Variations Of Excess Viscosities Of Alcohol-Water And Alcohol-Alcohol Mixtures With Temperature

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ABSTRACT: The variation of excess viscosity of several liquid mixtures base on mole fractions with temperatures have been done by many researchers. In this paper, we employed volume by volume ratio of mixing and determined the excess viscosity of four different mixtures of methanol-water, ethanol-water, methanol-ethanol, and methanol-ethanol-water at 308.15 -343.15 K. We found that the excess viscosity of the mixtures generally decrease with increase in temperature and all the values show negativity, indicating lowest interaction.

1. INTRODUCTION

Measuring viscosity is an effective way to know the state or fluidity of a liquid or gas, (Dikko, 2014). It plays an important role in the quality control and in various research and development stages of a wide range of industries, including Food, Chemical, Pharmaceutical, Petrochemical, Cosmetics, Paint, Ink, Coatings, Oil and Automotives. For example, the viscosity of a liquid is an important parameter for designing the piping in a plant or transporting crude oil or chemical agent through a pipeline. In the electronic engineering industry, photo resist fluid is used in the production processes of the printed circuit board, cathode-ray tube, and flat liquid crystal display. Controlling the viscosity of photo resist fluid is a crucial factor to determine the qualities, performance, and yields of finished products. Among those industries, it has been also recognized that controlling optimum viscosity reduces production costs. The characterization of mixtures through their thermodynamic and transport properties is important from the fundamental viewpoint of understand their mixing behaviour (Ezekiel et al, 2012). A thorough knowledge of transport properties of non-aqueous solutions is essential in many chemical and industrial applications (Sathyanarayana et al, 2007). The studies of excess properties such as deviation in viscosity, excess molar volume, excess Gibbs free energy of activation of viscous flow and Grunberg-Nissan interaction constant of binary mixtures are useful in understanding the nature of intermolecular interactions between two liquids (Bhatia et al, 2011, Baskaran et al, 2010, Fedeles et al, 2009). Properties such as density and viscosity at several temperatures both for pure chemicals and their binary liquid mixtures over the whole composition range are useful for understanding of the thermodynamic and transport properties associated with heat and fluid flow (Clara et al, 2010, Patil et al).

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Binary liquid mixtures due to their unusual behaviour have attracted considerable attention due to their importance from both theoretical and practical point of view because these mixtures are used in titration, calorimetry and reaction calorimetry, among other uses (Baskaran et al, 2010, Zivkovic et al, 2010). In this study, experimental viscosity is reported at eight temperatures 308.15, 313.15, 318.15, 323.15, 328.15, 333.15, 338.15 and 343.15 K for volume by volume mixtures of water and some alcohols namely methanol and ethanol, Excess viscosity, (μ^E) has been calculated at various temperatures using the modified logarithmic viscosity equation, (Dikko,2014) .

2. METHOD

Viscosity is generally temperature dependent, so the capillary viscometer is usually used in a controlled-temperature water bath set to a specific temperature. Base on this fact, a temperature control capillary viscometer (Plate 1) was locally constructed, (Dikko, 2014) and used to get the viscosities of the mixtures of methanol, ethanol (BDH grades, 99.4% v/v) with distilled water at various temperatures

Plate I: Photograph of the Constructed Temperature Control Viscometer

The excess viscosities were calculated using the modified logarithmic viscosity equation (Dikko, 2014) as

$$\ln(\mu) = \ln(\mu_\infty) + \frac{T_{ex}}{T}\ln\left(\frac{\mu_{ex} - \mu^E}{\mu_\infty}\right) \quad (2)$$

and recorded in Tables (1 - 4). The plot of ln(μ) against 1/T will give a slope = $T_{ex}\ln[(\mu_{ex}-\mu^E)/\mu_\infty]$ and intercept = $\ln(\mu_\infty)$ on the ln(μ) axis. It can be observed that the infinite viscosity can be determined from the intercept value $\ln(\mu_\infty)$ which is a constant, and in turn, the excess viscosity, μ^E is determined from the slope.

3. RESULTS AND DISCUSSIONS

The experimental viscosities (μ_{ex}), excess viscosities (μ^E) and various temperatures recorded during the studies are given in Tables (1 – 4).

Table 1 Variation of Viscosity (μ_{ex}) and (excess Viscosity (μ^E) with Temperatures for Methanol-Water Mixture, (volume to volume ratio of 1:1)

T (K) ±1	μ_{ex} (10^{-4}Pa.sec) ±0.001	μ^E (10^{-4}Pa.sec) ±0.001
308	6.010	-0.104
313	5.545	-1.205
318	5.125	-1.925
323	4.799	-2.519
328	4.405	-3.013
333	4.168	-3.450
338	3.923	-3.844
343	3.711	-4.163

Table 2 Variations of Viscosity (μ_{ex}) and (excess Viscosity (μ^E) With Temperatures for Ethanol-Water Mixture, (volume to volume ratio of 1:1)

T (K) ±1	μ_{ex} (10^{-4}Pa.sec) ±0.001	μ^E (10^{-4}Pa.sec) ±0.001
308	8.137	-0.233
313	7.425	-0.945
318	6.795	-1.575
323	6.284	-2.086
328	5.730	-2.640
333	5.283	-3.087
338	4.878	-3.492
343	4.536	-3.834

Table 3 Variation of Viscosity (μ_{ex}) and (excess Viscosity (μ^E) with Temperatures for Methanol-Ethanol Mixture, (volume to volume ratio of 1:1)

