Experimental measurement of thermophysical properties and solubility of carbon dioxide in mixtures of 1-ethyl-3-methylimidazolium ethyl sulfate ionic liquid with various alkanolamines

Fatemeh Karami, Abolfazl Shojaeian

Department of Chemical Engineering, Hamedan University of Technology, Hamedan,65155, Iran

(Shojaeian@hut.ac.ir)

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Abstract

One common method for removing the acid gases is absorption through chemical solvents. In the current research, an attempt has been made to measure the thermophysical properties such as density, viscosity, and refractive index for an ionic liquid mixture consisting of 1-ethyl-3-methyl imidazolium ethyl sulfate and methyl diethanolamine, diethanolamine, 2-amino-2-methyl-1-propanol, at different molar ratios and within the temperature range of 20 to 60 ℃ and ambient pressure.

Keywords: Alkanolamines, Ionic Liquids, Thermophysical Properties, CO_2 absorption.

Introduction

The expansion of industries and the production of combustion products have led to an increase in air pollution and acid rain. Among the pollutants, carbon dioxide is the primary combustion product, which contributes to greenhouse effects and climate change. Consequently, there is a growing interest in carbon dioxide absorption. The industry commonly uses chemical solvents, such as alkanolamines, for carbon dioxide absorption. However, these solvents pose challenges like corrosion, volatility, and toxicity. As an alternative, researchers have turned their attention to ionic liquids, which are liquid salts at room temperature and known for their environmentally friendly properties. Despite their high viscosity and challenging synthesis process, a current approach involves using a mixture of ionic liquids and alkanolamines to overcome their drawbacks. This study focuses on investigating the thermophysical properties of mixtures of imidazolium-based ionic liquid and various alkanolamines.

Materials and method

The thermophysical properties of binary mixtures of 1-ethyl-3-methyl imidazolium ethyl sulfate ([Emim][$EtSO_4$]) with N-methyl diethanolamine (MDEA), diethanolamine (DEA), and 2-amino-2-methyl-1-propanol (AMP) are measured using appropriate equipment. These properties include density, viscosity, and refractive index. The measurements are conducted at temperatures ranging from 20 to 60 ℃ and at ambient pressure. The mixtures are then exposed to carbon dioxide gas, and the solubility of carbon dioxide in the solvents is examined under various pressures. The results are analyzed using thermodynamic models, and Table1 provides details about the materials used.

Table1. details about used material

chemical	CAS number	supplier	nominal mass fraction purity
1-ethyl-3-methyl imidazolium ethyl sulfate([Emim][Et SO_4])	342573-75-5	IoLiTec	>95
N-methyldiethanolamine (MDEA)	105-59-9	Acros	>99
2-amino-2-methyl-1-propanol (AMP)	124-68-5	Acros	>99
diethanolamine (DEA)	111-42-2	Merck	>99

Approval

Results and Discussion

The results indicate that, at the same temperature, [Emim][Et SO_4] has the highest density compared to the other pure liquids. On the other hand, the AMP shows the lowest density. Furthermore, the density of DEA is higher than that of MDEA. At a constant temperature, the viscosity of pure DEA is the highest, whereas the viscosity of pure MDEA is the lowest. Figure 1 and Figure 2 respectively depict these situations. The results show that as temperature increases, all thermophysical properties of pure and binary systems such as density, viscosity and refractive index decrease. Additionally, the influence of concentration on thermophysical properties varies for each system due to the complexity of mixture behavior, and there is no overall trend for their changes. Finally, excess molar volume, viscosity deviation, and excess refractive index have been calculated based on measured density, viscosity, and refractive index properties.

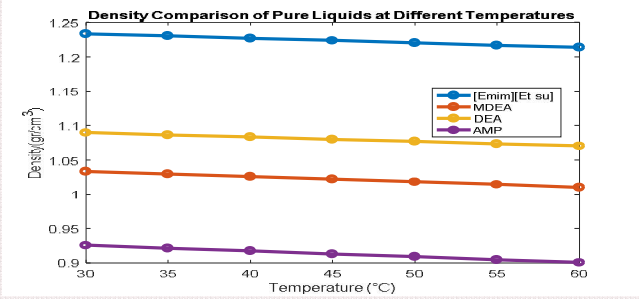

Fig. 1 Density of pure [Emim][Et SO4], MDEA, DEA, AMP

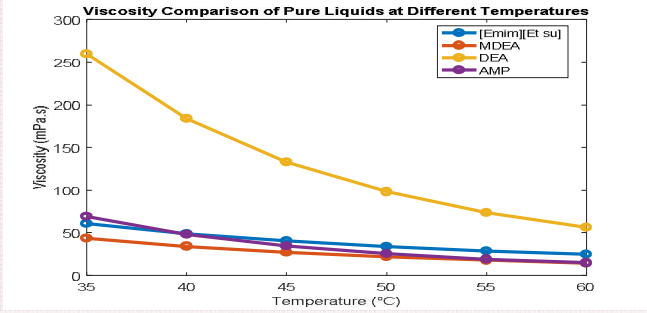

Fig. 2 Viscosity of pure [Emim][Et SO4], MDEA, DEA, AMP

Conclusions

The present study focuses on investigating the thermophysical properties of pure liquids and binary mixtures of ionic liquid and three common alkanolamines used for carbon dioxide absorption. These properties, including density, viscosity, and refractive index, play a crucial role in equipment design. To analyze these properties, thermodynamic models have been used to fit the data. Furthermore, the study also calculates the excess properties of these mixtures.

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