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A study on the Thermophysical Properties and Excess Functions of Binary Mixtures of the Ionic Liquid [BMIM][NTf_2] with 2-Methoxyethanol at 298.15–323.15 K

Chandrabhan Singh Niranjan[1], Rakesh Kumar Singh[2], Prakash Chandra[3]

[1]Research Scholar, Department of Chemistry, Bundelkhand University Jhansi, India
[2,3]Assistant Professor, Department of Chemistry, Government Degree College, Pawanikala, Sonebhadra,

Abstract

Experimental density (ρ) and viscosity (η) data were measured for binary mixtures of the ionic liquid [BMIM][NTf_2] with 2-methoxyethanol over the full composition range at temperatures from 298.15 to 323.15 K and atmospheric pressure. Excess molar volumes (V^E) and viscosity deviations (Δη) were derived to assess mixture non-ideality. Density increases with ionic liquid mole fraction and decreases slightly with temperature. Negative V^E values across most compositions indicate strong attractive interactions and efficient molecular packing. Viscosity rises markedly with ionic liquid content and decreases with temperature, while predominantly negative Δη values confirm significant non-ideal flow behavior due to specific intermolecular interactions. The combined volumetric and transport property data provide valuable insight into the molecular interactions governing the thermophysical behavior of [BMIM][NTf_2]–2ME mixtures and are expected to be useful for the design and optimization of ionic-liquid-based solvent systems in industrial and environmental applications.

1. Introduction

An increasingly important group of green solvents being explored by scientists is ionic liquids (ILs). The remarkable physicochemical properties and recyclability of ionic liquids, along with their unique characteristics, have enabled their widespread application across various scientific disciplines [1-5]. Often termed 'designer solvents,' ILs can be tailored to suit a wide variety of chemical processes due to the numerous possible combinations of cations and anions with tunable properties, enabling precise control over polarity, hydrophobicity, acidity/basicity, coordinating ability, and viscosity [6]. These attributes have driven their widespread adoption across diverse disciplines—from catalysis and separations to electrochemistry, biomass processing, and materials synthesis—positioning ILs as versatile, sustainable alternatives to conventional volatile organic solvents [7-10]. ILs are non-volatile in nature which minimizes environmental emissions, and biodegradable and recyclable, contributing to greener processes [11]. ILs have a low melting point and high thermal decomposition temperature, allowing them to remain in the liquid state over a wide temperature range and ensuring thermal stability [12-14]. Their excellent solvation ability enables them to dissolve a wide variety of substances, while their resistance to air and

moisture enhances their handling and storage. Furthermore, ILs exhibit high ionic conductivity, very low vapor pressure, and high selectivity in promoting various organic transformations, making them valuable as solvents, electrolytes, and reaction media [15-17].

Extensive data on the aspects of thermophysical and thermodynamic behavior of IL remain insufficient. On the other hand, the demand for precise thermodynamic measurements is becoming increasingly critical for their effective use in industrial applications. Imidazolium-based ionic liquids are more environmentally benign than many other ILs as they possess comparatively low viscosity, which enhances their ease of handling [18,] and are thermally more stable [19]. ILs 1-butyl-3-methylimidazolium bis-(trifluoromethylsulfonyl)imide ([Bmim][NTf_2]) stands out as a widely used ionic liquid, particularly as an electrolyte in capacitive energy storage systems and in nuclear fuel reprocessing [20, 21]. [Bmim][NTf_2] and their binary mixtures with organic solvents have been studied in past, but there are limited studies on the ternary mixture of ([Bmim][NTf_2]. Amphiphilic solvents such as alkoxyethanols (e.g., 2-methoxyethanol or 2ME) are used as they highly valuable in a variety of chemical applications due to the presence of both ether (−O−) and hydroxyl (−OH) functional groups within the same molecule. The incorporation of water can significantly influence the viscosity, density, and excess thermodynamic properties, thereby affecting the performance and efficiency of these mixtures in industrial processes [22]. These systems offer a unique combination of hydrogen bonding, dipolar interactions, and ionic effects, making them valuable in understanding complex solvation phenomena. Such mixtures are particularly useful in designing tailored solvents for applications in extraction, electrochemistry, biocatalysis, and CO_2 capture.

The primary aim of this investigation is to provide a comprehensive and precise set of experimental data on the density (ρ), viscosity (η), excess molar volume (V^E), and viscosity deviation (Δη) for the binary system over the temperature range of 298.15–323.15 K. These measurements enable a deeper understanding of the influence of composition and temperature on the thermophysical behavior of the system. The excess molar volume and viscosity deviation are calculated from experimental data to evaluate the non-ideality of mixing and to probe the nature of intermolecular interactions among the components. In particular, the interplay of hydrogen bonding, dipolar interactions, and ionic effects plays a key role in determining the structural and dynamic properties of the mixtures. The insights gained from this study are essential for optimizing solvent systems with improved selectivity, lower toxicity, enhanced recyclability, and better performance in industrial and environmental applications.

