

## CO<sub>2</sub> ABSORPTION KINETICS IN AQUEOUS OF BUTYLETHANOLAMINE AND ETHYLDIETHANOLAMINE

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### 1. Introduction

The removal of acid gas impurities such as CO<sub>2</sub>, H<sub>2</sub>S and COS from gas process streams is a major concern in the natural gas, petrochemical, coal gasification, and synthetic gas industries. Because each industry has differing objectives, the degree of removal for each acid gas component varies. For instance, in oil fields selective removal of sulfur gases from natural gas reduces pipeline corrosion while maintaining sufficient pipeline pressure. And because CO<sub>2</sub> has become an important commodity for use in enhanced oil recovery, subsequent removal of this component is desirable. In order to avoid catalyst poisoning in a petrochemical plant, treatment of the hydrocarbon feed for the removal of all acid gas components is necessary.

The objective of this research is to measure the properties needed to model the absorption of CO<sub>2</sub> into an aqueous blend of butylethanolamine (BEA) and methyldietanolamine (MDEA) and to obtain experimental absorption data under typical operating conditions in order to compare with mass transfer model predictions.

### 2. Material and Methods

The experiments were carried out in the modified Zipperclave reactor shown schematically in Figure 1. The reactor was then sealed and heated or cooled to the desired temperature by two external electric heating jackets and by an internal heating/cooling coil through which an antifreeze/water solution was circulated by an external constant temperature circulator. The temperature was maintained to within  $\pm 0.1$  K, and the absorption chamber and tubing were insulated. The solution was degassed in the absorption chamber under vacuum while stirring with the attached Magnetic drive packless stirrer. The vacuum was shut off after the pressure steadied, and the system was allowed to come to vapor-liquid equilibrium. At this equilibrium, the pressure was measured and recorded as the vapor pressure of the test solution ( $P_v$ ). With the stirrer shut off, the gas was allowed to flow through a coil submerged

in the external constant temperature bath and into the absorption chamber until an arbitrary pressure was reached. This pressure was recorded as the initial pressure ( $P_i$ ).

### 3. Results and Discussion

The cell pressure corresponding to the vapor pressure of the BEA solution ( $P_v$ ) is measured and  $\text{CO}_2$  gas is introduced into the cell from the gas storage vessel. The moles of  $\text{CO}_2$  transferred to the cell is calculated from the initial storage vessel ( $P_{if}$ ) and the pressure after the transfer is complete ( $P_{tf}$ )

$$A = \frac{(P_{if} - P_{tf})V_t}{RT_a} = \text{moles of CO}_2 \text{ transferred to the Zipperclave reactor}$$

$T_a$  = ambient temperature, K

The moles of  $\text{CO}_2$  that are absorbed into the BEA solution at equilibrium is equal to  $A - B$ , where  $B$  is the moles of  $\text{CO}_2$  remaining in the gas space of the Zipperclave reactor.

$$B = \frac{(P_f - P_v)V_g}{RT} = \text{moles of CO}_2 \text{ in gas space}$$

The  $\text{CO}_2$ -loading,  $L_{\text{CO}_2}$ , is defined as the moles of  $\text{CO}_2$  in solution per mole of amine.

$$L_{\text{CO}_2} = \frac{A - B}{C_{Am}V_l}$$

where  $C_{Am}$  = the amine concentration, gmoles/l

$V_l$  = volume of solution, l

After loading the amine solution in this manner, the solubility of  $\text{N}_2\text{O}$  in these solutions is determined as was done for the unloaded solutions by introducing  $\text{N}_2\text{O}$  into the gas space and measuring the pressure change. In research completed to date, we have :

(i) measured the solubility of  $\text{N}_2\text{O}$  in the Zipperclave reactor for 5, 10, 15, 20, 25 and 30 wt% BEA solutions at 25 and 60°C;

(ii) measured the density and viscosity of the aqueous BEA solutions as a function  $\text{CO}_2$  loading for  $\text{CO}_2$  loadings of 0.1, 0.3 and 0.5 and for 5, 15 and 30 wt% BEA solutions;

(iii) measured  $\text{CO}_2$  absorption rates into 9%BEA / 35% MDEA blends using the laminar-liquid jet apparatus at 25, 40 and 60°C; analysis of this data to determine the effect of MDEA on  $\text{CO}_2$  /BEA kinetics will be carried out after  $\text{N}_2\text{O}$  solubility measurements have been made for this solution.

(iv) set up the transient absorption apparatus using the Zipperclave reactor with computer data acquisition for high pressure  $\text{CO}_2$  absorption experiments.

The cell pressure corresponding to the vapor pressure of the BEA solution ( $P_v$ ) is measured and  $\text{CO}_2$  gas is introduced into the cell from the gas storage vessel. The moles of  $\text{CO}_2$  transferred to the cell is calculated from the initial storage vessel ( $P_i$ ) and the pressure after the transfer is complete ( $P_f$ )

$$A = \frac{(P_i - P_f)V_f}{RT_a} = \text{moles of } \text{CO}_2 \text{ transferred to the Zipperclave reactor}$$

$T_a$  = ambient temperature, K

The moles of  $\text{CO}_2$  that are absorbed into the BEA solution at equilibrium is equal to  $A-B$ , where  $B$  is the moles of  $\text{CO}_2$  remaining in the gas space of the Zipperclave reactor.

$$B = \frac{(P_f - P_v)V_g}{RT} = \text{moles of } \text{CO}_2 \text{ in gas space}$$

The  $\text{CO}_2$ -loading,  $L_{\text{CO}_2}$ , is defined as the moles of  $\text{CO}_2$  in solution per mole of amine.

$$L_{\text{CO}_2} = \frac{A - B}{C_{\text{Am}}V_l}$$

where  $C_{\text{Am}}$  = the amine concentration, gmoles/l

$V_l$  = volume of solution, l

After loading the amine solution in this manner, the solubility of  $\text{N}_2\text{O}$  in these solutions is determined as was done for the unloaded solutions by introducing  $\text{N}_2\text{O}$  into the gas space and measuring the pressure change.

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