Experimental determination of thermophysical properties of ethaline DES and 2-Amino-2-methyl-1-propanol (AMP) mixture

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Abstract

Global warming and climate change are significant issues that present pivotal challenges within our worldwide community. Deep eutectic solvents(DESs) have attracted significant attention from researchers in the field of carbon dioxide (CO2) capture due to their numerous advantageous properties. This research aims to measure the thermophysical properties, including density, viscosity, and refractive index, of the mixture of ethaline DES with 2-Amino-2-methyl-1-propanol(AMP) in different molar ratios within the temperature range of 20 to 60˚C and atmospheric pressure, Following they will be validated by fitting with appropriate equations using MATLAB software.

Keywords : CO2 absorption ,deep eutectic solvents, AMP, Thermophysical properties

Introduction

The industrial revolution, as a primary factor, has led to the emergence of the global warming phenomenon and climate changes .Greenhouse gases play a crucial role in propelling global warming, with CO2 being regarded as one of the most significant contributors among these gases . DESs are considered one of the primary alternatives to conventional amine-based solvents and ionic liquids for CO2 capture since these solvents possess all the advantages of conventional amine-based solvents and ionic liquids while lacking their drawbacks. In order to employ these solvents in various processes, it is necessary to have sufficient information regarding their thermophysical properties. Subject of study in this research is a deep eutectic solvent called Ethaline. This solvent has garnered attention due to its significantly lower viscosity compared to other DESs. In order to enhance the CO2 solubility, the combination of this DES with alkanolamine AMP has been studied, and its thermophysical properties have been measured.

Materials and method

The specifications of all materials used in this study have been provided in Table 1. The Ethaline DES has been synthesized using the conventional method found in literature, combining Choline chloride and Ethylene glycol in a 1:2 molar ratio. The thermophysical properties, including density, viscosity, and refractive index, of the binary mixture of Ethaline and AMP in molar ratios of 2, 4, 6, and 8, within the temperature range of 20 to 60 C at 5-degree intervals under atmospheric pressure, were measured using an Anton Parr density meter model DMA 4500M, viscometer model Lovis2000M, and refractometer model Abbemat300. Subsequently, to predict the thermophysical properties of the desired mixture, the experimental results obtained for density and refractive index were fitted with appropriate linear equations, while the viscosity was modeled using the Vogel-Fulcher-Tammann (VFT) equation.

Chemical	Cas number	Source	Purity(%)	Molecular weight ($g.mol^{-1}$)
Choline chloride (Chcl)	67-48-1	Sigma-aldrich	99%	139.62
Ethylene glycole (EG)	107-21-1	merck	>99%	62.07
2Amino2methyl1propanol (AMP)	124-68-5	acros	99%	89.136

Table 1. Specifications and characteristics of the materials.

Results and Discussion

The results indicate that at a constant temperature, pure Ethaline exhibits a higher density compared to pure AMP. Consequently, with an increase in the amount of AMP, the density has decreased. Moreover, generally, an increase in temperature leads to a linearly reduction in density due to the thermal expansion effect. Additionally, the viscosity results demonstrate that pure Ethaline has a remarkably low viscosity, while the viscosity of pure AMP is slightly higher than that of pure Ethaline. However, the combination of Ethaline and AMP exhibits a higher viscosity, and with an increase in the amount of AMP, the viscosity has increased which can be justified considering the hole theory. Furthermore, as expected, the viscosity values have exponentially decreased with an increase in temperature across all molar ratios. The refractive index results indicate that at a constant temperature, pure Ethaline has a higher refractive index compared to pure AMP, and with an increase in the molar ratio of AMP, the refractive index values decrease. Additionally, with increasing temperature, the refractive index values have linearly decreased for all molar ratios. Furthermore, the modeling results also demonstrate a good agreement between the experimental data and the predicted data.

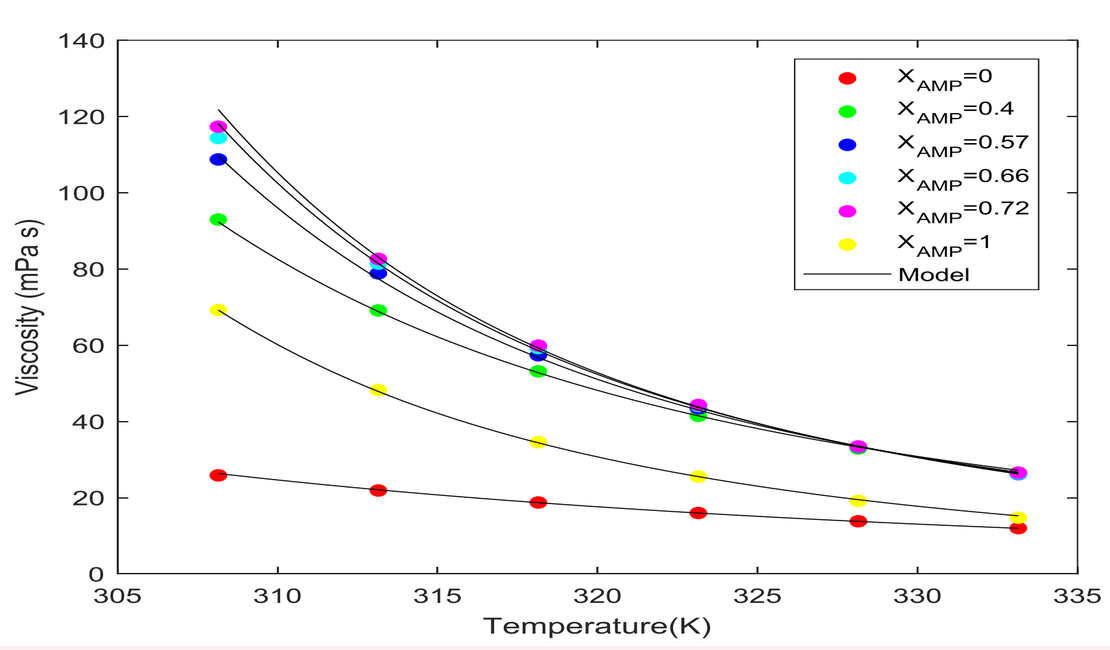

Fig. 1 The viscosity of Ethaline DES mixture with AMP

Conclusions

The study focused on Ethaline DES and its combination with AMP for CO2 capture application. Ethaline showed higher density and lower viscosity compared to pure AMP. Increasing AMP content reduced density but raised viscosity. Viscosity exponentially decreased with rising temperature across all AMP molar ratios. Refractive index showed Ethaline's superiority, decreasing with higher AMP molar ratios. In general, this study supports the potential of the Ethaline-AMP combination for CO2 capture, well-corroborated by modeled data. However, for a more conclusive determination, the actual CO2 absorption by these compounds should also be investigated.

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Approval