2. MATERIALS AND METHODS

2.1 Chemicals

Ionic liquid 1-butyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide, ([BMIM][NTf2]) - $C_{10}H_{15}F_6N_3O_4S_2$ procured from Merck, was ultrapure with 0.005 wt% water content, as determined by Karl Fisher titration (831 Karl Fischer colorimeter). 2-Methoxyethanol (2ME) - $C_3H_8O_2$ was purchased from Sigma-Aldrich and used after purification via distillation. The chemicals were vacuum dried for 72 h prior to the measurements at a pressure of 0.1MPa. Doubly distilled deionized (DI) water, sourced from the Milli-Q academic water purification system, was used for
preparing solutions. The chemical structure of IL and 2ME is given in **Figure 1**.

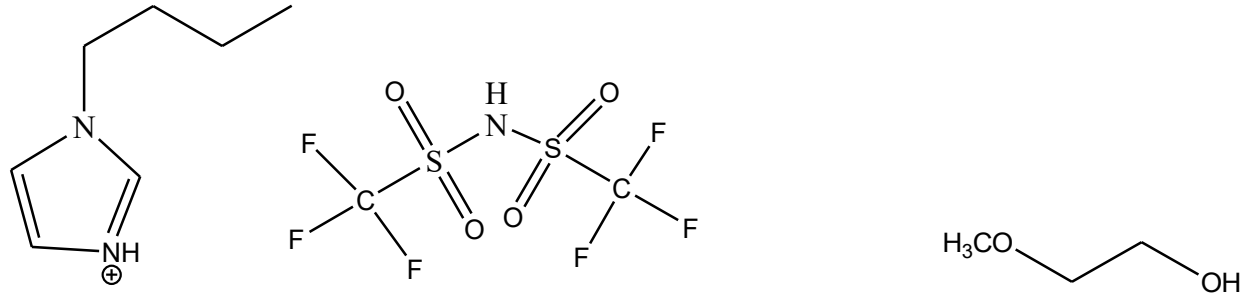

Figure 1. Chemical structure of 1-butyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide, ([BMIM][NTf2]) and 2-Methoxyethanol.

2.2 Apparatus and Procedure

The IL binary and ternary mixture samples were prepared in 20 mL glass vials were sealed with screw caps and parafilm to ensure a secure closure in order to prevent humidity. Before every measurement the samples were mixed via vortexer and degassed in a bath sonicator. The densities of the pure ionic liquid ([BMIM][NTf_2]), as well as its binary (IL + 2ME) mixtures, were measured using an Anton Paar DMA 4500 densimeter, calibrated with triply distilled degassed water and dry air at a pressure of 101 kPa. Density measurements were performed across a temperature range of 303.15 K to 343.15 K, at **5** K intervals. Correspondingly, the viscosities of these binary and ternary systems were determined using a Lovis 2000M microviscometer (Anton Paar, Austria) under the same experimental conditions. Viscosity determination was based on the rolling ball principle, where values were calculated using the equation:

$\eta = K(\rho_s - \rho)t$ ……. (Eq. 1)

The standard uncertainties associated with temperature and density measurements were ±1 K and ≤ 5 × 10^{-3} g/cm^3, respectively.

FT-IR studies were recorded using using PerkinElmer 3725 instrument from 500 to 4000 cm^{-1} range.

3. RESULTS AND DISCUSSION

For the purpose of volumetric analysis, the density and viscosity of the pure components were experimentally determined and are presented in **Table 1**. The obtained values are in good agreement with those reported in the literature.

3.1. Densities

The densities of binary mixtures of [Bmim][NTf_2] with 2ME were determined as a function of temperature over the range of 293.15 to 323.15 K. The experimental results are summarized in **Table 2**. The density (ρ) of the binary mixtures exhibits a clear dependence on both composition and temperature. As the mole fraction of IL increases, the density of the mixture rises almost linearly, reflecting the inherently higher density of IL compared to ME as seen in **Figure 2**. For instance, at 298.15 K, the density increases from 0.0950 g·cm^{-3} for pure XME to 1.4365 g·cm^{-3} for pure IL, indicating that even small additions of IL substantially increase the mixture's density. This trend demonstrates that the mixture density is primarily controlled by the proportion of the more densely packed IL molecules. In addition to composition, temperature also influences density. For a given composition, density decreases slightly with increasing temperature, which is consistent with the typical behavior of liquids undergoing thermal expansion. For example, the equimolar mixture shows a decrease in density from 0.7658 g·cm^{-3} at 298.15 K to 0.74993 g·cm^{-3} at 323.15 K. This minor reduction reflects the expansion of molecular volume due to increased thermal motion. Overall, the data indicates that while composition exerts the dominant effect on mixture

density, temperature induces predictable, modest decreases, highlighting the combined influence of molecular packing and thermal effects on the structural characteristics of binary mixtures.

3.2. Viscosities

The viscosity of binary mixtures exhibits a strong dependence on both composition and temperature as shown in **Table 2**, reflecting the differences in molecular size, interactions, and mobility of the components. At 298.15 K, the viscosity increases sharply with increasing IL content, from 1.540 mPa·s for pure ME to 50.715 mPa·s for pure IL. Even small additions of IL result in noticeable viscosity increases; for example, at IL = 0.3021, η reaches 4.425 mPa·s, highlighting the significant contribution of IL to resistance to flow. This trend persists across all measured temperatures, though the absolute values of viscosity decrease with increasing temperature as seen in **Figure 3**. This is due to enhanced molecular mobility and reduced intermolecular resistance. For instance, the equimolar mixture (IL = 0.5001) shows a viscosity of 8.838 mPa·s at 298.15 K, which decreases to 10.705 mPa·s at 323.15 K. These results indicate that the rheological behavior of the mixtures is dominated by the proportion of the highly viscous IL, while temperature acts to reduce viscosity by increasing molecular motion and weakening intermolecular interactions.

