에멀션액막에서 이산화탄소의 흡수
- AMP와 이산화탄소의 화학반응

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Absorption of carbon dioxide in w/o emulsion membrane
- Chemical reaction of carbon dioxide with AMP

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1.Introduction

If the system is water-in-oil (w/o) emulsion such that the dispersed phase is the aqueous-solution containing reactant, and the continuous phase is the organic solvent having larger solubility of gas than water, then the specific rate of absorption may be enhanced because of larger solubility and chemical reaction. A qualitative explanation of this phenomenon has been given by various authors [1-3]: small droplets of a liquid immiscible with the continuous liquid phase absorb the gas in the hydrodynamic mass-transfer film, after which desorption of the gas takes place in the gas-poor bulk of the liquid. It is considered worthwhile to investigate the effect of non-Newtonian rheological behavior on the rate of chemical absorption in w/o emulsion, where a reaction between CO_2 and reactant occurs in the dispersed phase.

In this study, the chemical absorption mechanism of CO_2 into w/o emulsion composed of aqueous AMP(2-amino-methyl-1-propano) solution and benzene solution of PB and PIB is presented, and the measured absorption rates of CO_2 are compared with those obtained from the model based on the penetration theory with chemical reaction. The volumetric mass transfer coefficient obtained from the previous work[4] is used to estimate the enhancement factor due to chemical reaction.

2. Theory

In case of absorption of CO_2(A) into w/o emulsion with benzene solution of PB and PIB-aqueous AMP(B) solution as shown in Figure 1, the mathematical model is developed to describe the absorption of CO_2 into the continuous benzene phase through the gas-liquid interface under unsteady-state and transfer into the dispersed aqueous droplets through the liquid-liquid interface under steady-state, where the chemical reaction of CO_2 occurs.

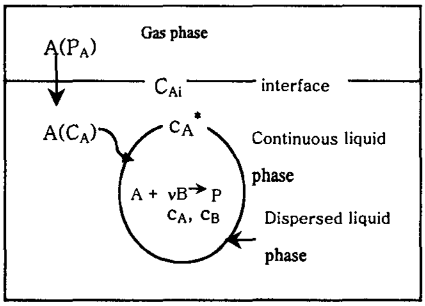

Fig 1. Chemical absorption path of gas(A) into w/o emulsion.

The conservation equations of CO_2 transferred into the dispersed aqueous phase are given as

$$D_{eA}\left(\frac{d^2c_A}{dr^2}+\frac{2}{r}\frac{dc_A}{dr}\right)=k_2c_Ac_B \tag{1}$$

$$D_{eB}\left(\frac{d^2c_B}{dr^2}+\frac{2}{r}\frac{dc_B}{dr}\right)=vk_2c_Ac_B \tag{2}$$

Boundary conditions to be imposedare

$$r=R;\quad c_A=c_A^*=H_AC_A,\quad \frac{dc_B}{dr}=0 \tag{3}$$

$$r=0;\quad \frac{dc_A}{dr}=\frac{dc_B}{dr}=0 \tag{4}$$

The conservation equation for the dissolved gas in the continuous phase with its volume fraction of at unsteady-state is written as

$$D_A\frac{\partial^2C_A}{\partial z^2}=\frac{\partial C_A}{\partial t}+(1-\varepsilon)k_2c_A^*c_{B0}E_f \tag{5}$$