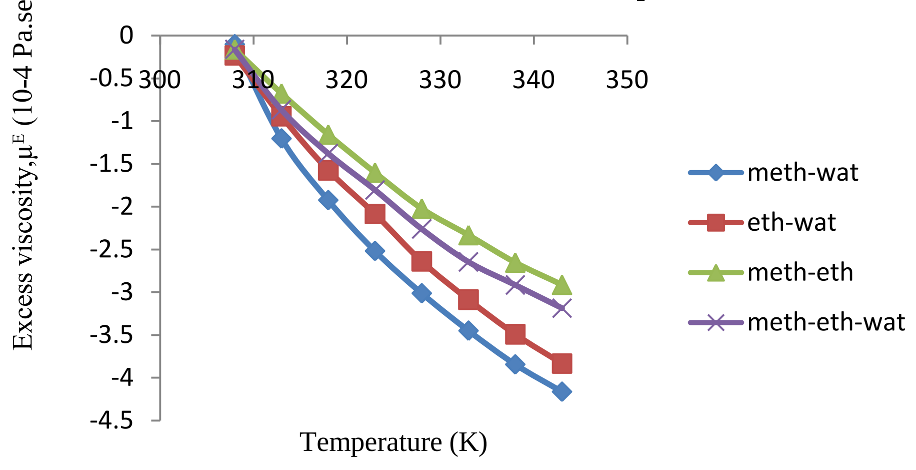
T (K) ±1	μ_{ex} (10^{-4}Pa.sec) ±0.001	μ^E (10^{-4}Pa.sec) ±0.001
308	6.955	-0.162
313	6.440	-0.677
318	5.960	-1.157
323	5.515	-1.602
328	5.095	-2.022
333	4.785	-2.332
338	4.465	-2.652
343	4.205	-2.912

Table 4 Variation of Viscosity (μ) and (excess Viscosity (μ^E) with Temperatures for Methanol-Ethanol-Water Mixtures, (volume to volume ratio of 1:1:1).

T (K) ±1	μ_{ex} (10^{-4} Pa.sec) ±0.001	(μ^E) (10^{-4}Pa.sec) ±0.001
308	7.175	-0.164
313	6.470	-0.869
318	5.960	-1.379
323	5.533	-1.806
328	5.077	-2.262
333	4.692	-2.647
338	4.422	-2.917
343	4.151	-3.188

Excess viscosities are negative over the entire temperature range at the eight temperatures. When temperature increase, (Fig 1) the excess viscosities decrease in such a way that mixture of methanol-water shows the lowest decrease, and methanol-ethanol shows highest decrease. The viscosity behaviour of these mixtures is mainly due to changes in the liquid associated structures of alcohols, (Ezekiel et al, 2012).

Figure 1: Variation of excess viscosities of alcohol-water and alcohol-alcohol mixtures with temperature



These mixtures show no positive values of excess viscosity, indicating that the interactions are lowest in these mixtures, towards an ideal system. In other words, as the molecular size decreases, the magnitude of the excess viscosity decreases, that is, becomes more negative, showing a tendency to the ideal behaviour. Various molecules may mix and dissolve in each other if they have approximately the same type of polarity. In the case of water and alcohol, this is the situation. The hydrogen of the -OH group on alcohol is polar as it is in the water molecule. Also, in solvents such as alcohol, which can take part in hydrogen bond formation, the self-association of alcohols may be increased in favour of hydrogen - bonded forms between solute and solvent, (Ezekiel et al, 2012, Hulya, 2000, Abdollah et al, 2010, Atamas, et al 2009).

4. CONCLUSION

The excess viscosities of the mixtures of alcohol-alcohol and alcohol-water with the mixing ratio of 1:1, volume by volume generally decreases with increase in temperature. All excess viscosity values of the mixtures within the temperature range considered in this study are negative, indicating lowest interaction. The values of the excess viscosities determine from this research are much comparable to the existing values in literature.

References

[1] Abdollah O., Abbas A. R., Maryam M., (2010). Journal of Molecular Liquids. Key: **citeulike:7719392**

[2] Atamas N. A. and Atamas A. A. (2009), World Academy of Science, Engineering and technology, **55.**

[3] Baskaran R., Kubendran T. R. (2010). Int. Journal of Appl. Sci. Engineering **8(2)** 149.

[4] Bhatia S. C., Sangwan, R. Bhatia J. (2011). Molecular Liquids, **161**, 95.

[5] Clara R. A., Marigliano A. C. G., Campos V. V., Solimo H. N. (2010). Fluid Phase Equilib. **293** , 151.

[6] Dikko A. B., (2014), PhD Thesis, Department of Physics, Modibbo Adama University of Technology, Yola.

[7] Ezekiel D. D., Simphiwe M. N., David A. I., Eno E. E., (2012) Int. J. Electrochem. Science, 7 11101 – 11122

[8] Fedeles, O. C., Iulian O. (2009), U. P. B. Science Bulletin, B 71 (4) 99.

[9] Hulya, Y. (2000), Excess Properties of Alcohol - Water Systems at 298.15 K. Turk J Phys **26** pp 243 = 246.

[10] Kijevcanin M. L. J., Kostic V. Z., Radovic I. R., Djordjevic B. D., Serbanovic S. P. (2008). Chem. Ind. Chem Eng. **14(4)** 223.

[11] Patil S. S., Mirgane R. S. R. (2011) J. Chem. **4(2)** 445.

[12] Sathyanarayana J. B., Ranjithkumar B., Jyostna T. S., Satyanarayana N. (2007). J. Chemical Thermodynamics, **39** 16.

[13] Zivkovic E. M., Kijevcanin M. L., Radovic I R., Serbanovic S. P., Djordjevic B. D (2010). Fluid Phase Equilib. **299** 191.