3.3 Excess Molar Volumes

The excess molar volume (V^E) of the binary mixture as calculated is also given in **Table 2**. It provides insight into the nature of molecular interactions and packing within the system. The excess molar volume is calculated using the following equation:

$$V^E = \left(\frac{x_1M_1 + x_2M_2}{\rho}\right) - \left(\frac{x_1M_1}{\rho_1} + \frac{x_2M_2}{\rho_2}\right)$$

Where, where ρ_1, ρ_2, and ρ are the densities of[Bmim][NTf2],2ME and the binary mixture, respectively, and x_1 and x_2 are the mole fractions and M_1 and M_2 the molar masses of [Bmim][NTf2] and 2ME, respectively.

Across almost the entire composition range, V^E is negative, with values approaching zero only for the pure components, as seen in **Figure 4** indicating strong attractive interactions between IL and ME molecules. The negative V^E suggests that the mixture forms a more compact structure than predicted for an ideal mixture, likely due to efficient molecular packing and favorable intermolecular forces. The magnitude of V^E is most negative at intermediate compositions, roughly between IL mole fractions of 0.02 and 0.6, with values such as −285.74 $cm^3 \cdot mol^{-1}$ at IL = 0.3021 and −222.83 $cm^3 \cdot mol^{-1}$ at IL = 0.5001 at 298.15 K, reflecting maximal interaction and optimal packing in this region. With increasing temperature, the magnitude of negative V^E decreases slightly; for instance, at IL = 0.5001, V^E changes from −222.83 $cm^3 \cdot mol^{-1}$ at 298.15 K to −240.83 $cm^3 \cdot mol^{-1}$ at 323.15 K. This reduction indicates that thermal motion partially disrupts intermolecular attractions, slightly expanding the mixture. Overall, the excess molar volume data confirm pronounced non-ideal behavior in the binary system, highlighting the significant role of molecular interactions and composition in determining mixture structure.

The Redlich–Kister coefficients (A_0, A_1, A_2, A_3) for excess molar volume (V^E) of the binary mixture ([bmim][NTf_2] + ME) were determined by fitting experimental data to the Redlich–Kister polynomial over the temperature range 298.15–323.15 K at atmospheric pressure.

The experimental values of excess molar values have been fitted to Redlich- Kister type polynomials as given below:

$$V^E = x_1 x_2 \sum_i A_i (x_1 - x_2)^i$$

The fitted coefficients, presented in **Table 3**, exhibit a systematic variation with temperature, reflecting the non-ideal behavior of the mixture. The negative values of A_0 and higher-order coefficients indicate strong attractive interactions between the ionic liquid and methyl ethyl component, resulting in significant volume contraction. As temperature increases, A_0 becomes slightly more negative, while A_2 and A_3 show larger negative magnitudes, suggesting enhanced structural rearrangements and packing effects at elevated temperatures. The standard deviations associated with each coefficient are relatively small, confirming the reliability of the fit. These coefficients are essential for thermodynamic modeling and provide insight into molecular interactions governing the volumetric properties of ionic liquid–solvent systems.

3.4 Viscosity Deviation

The viscosity deviation (Δη) further highlights the non-ideal flow behavior of the binary mixtures.
Deviation of viscosity is calculated by the following equation:

$$\Delta\eta = \eta_m - x_1\eta_1 - (1 - x_1)\eta_2$$

Whereas $\eta_m, \eta_1 and\ \eta_2$ are the viscosities of binary mixture, IL and ME respectively.

Δη is predominantly negative across intermediate compositions, indicating that the observed viscosities are lower than those predicted by ideal mixing rules as seen in **Figure 5**. For example, at 298.15 K and x_{IL} = 0.5001, Δη reaches −17.292 mPa·s, demonstrating significant deviation from ideality. The negative Δη suggests that molecular interactions between IL and ME disrupt the expected viscous behavior, potentially by creating structural arrangements that facilitate flow or reduce internal friction. As temperature increases, the magnitude of Δη decreases markedly; at IL = 0.5001, Δη reduces to −0.005 mPa·s at 323.15 K, reflecting the weakening of these interactions and the increased dominance of thermal motion. The variation of Δη with composition and temperature thus confirms that the IL–ME system exhibits significant non-ideal behavior, with both strong intermolecular interactions and temperature-dependent structural effects influencing viscosity.

4. Conclusion

The thermophysical properties of binary mixtures of the ionic liquid [BMIM][NTf_2] with 2-methoxyethanol were systematically investigated over the temperature range 298.15–323.15 K. Experimental density and viscosity data were used to determine excess molar volumes (V^E) and viscosity deviations (Δη), enabling a comprehensive assessment of the non-ideal volumetric and flow behavior of the system.

