CHAPTER 6

CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The densities of binary mixtures of water with piperazine, water with DEA, DEA with piperazine and the ternary mixture of water + piperazine + DEA have been measured in the temperature range from 30 to 80 °C with piperazine concentration varying from 0.01 to 1 M. The results of these measurement show that the binary and ternary systems exhibit different trends of the density curves. Based on the density data collected, a generalized set of interaction parameters to calculate the density were determined for the aqueous piperazine, DEA, DEA + PZ mixtures and activated DEA solutions. The overall deviation of the experimental and calculated density values for the PZ + H_2O, DEA + H_2O, DEA + PZ mixtures and activated DEA solutions for 2 M and 4 M are 0.02 %, 0.04 %, 0.07 %, 0.24 % and 0.37 % respectively.

Investigations on equilibrium solubility of carbon dioxide into aqueous piperazine and activated solution have been conducted in a double jacketed stirred cell reactor at CO_2 partial pressures ranging from 0.4 to 96 kPa and temperatures from 20 to 50 C. The concentration of piperazine varied from 0.1 to 1 M and 0.05 to 1 M in aqueous piperazine and activated DEA solution respectively. It was observed that the

solubility of CO_2 in both aqueous piperazine and activated DEA solution exhibit the same trend as other typical amines, whereby the solubility of CO_2 increases with increase in CO_2 partial pressure. However, increasing either the temperature or piperazine concentration will cause the CO_2 loading to decrease. The aqueous piperazine solution exhibits an interesting behavior at high partial pressure with low piperazine concentrations where the solubility of CO_2 exceeds the theoretical value. This is due to the dominant role of physical absorption.

In the activated DEA solution of equal molarity, the solubility of CO_2 decreases as the concentration of piperazine increases at high CO_2 partial pressure and a small increase at low CO_2 partial pressure which is not significant in enhancing the CO_2 oading. Compared to amine mixtures of DEA + MDEA and MEA + MDEA, activated DEA solutions show better CO_2 absorption capacity especially at low CO_2 partial pressure. This indicates that the aqueous activated DEA is a potential solvent to be used in gas treatment industries.

Generally, for CO_2 absorption in the aqueous piperazine solution, the Kent and Eisenberg model fairly well with the experimental data except at high CO_2 partial pressures and low piperazine concentrations which is due to the dominant role of physical absorption. Beside, the small amount of the CO_2 loading measured may also have generated error. Thus, the model is expected to be unreliable at these two conditions. The Kent and Eisenberg model was also applied to the activated DEA system and it also predicts the CO_2 loading fairly well. Only at low CO_2 partial pressures and high temperature conditions did the predicted CO_2 loading values

deviate more than 50 % from the experimental data which may be due to the limitation of Henry's Constant and equilibrium constants used in this region.

6.2 Recommendations

A more comprehensive study on physical properties of the activated amine system would be interesting to explore in order to provide quantitative estimates of equilibrium properties for amine mixtures which are required in chemical production and process design.

Based on the experimental data, at high CO_2 partial pressures and low piperazine concentrations, the solubility of CO_2 in the aqueous piperazine solution exceeds the theoretical value. This highlights the necessity to determine the physical solubility and diffusivity experimentally in order to obtain fundamental understanding of absorption mechanism in this system.

The large deviations of CO_2 loading between the model and the experimental data at certain conditions suggest that an improved model is desirable for quantitative prediction of CO_2 loading. The model should take into account the ionic parameters to represent the non-ideality of the system. The Kent and Eisenberg model may also have some deficiencies. It is only applicable to a limited loading range and its extension to acid gas mixtures is less successful (Liu et al., 1999a). Therefore, this model may not be able to represent the CO_2-activated system accurately in a wider range due to the complicated reaction which occurs in the CO_2-H_2O-PZ-DEA system.

The results from this work also identify that activated DEA is a potential solvent to be used in the gas treatment industries. Therefore, future works on degradation and corrosion effects of activated DEA in stripping process is recommended, since it contributes major problems in operating gas treatment plants. Extension work on kinetic and scale-up is desirable to ensure the ability of this solvent to absorb CO_2 effectively and efficiently at lower cost.