Diffusivity of Nitrous Oxide in *N*-Methyldiethanolamine + Diethanolamine + Water

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The diffusion coefficients for nitrous oxide in aqueous solutions consisting of *N*-methyldiethanolamine (MDEA) and diethanolamine (DEA) were measured over the temperature range 293–353 K for a total amine concentration of 50 mass % and for the mass ratio of DEA to MDEA varying from 0.0441 to 0.588. The experimental diffusion coefficients were found to be relatively insensitive to the mass ratio of amines.

Introduction

The tertiary amine *N*-methyldiethanolamine (MDEA) and the secondary amine diethanolamine (DEA) are commonly used in the gas-treating industry as chemical solvents for the removal of acid gases such as CO_2 and H_2S. Recently, blended aqueous solutions of these two amines have found application for selective absorption of H_2S in the presence of CO_2. The diffusion coefficients of all species in the liquid phase are important parameters required for modeling the mass transfer process.

The diffusion coefficient cannot be measured directly since CO_2 undergoes a chemical reaction with both amines. It is customary to use the "N_2O analogy" proposed by Clarke (*1*) to infer the diffusivity of CO_2 in aqueous amine solutions. To implement this method, it is necessary to know the diffusion coefficient of N_2O in the solution for which it is desired to predict the CO_2 diffusivity. In this paper, we report our measurements of the diffusion coefficients for N_2O in aqueous amine solutions consisting of MDEA and DEA. The total amine concentration was held constant at 50 mass %, and the DEA/MDEA mass ratio was varied from 0.0441 to 0.5883. The temperature for these measurements varied from 293 to 353 K.

Experimental Section

A wetted-sphere apparatus was used in this research. The method consists of measuring the rate of N_2O absorption into an amine solution flowing in laminar flow over a sphere. A theoretical solution for this physical absorption process given by Olbrich and Wild (*2*) is used to interpret the absorption rate data to determine the N_2O diffusion coefficient. A description of the experimental setup and procedure used together with the data reduction methodology has been given in detail in a previous paper (*3*). The solubility values for N_2O in the blended amine solutions, which are needed to calculate the diffusivities from the rates of absorption, are given elsewhere (*4*).

The N_2O gas used in this research was of medical grade with a purity greater than 99.99%. The DEA used was of reagent grade with a purity greater than 99%. The MDEA was donated by Union Carbide and had a purity greater than 99% as determined by titration. Deionized water was used in preparing the amine solutions.

Results

Table 1 gives the values of the diffusivities as measured in this work. Each measurement reported in Table 1 is the average of at least two measurements with the standard deviation listed in the table. The temperatures were controlled and measured to within ±0.1 °C. The standard deviations between individual experimental runs indicate that the error is between 1 and 7%, while a more realistic estimate of the average maximum experimental error is approximately 10%. The estimated experimental error is dominated by the errors in the volumetric rate of absorption and Henry's law constant.

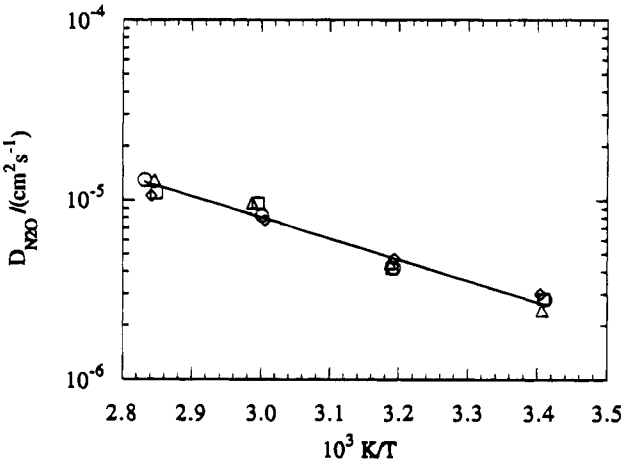

Figure 1. Diffusivity of N_2O in 50 mass % blends of DEA + MDEA + Water: ○, 0.0441 DEA/MDEA; □, 0.2206 DEA/MDEA; ◇, 0.4413 DEA/MDEA; △, 0.5883 DEA/MDEA.

Table 1. Diffusivities of N_2O in 50 Mass % Blends of DEA and MDEA

mass ratio (g of DEA/g of MDEA)	t/°C	$10^5 D_{N_2O}$/ (cm^2·s^{-1})	$10^5\sigma$/ (cm^2·s^{-1})
0.0441	20	0.280	0.021
	40	0.420	0.014
	60	0.820	0.028
	80	1.30	0.034
0.2206	20	0.282	0.012
	40	0.418	0.017
	60	0.916	0.031
	80	1.10	0.026
0.4413	20	0.300	0.013
	40	0.470	0.006
	60	0.770	0.019
	80	1.06	0.041
0.5883	20	0.244	0.010
	40	0.446	0.016
	60	0.965	0.018
	80	1.03	0.023

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It may be seen that the diffusivity of N_2O in these aqueous solutions of 50 mass % total amine is relatively insensitive to the mass ratio of DEA to MDEA. This is illustrated in Figure 1, which shows all of the data given in Table 1.

Literature Cited

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