The density of the mixtures increases monotonically with increasing ionic liquid mole fraction and decreases slightly with temperature, reflecting the dominant contribution of the high-density ionic liquid and the effect of thermal expansion. The excess molar volumes are negative across almost the entire composition range, with maximum negative values observed at intermediate compositions, indicating strong attractive interactions and efficient molecular packing between [BMIM][NTf_2] and 2-methoxyethanol molecules.

Viscosity shows a strong dependence on both composition and temperature, increasing sharply with increasing ionic liquid content and decreasing significantly with increasing temperature due to enhanced molecular mobility. The viscosity deviations are predominantly negative over intermediate compositions, confirming pronounced non-ideal flow behavior. These negative Δη values suggest that specific intermolecular interactions, including hydrogen bonding, dipolar interactions, and ionic effects, reduce

resistance to flow relative to ideal mixing predictions. The magnitude of Δη decreases with increasing temperature, indicating weakening of structured interactions at elevated temperatures. The experimental excess molar volume data were successfully correlated using the Redlich–Kister polynomial. The fitted Redlich–Kister coefficients (A_0–A_3) exhibit systematic temperature dependence, reflecting changes in intermolecular interactions with temperature. The negative values of A_0 and higher-order coefficients confirm volume contraction upon mixing, while the small standard deviations associated with the coefficients demonstrate the reliability of the fitting. These parameters are essential for thermodynamic modeling and predictive calculations.

Overall, the combined volumetric, viscous, and excess property data provide valuable molecular-level insight into the interactions governing the behavior of the [BMIM][NTf_2]–2-methoxyethanol system. The results reported in this study are expected to be useful for the design and optimization of ionic-liquid-based solvent systems in separation processes, electrochemical applications, and other industrial and environmental technologies.

References

1. Morawska, K., & Wardak, C. (2024). Application of ionic liquids in ion-selective electrodes and reference electrodes: A review. ChemPhysChem, 25(7), e202300818.
2. Barbará, P. V., Choudhary, H., Nakasu, P. S., Al-Ghatta, A., Han, Y., Hopson, C., ... & Hallett, J. P. (2025). Recent Advances in the Use of Ionic Liquids and Deep Eutectic Solvents for Lignocellulosic Biorefineries and Biobased Chemical and Material Production. Chemical Reviews, 125(12), 5461.
3. Anceschi, A., Riccardi, C., & Patrucco, A. (2025). The role of ionic liquids in textile processes: a comprehensive review. Molecules, 30(2), 353.
4. Kaur, H., Thakur, A., Thakur, R. C., & Kumar, A. (2025). A review on multifaceted role of ionic liquids in modern energy storage systems: from electrochemical performance to environmental sustainability. Energy & Fuels, 39(8), 3703-3734.
5. Zhao, H., Xia, S., & Ma, P. (2005). Use of ionic liquids as ‘green’solvents for extractions. Journal of Chemical Technology & Biotechnology: International Research in Process, Environmental & Clean Technology, 80(10), 1089-1096.
6. Plechkova, N. V., & Seddon, K. R. (2007). Ionic liquids:“designer” solvents for green chemistry. Methods and Reagents for Green Chemistry: An Introduction, 103-130.
7. Olivier-Bourbigou, H., Magna, L., & Morvan, D. (2010). Ionic liquids and catalysis: Recent progress from knowledge to applications. Applied Catalysis A: General, 373(1-2), 1-56.
8. Tiago, G. A., Matias, I. A., Ribeiro, A. P., & Martins, L. M. (2020). Application of ionic liquids in electrochemistry—recent advances. Molecules, 25(24), 5812.
9. Tadesse, H., & Luque, R. (2011). Advances on biomass pretreatment using ionic liquids: an overview. Energy & Environmental Science, 4(10), 3913-3929.
10. Mugadza, K., Stark, A., Ndungu, P. G., & Nyamori, V. O. (2020). Synthesis of carbon nanomaterials from biomass utilizing ionic liquids for potential application in solar energy conversion and storage. Materials, 13(18), 3945.
11. Earle, M. J., & Seddon, K. R. (2000). Ionic liquids. Green solvents for the future. Pure and applied chemistry, 72(7), 1391-1398.
12. Rooney, D., Jacquemin, J., & Gardas, R. (2009). Thermophysical properties of ionic liquids. Ionic liquids, 185-212.