Boundary and initial conditions are given as

$$z=0,\ t>0;\ C_A=C_{Ai} \tag{6}$$

$$z>0,\ t=0;\ C_A=0 \tag{7}$$

$$z=\infty,\ t>0;\ C_A=0 \tag{8}$$

3.Experiment

The w/o type emulsion made from benzene solution of PB(Mw=680) and PIB(Mw=1000000) and water was made by the same procedure as those reported elsewhere [4] by adding Tween 80 (Aldrich Chem. Co.) and Arlacel 83 (Aldrich Chem. Co.) as surfactant, by using a homogenizer (Fisher Scientific Co.) in the range of agitation speed of 1500-10,000 rev/min, and the mean size of aqueous droplets was measured by Image Analyzer (Leitz TAS Plus Co.), and its value was 4×10^{-5} m. The rheological properties of w/o emulsion were measured by the parallel disk type rheometer(Ares, Rheometrics, U.S.A.) of the diameter of 0.05 m and the gap of 0.001 m. The w/o emulsion was composed of aqueous AMP droplets as a dispersed phase and non-Newtonian viscoelastic benzene solutions of PB and PIB as a continuous phase. The absorption rates of CO_2 were measured along the procedure similar to those reported elsewhere[5] at 25℃ and an atmospheric pressure.

4.ResultandDiscussion

The mass transfer coefficient, k_L, of CO_2 in CO_2/emulsion system without AMP in the aqueous droplets was estimated by using the empirical equation [5] correlating the relationship between k_La and the experimental variables in the w/o emulsion of non-Newtonian liquid as follows.

$$k_L a d^2 / D_{eff} = 6.348 \times 10^{-9} \left(d^2 N \rho / \mu\right)^{2.536} (\mu / \mu_o)^{2.397} (1 + 2461.3 De)^{-0.274} (\sigma / \sigma_o)^{-0.039} \quad (9)$$

where De is Deborah number defined as the ratio of the characteristic material time to the characteristic process time in the rheological behaviour.

To observe the effect of viscoelasticity on the mass transfer coefficient of CO_2, k_L, in w/o emulsion of H_2O/(PB/PIB/Bz) system, the effect of viscosity on kL was observed. The values of k_L were estimated using Eq. (9), and Fig. 2 show typically plots of k_L against concentration of PIB at PB of 30 wt %. As shown in Fig. 2 k_L decreases with increasing the viscosity. Note that mass transfer coefficient of a solute in the liquid phase is in inverse proportional to the viscosity of the liquid phase, because the diffusivity of the solute is in inverse proportional to the viscosity.

To observe the effect of concentration of AMP on the rate of chemical absorption, the rate of chemical absorption was measured according to the change of AMP concentration. Fig. 3 shows typically a plot of R_A against AMP concentration at PB of 30 wt% and PIB of 1 wt%.

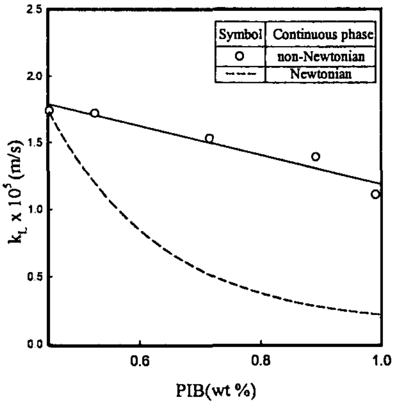

Fig. 2. Effect of viscosity on the mass transfer coefficient for w/o emulsion with PB of 30 wt% and PIB of 0.1∼1 wt%.

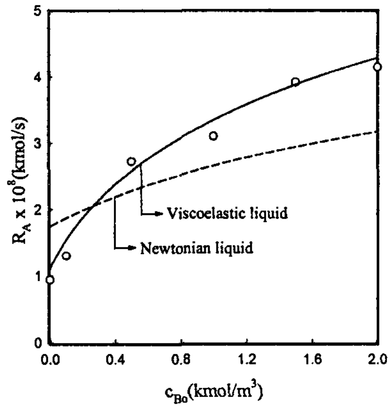

Fig. 3. Effect of AMP concentration on the rate of chemical absorption into the w/o emulsion with PB of 30 wt% and PIB of 1 wt%.

As shown in Fig. 3, R_A increases with increasing AMP concentration. The rates of chemical absorption into w/o emulsion with the non-Newtonian and Newtonian liquid as the continuous phase are shown as a solid and dotted line in Fig. 3, respectively. As shown in Fig. 3, the value of the dotted line smaller than that of the solid line for larger concentrations of AMP than 0.4 kmol/m^3. This means that the elastic due to PIB also accelerates the rate of chemical absorption.

Acknowledgements

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