Study on apparent absorption rate of H_2S in MDEA-PZ aqueous solutions at 313.2K

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Abstract: The apparent absorption rate of H_2S in piperazine (PZ) promoted N-methyldiethanol- amine (MDEA) aqueous solution was determined at 313.2K.The mass fractions of PZ ranged from 0 to 0.1. The pressures of H_2S ranged from 300Pa to 500Pa.On the basis of experimental measurements, the influences of partial pressure and mass fractions of PZ on the apparent absorption rate of H_2S were demonstrated.

1. Introduction

The catalysts poisoning, human health and equipment corrosion in the coking industry caused by the emissions of hydrogen sulphide (H_2S) have attracted increasing attentions worldwide and the reduction of H_2S has become a global issue[1–3].A wide range of approaches, including liquid absorption, solid adsorption, biological degradation, membrane separation [4-6], have been developed for H_2S removal. Among these technologies, amine-based absorption technologies are widely used in the gas separation for mixture gas containing H_2S[7].Alkanolamines, such as N-methyldiethanolamine (MDEA), diisopropanolamine (DIPA), sterically hindered amines such as 2-amino-2-methyl-1-propanol (AMP) and the chemical activators such as piperazine (PZ) have been widely applied to remove the acid gases in industrial processes [8-10]. However, the major disadvantages of traditional alkanolamine aqueous solutions are the high energy cost of regeneration and the corrosion. Due to the disadvantages of traditional alkanolamines, new absorbents with low corrosivity, low energy cost in regeneration, high absorption capacity and high reaction rate are urgently required [11].

As one of the tertiary amines, MDEA has the advantages of high resistance to thermal and chemical degradation, and low corrosivity [12]. Rinker et al. [13] shown that the density of aqueous MDEA increased with increasing H_2S loading while the viscosity decreases with increasing H_2S loading. MDEA is a tertiary amine that is widely used in the gas-processing industry and has proven to be an effective chemical solvent for selective absorption of H_2S [13]. And it has been well documented that adding activators such as PZ (piperazine) into alkanolamine aqueous solutions can improve absorption performance.

Mazloumi et al. [14] obtained that at acid gas loadings below the crossing point, and the H_2S solubility is enhanced with increasing PZ concentration. Haghtalab et al. [15] measured that at fixed partial pressure and constant mass percent of (AMP + PZ), with decreasing temperature the H_2S loading is enhanced. Speyer and Maurer [16] measured the solubility of H_2S in the aqueous of PZ at T = (313.5 and 392.2) K in the low loading region. However, the influences of concentration and partial pressure on apparent absorption rate of H_2S are still unknown.

The main purposes of this work are to experimentally determine the apparent absorption rate of H_2S in MDEA-PZ aqueous solution and demonstrate the effects of concentration and the partial

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pressure of H_2S.

2. Experimental Section

2.1. Materials

The MDEA was manufactured by Shanghai Aladdin Reagent, with a mass purity ≥ 99%. The PZ was purchased from Sinopharm chemical reagent, with mass purity≥ 99%. They were used without further purification. Aqueous solutions of MDEA-PZ were prepared by adding the high purity water.

2.2. Apparatus and procedure

The apparent absorption rate was measured by the equipment composed of one high-pressure H_2S tank, one mass flow controller (MFC), one mass flow meter (MFM), one absorption bottle, one constant temperature water bath, one desiccator and one H_2S analyzer(manufactured by Germany Sensors Europe GmbH, the accuracy is ±2%).

During the experiment, H_2S and N_2 from high-pressure tanks were respectively inlet into the mass flow controllers to maintain constant flow rates v_{H2S} and v_{N2}, and then into the gas mixer. The gas mixture with certain volume fraction of H_2S flowed into the absorption bottle and then was absorbed by the solution. The residual and unabsorbed gas firstly flowed into the desiccator, and then into the H_2S analyser and finally into the mass MFM. The volume concentration of H_2S (C_i) was measured by the H_2S analyser, and the flow rate (v_i) was measured by the MFM. The C_i and the corresponding time (t_i) were simultaneously recorded by the computer (interval time Dt = 1s). We defined the absorption rate (R/g H_2S 100g aqueous solution min^{-1}) as 0.5m/t 0.5 ($t_{0.5}$ is the absorption time at which 50% of the absorption capacity is achieved).