13. Aparicio, S., Atilhan, M., & Karadas, F. (2010). Thermophysical properties of pure ionic liquids: review of present situation. Industrial & Engineering Chemistry Research, 49(20), 9580-9595.
14. França, J. M., Nieto de Castro, C. A., Lopes, M. M., & Nunes, V. M. (2009). Influence of thermophysical properties of ionic liquids in chemical process design. Journal of Chemical & Engineering Data, 54(9), 2569-2575.
15. Rehman, A., & Zeng, X. (2012). Ionic liquids as green solvents and electrolytes for robust chemical sensor development. Accounts of chemical research, 45(10), 1667-1677.
16. Fernicola, A., Scrosati, B., & Ohno, H. (2006). Potentialities of ionic liquids as new electrolyte media in advanced electrochemical devices. Ionics, 12(2), 95-102.
17. Picquet, M., Poinsot, D., Stutzmann, S., Tkatchenko, I., Tommasi, I., Wasserscheid, P., & Zimmermann, J. (2004). Ionic liquids: media for better molecular catalysis. Topics in catalysis, 29(3), 139-143.
18. Atilhan, M., Jacquemin, J., Rooney, D., Khraisheh, M., & Aparicio, S. (2013). Viscous behavior of imidazolium-based ionic liquids. Industrial & Engineering Chemistry Research, 52(47), 16774-16785.
19. Ngo, H. L., LeCompte, K., Hargens, L., & McEwen, A. B. (2000). Thermal properties of imidazolium ionic liquids. Thermochimica Acta, 357, 97-102.
20. Kareem, M. O., Amusa, H. K., & Nashef, E. M. (2023, July). Evaluation of the Ionic Liquid, 1-Butyl-1-Methylpyrrolidinium Bis (Trifluoromethylsulfonyl) imide, as a Sustainable Material for Modern Energy Devices. In SPE Nigeria Annual International Conference and Exhibition (p. D032S027R003). SPE.
21. Sultana, S., Ahmed, K., Jiwanti, P. K., Wardhana, B. Y., & Shiblee, M. N. I. (2021). Ionic liquid-based gels for applications in electrochemical energy storage and conversion devices: A review of recent progress and future prospects. Gels, 8(1), 2.
22. Martins, M. A., Neves, C. M., Kurnia, K. A., Carvalho, P. J., Rocha, M. A., Santos, L. M., ... & Freire, M. G. (2016). Densities, viscosities and derived thermophysical properties of water-saturated imidazolium-based ionic liquids. Fluid phase equilibria, 407, 188-196.
23. Troncoso, J., Cerdeiriña, C. A., Sanmamed, Y. A., Romaní, L., & Rebelo, L. P. N. (2006). Thermodynamic properties of imidazolium-based ionic liquids: densities, heat capacities, and enthalpies of fusion of [bmim][PF6] and [bmim][NTf2]. Journal of Chemical & Engineering Data, 51(5), 1856-1859.
24. Vraneš, M., Zec, N., Tot, A., Papović, S., Dožić, S., & Gadžurić, S. (2014). Density, electrical conductivity, viscosity and excess properties of 1-butyl-3-methylimidazolium bis (trifluoromethylsulfonyl) imide+ propylene carbonate binary mixtures. The Journal of Chemical Thermodynamics, 68, 98-108.
25. Harris, K. R., Kanakubo, M., & Woolf, L. A. (2007). Temperature and pressure dependence of the viscosity of the ionic liquids 1-hexyl-3-methylimidazolium hexafluorophosphate and 1-butyl-3-methylimidazolium bis (trifluoromethylsulfonyl) imide. Journal of Chemical & Engineering Data, 52(3), 1080-1085.
26. Salgado, J., Regueira, T., Lugo, L., Vijande, J., Fernández, J., & García, J. (2014). Density and viscosity of three (2, 2, 2-trifluoroethanol+ 1-butyl-3-methylimidazolium) ionic liquid binary systems. The Journal of Chemical Thermodynamics, 70, 101-110.
27. de Castro, C. A. N., Langa, E., Morais, A. L., Lopes, M. L. M., Lourenço, M. J., Santos, F. J., ... & Afonso, C. A. (2010). Studies on the density, heat capacity, surface tension and infinite dilution

diffusion with the ionic liquids [C4mim][NTf2],[C4mim][dca],[C2mim][EtOSO3] and [Aliquat][dca]. Fluid Phase Equilibria, 294(1-2), 157-179.

28. Bettini, L. G., Galluzzi, M., Podestà, A., Milani, P., & Piseri, P. (2013). Planar thin film supercapacitor based on cluster-assembled nanostructured carbon and ionic liquid electrolyte. Carbon, 59, 212-220.
29. Vranes, M., Dozic, S., Djeric, V., & Gadzuric, S. (2012). Physicochemical Characterization of 1-Butyl-3-methylimidazolium and 1-Butyl-1-methylpyrrolidinium Bis (trifluoromethylsulfonyl) imide. Journal of Chemical & Engineering Data, 57(4), 1072-1077.
30. Roy, M. N., Sarkar, B. K., & Chanda, R. (2007). Viscosity, density, and speed of sound for the binary mixtures of formamide with 2-methoxyethanol, acetophenone, acetonitrile, 1, 2-dimethoxyethane, and dimethylsulfoxide at different temperatures. Journal of Chemical & Engineering Data, 52(5), 1630-1637.
31. Victor, P. J., & Hazra, D. K. (2002). Excess molar volumes, viscosity deviations, and isentropic compressibility changes in binary mixtures of N-methylacetamide+ 2-methoxyethanol and N-methylacetamide+ water at (308.15, 313.15, and 318.15) K. Journal of Chemical & Engineering Data, 47(1), 79-82.

