and physical absorbents may have the potential of solving this problem. Several studies on the removal of acid gases by using aqueous alkanolamine solutions mixed with physical absorbents have been recently reported in the literature (Roberts and Mather, 1988; Woertz, 1972; Henni and Mather, 1995; Oyevaar et al., 1989). Also in our previous work (Song et al., 1996), we measured the solubility of carbon dioxide in aqueous MEA solutions mixed with ethylene glycol (EG) and poly(ethylene glycol) (PEG) as physical absorbents at 313.2 K. The temperature effect on the solubility was carefully checked in this study.

Experimental Section

Table 1. Solubility of Carbon Dioxide in 15.3 Mass % Aqueous MEA Solutions Mixed with EG and PEG at 333.2 K

P/kPa	α/(mol of CO_2/mol of MEA)	P/kPa	α/(mol of CO_2/mol α/MEA)
MEA 15.3 mass % + EG 15.3 mass %			
6.32	0.427	388.5	0.694
19.90	0.496	1443	0.818
98.01	0.571	2334	0.884
MEA 15.3 mass % + EG 42.3 mass %			
3.46	0.379	324.9	0.598
12.37	0.446	961.4	0.722
60.66	0.515	2195	0.806
MEA 15.3 mass % + PEG 15.3 mass %			
1.98	0.361	211.8	0.625
10.45	0.463	606.3	0.723
36.42	0.527	1244	0.809
108.3	0.585	2135	0.890
MEA 15.3 mass % + PEG 42.3 mass %			
6.12	0.389	270.4	0.594
25.77	0.459	993.9	0.691
95.01	0.530	2280	0.806

Apparatus and Procedure. Equilibrium apparatus and procedures of experiments are the same as those of our previous work (Song et al., 1996). The equilibrium pressure was measured by a Heise gauge (CM 118324, (0 to 500) psi range) with an accuracy of ±0.1% of the gauge range. The temperature in the cell was monitored by a K-type thermocouple with a digital thermometer (Cole-Parmer, 8535-26) within an accuracy of ±0.1 K. The vapor phase was analyzed by a gas chromatograph (Hewlett-Packard, 5890A) with a thermal conductivity detector (TCD) and a 6 ft by $^1/_8$ in. diameter column packed with Porapak Q. The temperatures of the oven, injector, and detector were 50, 90, and 120 °C, respectively. Most compartments of the equilibrium apparatus were kept in the air bath and controlled to ±0.1 K by a PID temperature controller. The equilibrium state was assumed when the system pressure and vapor phase composition did not change for 4 h. The analysis of liquid samples was

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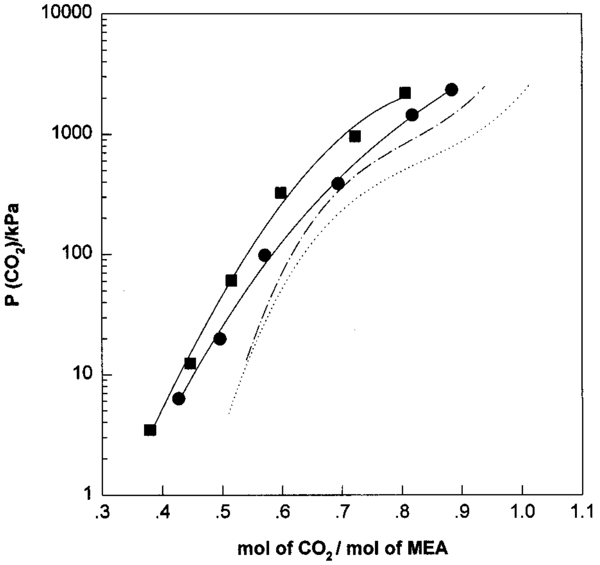

Figure 1. Solubility of carbon dioxide in MEA + EG + water system at 333.2 K: (●) 15.3 mass % MEA + 15.3 mass % EG; (■) 15.3 mass % MEA + 42.3 mass % EG; (···) 15.3 mass % MEA + 15.3 mass % EG at 313.2 K (Song et al., 1996); (– • –) 15.3 mass % MEA + 42.3 mass % EG at 313.2 K (Song et al., 1996).

performed by the same method of our previous study (Song et al., 1996).

Materials. The solvents and absorbents used in this study were purchased from Sigma-Aldrich Chemical Co. with a minimum purity of 99 mol % and were used without further purification. A PEG of molecular weight 400 was used. All solutions were prepared with distilled water. The carbon dioxide and nitrogen gases provided were of a commercial grade with a purity of 99.5 mol %.

Results and Discussion

The reliability for apparatus and experimental procedures was proved in our previous work, so the detailed test for them was omitted. The solubilities of carbon dioxide in aqueous MEA + EG and MEA + PEG solutions have been measured at 333.2 K. The overall results are summarized in Table 1 and plotted in Figures 1 and 2. The solubility of carbon dioxide at fixed carbon dioxide partial pressure gradually decreases at higher EG and PEG mass fractions. When compared with our previous study, the

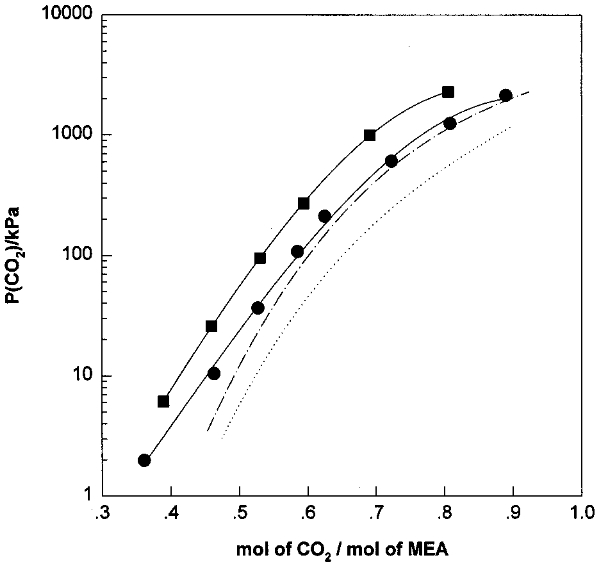

Figure 2. Solubility of carbon dioxide in MEA + PEG + water system at 333.2 K: (●) 15.3 mass % MEA + 15.3 mass % PEG; (■) 15.3 mass % MEA + 42.3 mass % PEG; (···) 15.3 mass % MEA + 15.3 mass % PEG at 313.2 K (Song et al., 1996); (– • –) 15.3 mass % MEA + 42.3 mass % PEG at 313.2 K (Song et al., 1996).

loading capacities of all systems decreased with increasing temperature.

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