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Solubility of Nitrous Oxide in Aqueous Amine Solutions

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1. Introduction

The removal of carbon dioxide and hydrogen sulfide from process gas streams in the petrochemical and natural gas industry is commonly achieved by reacting these impurities with aqueous alkanolamines. Alkanolamines used for this purpose include diethanolamine(DEA), and methyldiethanolamine(MDEA) and, more recently, their mixtures.

The purpose of this work is to measure the physical solubility of nitrous oxide in partially loaded solutions of DEA, and MDEA and their blends and to develop empirical equations to predict the solubility at any amine concentration and carbon dioxide loading. These equations can then be used to predict the physical solubility of carbon dioxide via the nitrous oxide analogy.

2. Materials and Methods

The solubility experiments were carried out in a modified Zipperclave reactor shown in Figure 1. The DEA was obtained from Fisher Scientific with a minimum purity of 99 mass%. The MDEA was donated by Union Carbide Corp. with a minimum purity of 99 mass%. The nitrous oxide was medical grade with a stated purity of 99.99%. The water used in this work was deionized. The concentration of the amine in solution was determined by titration with hydrochloric acid.

A weighed sample of approximately 400g of test solution was injected into the 1.02815×10^{-3} m^3 (at 298 K) stainless steel chamber. 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 ±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 Magnedrive 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). The absorption chamber was then resealed by closing the valve connecting it to the gas storage chamber, and the stirrer was started at about 1500 rpm. The system was allowed to reach vapor-liquid equilibrium at which point the final pressure (P_f) was measured and recorded.

3. Results and Discussion

In order to determine the accuracy of the experimental method, the Henry constant of nitrous oxide in water was measured repeatedly. As the value for the Henry constant for pure water is well established, this would indicate that their measured data for the amine solutions are low. The data from these researchers are also linear functions of amine concentration with the exception of the pure water data points. As the value for the Henry constant for pure water is well established, this would indicate that their measured data for the amine solutions are low.

The solubility of nitrous oxide (N_2O) in aqueous solutions of 0wt% - 50wt% methyldiethanolamine, 0wt% - 30wt% diethanolamine, and 50wt % total amine with diethanolamine/methyldiethanolamine molar ratios of 0.05, 0.25, 0.5, and 0.67 was measured using a modified Zipperclave reactor over the temperature range 293-353 K and at N_2O partial pressures near atmospheric. The solubility data from this work were found to be in fair agreement with the literature where data were available. The predicted Henry's constants show fairly good agreement with an average deviation of only 4.1% from the experimental data.

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