Table 1. Comparison of Measured Densities and Dynamic Viscosities with Literature Values for Pure Components at T = (293.15 to 323.15) K

		Density (ρ)		Viscosity (η)	
Component	**temp. (K)**	**exp.**	**lit.**	**exp.**	**lit.**
[BMIM][NTf_2]	298.15	**1.43640**	1.43410 [23]	**50.68**	50.05 [24]
			1.43430 [24]		50.9 [25]
			1.43664 [25]		52 [28]
			1.4368 [26]		50 [29]
			1.4365 [27]		
	303.15	**1.43105**	1.42931 [23]	**41.5**	41.24 [24]
			1.42940 [24]		41.5 [25]
			1.43186 [25]		41 [29]
			1.4320 [26]		
			1.43169 [27]		
	308.15	**1.42407**	1.42454 [23]	**33.68**	34 [29]
			1.42457 [24]		
			1.4272 [26]		
			1.4269 [27]		
	313.15	**1.41895**	1.41978 [23]	**28.45**	28.28 [24]
			1.41961 [24]		28.5 [25]
			1.42234 [25]		28 [29]
			1.4221 [27]		
			1.4225 [26]		
	318.15	**1.41224**	1.41504 [23]	**23.27**	23 [29]
			1.41467 [24]		
			1.41287 [25]		
			1.4178 [26]		
			1.4174 [27]		
	323.15	**1.40981**	1.41031 [23]	**20.52**	20.26 [24]
			1.40965 [24]		20.5 [25]
			1.4131 [26]		20 [29]
			1.41270 [27]		
2ME	298.15	**0.09594**	0.09597 [30]	**1.544**	1.543 [30]
			0.095975 [31]		1.543 [31]
	303.15	**0.09552**		**1.368**	
	308.15	**0.09510**	0.09515 [30]	**1.255**	1.257 [30]
			0.095251 [31]		1.257 [31]
	313.15	**0.09472**		**1.118**	
	318.15	**0.09452**	0.09459 [30]	**1.052**	1.051 [30]
			0.094623 [31]		1.050 [31]
	323.15	**0.09004**		**0.892**	

Table 2. Density, Excess Molar Volumes, Viscosity and Viscosity deviations of ([bmim][NTf2]+ME) binarymixtures as a function of [bmim][NTf2] molefraction in the temperature range from(298.15 to 323.15)K at atmospheric pressure.

X_{IL}	X_{ME}	ρ (g cm^3)	V^E (cm^3 mol^{-1})	η(mPa·s)	Δη
T=298.15					
0.0000	1.0000	0.0950	-0.0136	1.540	0.000
0.0102	0.9898	1.0841	-0.2849	1.596	−0.446
0.0231	0.9769	1.1682	-0.4471	1.669	−1.006
0.3021	0.6979	1.1833	-0.5373	4.425	−11.986
0.4211	0.5789	1.2360	-0.5863	6.706	−15.550
0.5001	0.4999	1.2670	-0.5818	8.838	−17.292
0.6301	0.3699	1.2802	-0.5072	13.918	−18.612
0.7003	0.2997	1.3010	-0.4286	17.787	−18.083
0.8402	0.1598	1.3276	-0.2304	28.998	−13.933
0.8998	0.1002	1.3621	-0.1292	35.711	−10.313
1.0002	0.0000	1.4365	-0.0135	50.715	−0.009
T=303.15					
0.0000	1.0000	0.09552	-0.0002	1.368	0.000
0.0102	0.9898	0.22907	-0.2910	1.416	−0.361
0.0231	0.9769	0.36262	-0.4569	1.480	−0.815
0.3021	0.6979	0.49617	-0.5429	3.835	−9.657
0.4211	0.5789	0.62972	-0.5836	5.756	−12.518
0.5001	0.4999	0.76328	-0.5864	7.537	−13.914
0.6301	0.3699	0.89683	-0.5194	11.745	−14.942
0.7003	0.2997	1.03038	-0.4371	14.925	−14.819
0.8402	0.1598	1.16393	-0.2467	24.056	−11.065
0.8998	0.1002	1.29748	-0.1246	29.482	−8.653
1.0002	0.0000	1.43105	0.0031	41.528	−0.008
T=308.15					
0.0000	1.0000	0.951	-0.0144	1.255	0.000
0.0102	0.9898	1.0005	-0.3086	1.587	0.001
0.0231	0.9769	1.048	-0.4710	1.999	−0.004
0.3021	0.6979	1.0975	-0.5614	10.041	−1.015
0.4211	0.5789	1.1458	-0.6065	14.919	−0.095
0.5001	0.4999	1.1936	-0.6002	17.468	−0.002
0.6301	0.3699	1.2412	-0.5423	21.673	−0.001
0.7003	0.2997	1.2881	-0.4639	23.922	−0.010
0.8402	0.1598	1.3348	-0.2722	28.481	−0.019
0.8998	0.1002	1.3811	-0.1547	30.432	−0.006
1.0002	0.0000	1.42407	-0.0124	33.681	−0.006