3. Result and discussion

The experimental results for absorption rate of H_2S in MDEA-PZ aqueous solutions are shown in Table 1

Table 1.Absorption rate (R) of H_2S in MDEA-PZ aqueous solutions. Pressure (p) = 101 kPa.Temperature (T) = 313.2K

w_{MDEA}	w_{pz}	*R*100/* (g H_2S/100g aqueous solution/min)		
		300 Pa	400 Pa	500 Pa
	0.00	0.397	0.411	0.422
0.3	0.05	0.519	0.528	0.544
	0.075	0.630	0.654	0.667
	0.00	0.396	0.511	0.624
0.4	0.05	0.400	0.523	0.645
	0.075	0.405	0.535	0.647

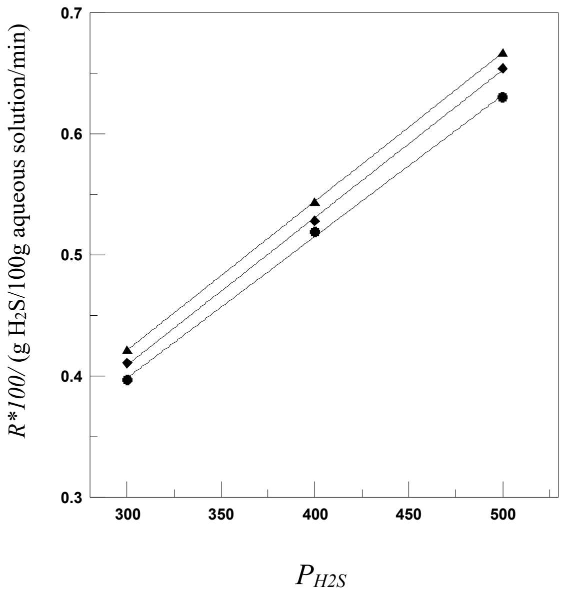

Figure 1. Effect of P_{H2S} on the absorption rate of H_2S in 30%MDEA aqueous solution. Symbols: experimental data; ●w_{pz}=0; ◆w_{pz} =0.05; ▲w_{pz} =0.075. Lines: for guiding the eyes.

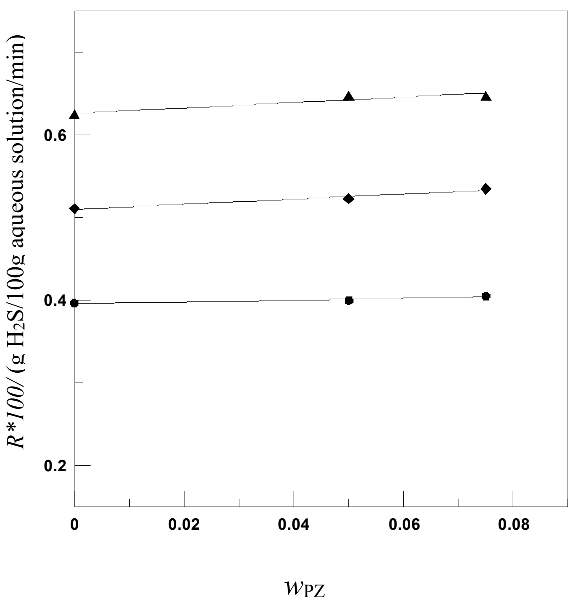

Figure 2. Effect of w_{pz} on the absorption rate of H_2S in 40%MDEA aqueous solution. Symbols: experimental data; ●P_{H2S}=300Pa; ◆P_{H2S} =400Pa; ▲P_{H2S} =500Pa. Lines: for guiding the eyes.

Figure 1 shows the effect of P_{H2S} on the absorption rate of H_2S in 30%MDEA aqueous solution, indicating that at given temperature the absorption rate increases with increasing partial pressure of H_2S.

Figure 2 shows the effect of w_{PZ} on the absorption rate of H_2S in 40%MDEA aqueous solution, indicating that at given temperature the absorption rate increases with increasing w_{pz}.

4. Conclusions

In this work, apparent absorption rate of H_2S in MDEA-PZ aqueous solution was determined. The effects of the mass fraction of PZ and different pressures of H_2S on apparent absorption rate were demonstrated. Our results show that:

(1) For MDEA-PZ aqueous solution, the absorption rate increases with the increase of P_{H2S} at given temperature and w_{MDEA}. The absorption rate of H_2S in MDEA aqueous solution is greatly affected by the partial pressure of H_2S.

(2) The absorption rate increases with the increase of the w_{PZ} at given w_{MDEA} and temperature.

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