High pressure measurement of the solubility of H$_2$S in aqueous solution of N-methyldiethanolamine+2-amino-2-methyl-1-propanol + Piperazine

A. Haghtalab*, A. Izadi, A. Shojaeian, M. Kazemian
Department of Chemical Engineering, Tarbiat Modares University, Tehran, Iran
haghtala@modares.ac.ir

Abstract
Removal of hydrogen sulfide and carbon dioxide from sour gas is important in the gas treatment process and flue gases. In this work, using a volumetric static method, the solubility of H$_2$S in aqueous blends of N-methyldiethanolamine (MDEA), 2-amino-2-methyl-1-propanol (AMP) and Piperazine (Pz) are obtained at 313.15, 328.15 and 343.15 K over the pressure range of 1-21 bar and the different compositions. The composition of the MDEA is fixed at 25 wt% and the composition of the AMP and Pz are changed as (20, 15, 10, 5 wt%) and (0, 5, 10, 15 wt%), respectively. The experimental data are presented as the partial pressure of H$_2$S against acid gas loading (moles H$_2$S / total moles of amine). It is observed that in the low gas loading region less than one, blending Pz with aqueous solution of MDEA+AMP leads to reduction of absorption of H$_2$S.

Keywords: H$_2$S solubility, N-methyldiethanolamine, 2-amino-2-methyl-1-propanol, piperazine.

Introduction
Acid gases removal from natural gas is one of the major process in a gas treatment plant [1]. The different techniques such as physical and chemical absorption are used for gas purification in which the alkanolamines are widely used as a chemical absorbent for acid gas removal because of their highly reactive nature and low cost [2]. There are various alkanolamines with difference in their properties and specifications. DIPA as a secondary alkanolamine has been used in ADIP, Sulfinol and SCOT processes [3]. MDEA is a tertiary amine that does not form carbamate in reaction with CO$_2$ and its most striking feature is the selective removal of H$_2$S from sour gases. In the recent years, sterically hindered amines have been considered, because of their high absorption capacity and high absorption rate [4]. The 2-amino-2methyl-1-propanol (AMP) is the most known of this type of amines that is a kind of the hindered form of MEA. Moreover, in the recent decays the activators are added to the blended alkanolamines to enhance the reaction rate of acid gases and pronounce the absorption rate of CO2 [5]. One of the most common activators is piperazine (PZ) as secondary amine that its corrosion activity is lower than MEA and DEA [6]. As a result, presently using a blended alkanolamines with an activator has received highly demanded. To achieve optimum conditions for designing of an absorption process, it is necessary to use the solubility data of the acid gases in aqueous solution of alkanolamines in a wide range of
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... temperatures and pressures. There are little data on the solubility of H$_2$S in blend of alkanolamines. Xia et al. [7] that obtained data for solubility of H$_2$S in Pz+MDEA and Maria Esther Rebollo et al. [8] measured the solubility of H$_2$S in MDEA+DEA+AMP. MacGregor et al. [9] investigated the solubility of H$_2$S in a mixed aqueous solvent consisting of MDEA and sulfolane. Due to importance of removal H$_2$S from sour natural gas and its elimination from flue gas and the lack of low solubility data in mixed amines, thus the purpose of this work is to obtain the solubility of H$_2$S in aqueous MDEA+AMP+Pz system. The data are measured at fixed 45 weight percent of total amine so that the blending of Pz with the MDEA+AMP system is investigated under isothermal conditions at 313.15, 328.15 and 343.15 K in the pressure range of (1-21) bar.

Experimental
N-Methyldiethanolamine and Piperazine with mass fraction purity > 0.99 were supplied from Sigma-Aldrich and AMP with mass fraction purity > 0.97 was purchased from Fluke. H$_2$S was supplied by Technical Gas Service Company with the mole fraction purity of 99.99%. All of the materials were used without further purification. A digital balance with accuracy of ±0.001 g was used to weighing of the amines and water. The deionized and degassed water were used to prepare the present aqueous alkanolamines systems. Apparatus and procedure of measurement of H$_2$S solubility is described in details in the literature [10].

Results and Discussion
To validate the present experimental data and the procedure using the present apparatus, the solubility of H$_2$S in the aqueous solution of 2 molal Pz at 313 K was obtained as shown in Table 3 and the results were compared with those given by Xia et al. [7]. As shown in figure 1, there is a good agreement between the experimental results of this work and those obtained by Xia et al.

![Fig. 1](https://example.com/fig1.png)

**Fig. 1.** The partial pressure of H$_2$S versus loading of the acid gas in the aqueous 2 molal Pz at 313 K to Compare the present experimental solubility data with those obtained by Xia et al. [7].

The experimental data of the solubility of H$_2$S in the given aqueous alkanolamine systems was obtained at 313.15, 328.15 and 343.15 K in the pressure range of 1-21 bar. The investigated aqueous alkanolamine mixtures are the MDEA+AMP (25, 20wt%), the MDEA+AMP+Pz (25, 15, 5wt%), the MDEA+AMP+Pz (25, 10, 10wt%) and the MDEA+AMP+Pz (25, 5, 15wt%) systems. Figure 2 show the partial pressure of H$_2$S versus the H$_2$S loading at the various compositions and temperatures.
Fig. 2. The partial pressure of H$_2$S versus loading of the acid gas at different temperatures. (a) MDEA+AMP (25, 20wt%). (b) MDEA+AMP+Pz (25, 15, 5wt%). (c) MDEA+AMP+Pz (25, 10, 10wt%). (d) MDEA+AMP+Pz (25, 5, 15wt%).

As it can be seen from figure 2, within the pressure and temperature ranges, for each system at the given composition and a fixed partial pressure, by enhancing temperature the loading of H$_2$S was reduced. Also, from figure 2 one can see the influence of temperature on the acid gas loading so that as the loading enhances the solubility reduces at higher temperature, however at very low loading, the effect of temperature is diminishing on the solubility. Moreover, one can see by enhancing Pz and reducing AMP in aqueous solution of MDEA+AMP+Pz, reduce the temperature effect on the solubility.

Conclusions

Using a quasi-static equilibrium method, the solubility of H$_2$S in the different aqueous alkanolamine systems were obtained through the gas-liquid equilibrium pressure measurements. For all of the aqueous alkanolamine systems with enhancing temperature the solubility of H$_2$S decreased at a fixed partial pressure. By enhancing Pz and reducing AMP in aqueous solution of MDEA+AMP+Pz, reduce the temperature effect on the solubility.
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References
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