T=313.15					
0.0000	1.0000	0.09472	-0.0062	1.118	0.000
0.0102	0.9898	0.22715	-0.3185	1.397	0.000
0.0231	0.9769	0.35958	-0.4859	1.748	−0.001
0.3021	0.6979	0.492	-0.5745	9.388	0.011
0.4211	0.5789	0.62443	-0.6031	12.626	−0.005
0.5001	0.4999	0.75686	-0.6048	14.785	−0.001
0.6301	0.3699	0.88928	-0.5381	18.340	−0.003
0.7003	0.2997	1.02171	-0.4715	20.244	−0.0004
0.8402	0.1598	1.15414	-0.2928	24.107	−0.002
0.8998	0.1002	1.28656	-0.1600	25.827	−0.002
1.0002	0.0000	1.41895	0.0000	28.455	−0.005
T=318.15					
0.0000	1.0000	0.09452	-0.0035	1.052	0.000
0.0102	0.9898	0.22629	-0.3380	1.278	−0.001
0.0231	0.9769	0.35806	-0.5053	1.565	−0.002
0.3021	0.6979	0.48983	-0.5856	7.762	-0.003
0.4211	0.5789	0.6216	-0.6311	10.398	−0.008
0.5001	0.4999	0.75337	-0.6260	12.163	−0.003
0.6301	0.3699	0.88514	-0.5670	15.065	−0.003
0.7003	0.2997	1.01691	-0.4905	16.604	−0.003
0.8402	0.1598	1.14868	-0.3166	19.706	−0.001
0.8998	0.1002	1.28045	-0.1844	21.003	−0.017
1.0002	0.0000	1.41224	-0.0035	23.274	−0.004
T=323.15					
0.0000	1.0000	0.09004	-0.0069	0.892	0.000
0.0102	0.9898	0.22202	-0.3533	1.092	−0.002
0.0231	0.9769	0.354	-0.5247	1.345	−0.003
0.3021	0.6979	0.48598	-0.6069	6.824	-0.005
0.4211	0.5789	0.61795	-0.6410	9.152	−0.006
0.5001	0.4999	0.74993	-0.6254	10.705	−0.005
0.6301	0.3699	0.88191	-0.5772	13.268	−0.003
0.7003	0.2997	1.01389	-0.5015	14.642	−0.001
0.8402	0.1598	1.14587	-0.3263	17.373	−0.001
0.8998	0.1002	1.27784	-0.2061	18.419	−0.001
1.0002	0.0000	1.40981	-0.0120	20.531	−0.003

Table 3. Final Redlich–Kister Coefficients								
T(K)	A_0	A_1	A_2	A_3	$\sigma(A_0)$	$\sigma(A_1)$	$\sigma(A_2)$	$\sigma(A_3)$
298.15	-1.9731	0.61397	-5.31731	-10.00252	0.24876	0.96068	1.79078	3.05769
303.15	-1.98191	0.733	-5.54096	-10.43753	0.24819	0.9585	1.78672	3.05076
308.15	-2.04212	0.78237	-5.95504	-10.63062	0.26052	1.00609	1.87543	3.20223
313.15	-2.02746	0.78713	-6.38888	-10.9176	0.26424	1.02045	1.9022	3.24795
318.15	-2.10287	0.86493	-6.69359	-11.18503	0.28629	1.10563	2.06098	3.51906
323.15	-2.10868	0.84408	-7.21985	-11.52648	0.29385	1.13481	2.11537	3.61192

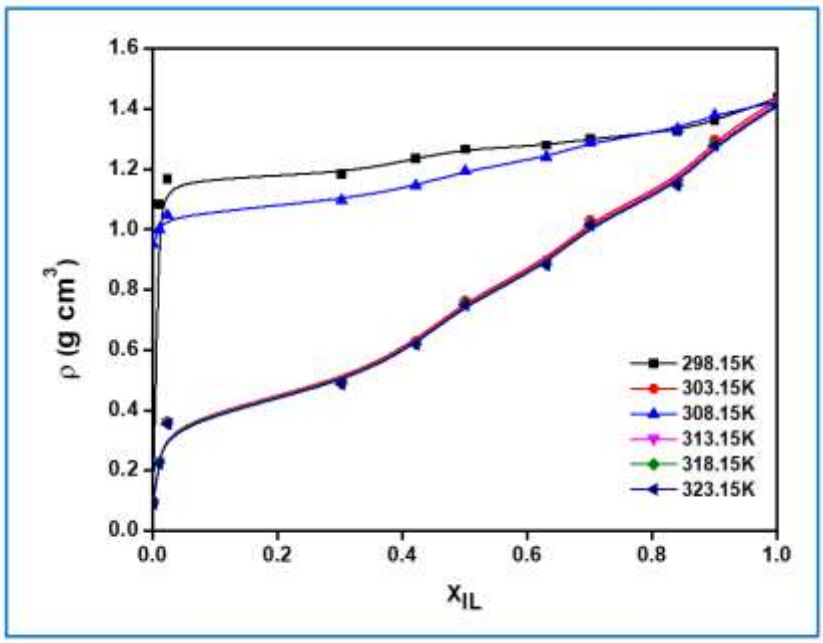

Figure 2. Density of [BMIM][NTf2] + ME binary mixtures against temperature as function of [BMIM][NTf2] mol fraction

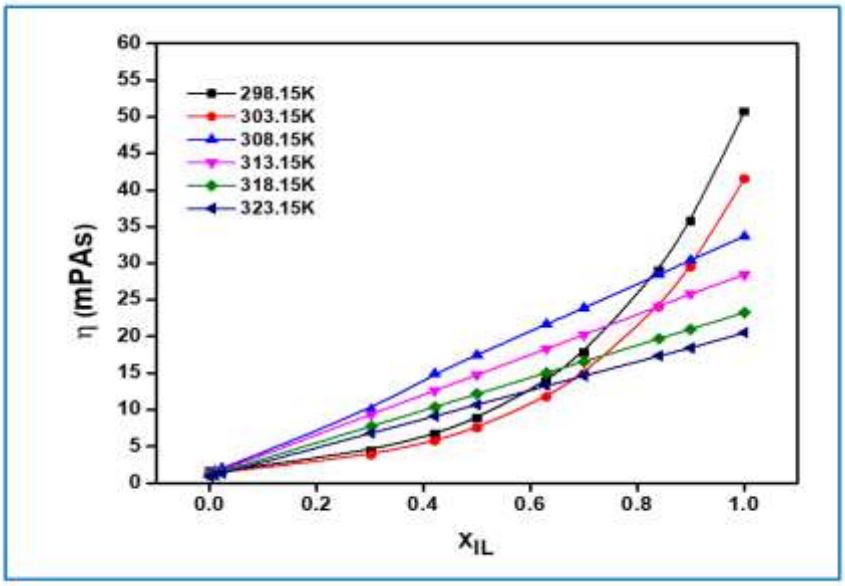

Figure 3. Viscosity of [BMIM][NTf2] + ME binary mixtures against temperature as function of [BMIM][NTf2] mol fraction

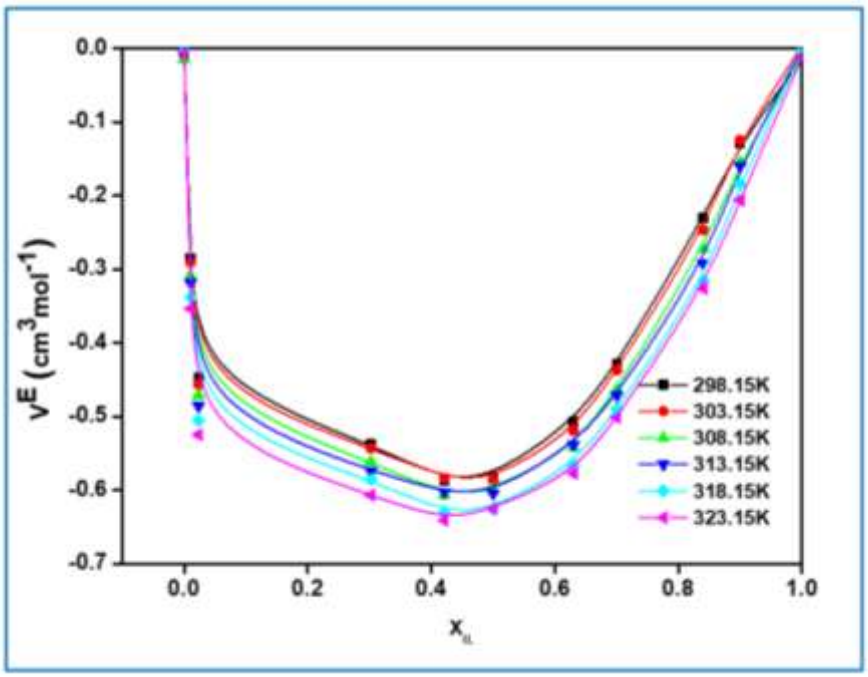

Figure 4. Excess molar volume of [BMIM][NTf2] + ME binary mixtures against temperature as function of [BMIM][NTf2] mol fraction.

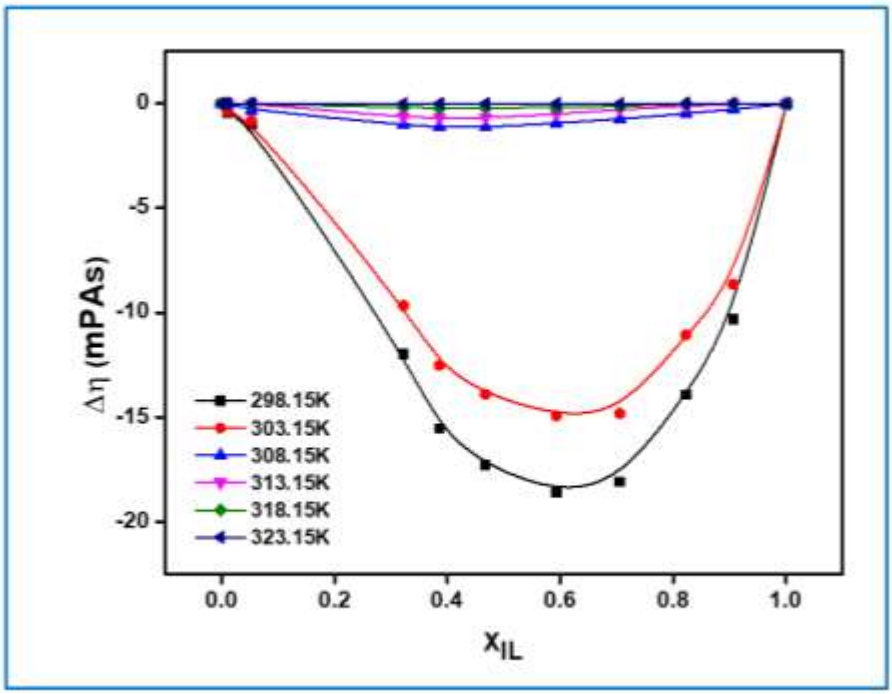

Figure 5. Viscosity deviation of [BMIM][NTf2] + ME binary mixtures against temperature as function of [BMIM][NTf2] mol fraction