Journal of Advances in Applied Sciences and Technology

ISSN : 2393-8188 (print)
2393-8196 (online)
www.milliyasrcollege.org.journal.php

DENSITY, ULTRASONIC VELOCITY AND VISCOSITY STUDY OF NITROMETHANE+ETHANOL BINARY LIQUID MIXTURE AT 313K.

***Hanuman Thorat*[*1,] *Surekha Patankar*[2], *Aruna Patil*[3], *Aruna Maharolkar*[4],**

[1]Department of Physics, Dr. Babasaheb Ambedkar Marathwada University Aurangabad-431004. India
[2]Vasantarao Naik Mahavidyalaya Aurangabad.
[3]Vivekanand Arts Sardar Dalipsingh Commerce and Science College, Aurangabad.
[4]G. S. Mandal's Maratwada Institute of Technology, Aurangabad.
*Corresponding author email:phys.hnthorat@gmail.com

ABSTRACT: Density (ρ), Ultrasonic velocity (U) and Viscosity (η) of Nitromethane+Ethanol binary liquid mixture have been measured at 313.15K, at atmospheric pressure. The mixture of solute and solvent is carried out as a function of volume concentration. From the experimental data, the theoretical properties such as Acoustic Impedance (Z), Adiabatic Compressibility (β) and Intermolecular Free Length (L_f) along with their excess properties have been calculated. The deviation of these excess properties reveals the strength of interactions present in the pure and mixed component and also predicts the type of intermolecular interactions.
KEYWORDS: Excess properties; binary liquid mixture; intermolecular interactions; Acoustic Impedance.

1. INTRODUCTION

The complete knowledge of thermodynamic and transport properties of the organic compounds, makes it useful in Industrial and Non-industrial application. From the practical point of view, physico-chemical properties plays a vital role in applicability, so which makes it thrust area to understand the molecular properties of the mixture. Over the past several decades various researchers [1-3] are engaged with the study of thermodynamic and acoustical properties of organic compounds, because of tremendous Industrial and consumer applications.

The practically observed and theoretically calculated properties of the liquid mixtures are routinely used now a day. The importance of these properties is of considerable importance because of its use in processing of goods or even product formulation with the help of various liquid mixtures.

As an organic solvent Ethanol and Nitromethane both the liquids are widely used in various industries where as the Ethanol from the family of Alcohol play an important role in many medical as well as consumer applications. The NM studies are of great interest because of its use in a detonating homogeneous liquid explosive [4] and in lots of industrial applications such as in extractions, as a reaction medium, and as a cleaning solvent.

The physical properties such as density, viscosity, ultrasonic velocity and acoustic parameters such as acoustic impedance, adiabatic compressibility and Intermolecular free length and their excess values as excess velocity, excess density, excess molar volume, excess compressibility and excess intermolecular free length are determined using the measured data. The calculated excess parameters have been fitted to Redlich-Kister polynomials equation [5], and the results are used to predict the intermolecular interactions.

2. EXPERIMENTAL

2.1 CHEMICALS

The chemicals used in the present work, Ethanol and Nitromethane, were of Spectroscopic grade and were obtained Ethanol from Spectrochem Pvt. Ltd. Mumbai (India) and that of Nitromethane form Les Alcools De Commerce Inc. Brampto, Ontario (Canada). Both the chemicals are commercially with <99.8% purity and were used without further purifications. The solutions were prepared at different volume percentage of Nitromethane in Ethanol in the steps of 10% at room temperature. The special airtight bottles are used to prepare and keep the samples. The samples were used within the

four hours from the time of preparation to avoid the further contamination or additional reactions.

2.2 INSTRUMENTATION

The densities of pure and binary mixtures were measured using a portable Digital Density meter (Model Anton Paar DMA-35). It is based on the principle of vibrating U-tube to calculate the density of sample. The quantity required to measurement is 2ml and the accuracy of the instrument is 10^{-4} gm/cm^3. Before use the instrument is calibrated with the help of doubly distilled water and some pure liquids of known densities, and it seems to be in good agreement with known values.

The Ultrasonic velocity measurements are carried out with the help of Ultrasonic Interferometer for liquid (Model F-05 supplied by Mittal Enterprises, New Delhi). The instrument uses single crystal infrastructure operating at fixed 2MHz frequency. The required sample for measurement is 10 ml. The sample cell is double coated to circulate the water between the walls to maintain the temperature of the sample. An electronically programmable water bath is used to control the temperature of the sample. Also the temperature of the sample in sample cell is checked with the digital thermometer (Fisher Scientific) of the range -50^{0}C to +150^{0}C.

All the measurements for pure and binary mixtures were performed for 3 to 5 times and the average of these values was used in all the calculations.

2.3 THEORETICAL ANALYSIS

Acoustic Impedance (Z):

Acoustic impedance is the property of a medium, which shows the opposition exerted by the medium to displacement of the medium's particles by the sound energy (immersed through the medium). If the molecular interaction occurs, the acoustic impedance exhibits in nonlinear variations with increasing mole fractions of solute. This is an essential tool to predict interactions of molecular level in liquid mixtures [6]. The specific acoustic impedance is given by the equation as given below,

$$Z = U.\rho \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Adiabatic Compressibility (β)

The adiabatic compressibility is the fractional decrease of the volume per unit increase of pressure, when no heat flows in or out of the medium. It is calculated from the measured values of Ultrasonic velocity (U) and the density (P) of the medium by using the equation,

$$\beta = \frac{1}{U^2\rho} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Where U is the ultrasonic velocity and ρ is the density of the sample.

Intermolecular free length (L_f):

Intermolecular free length L_f is the measure of the distance between to atoms of the molecules. It is a predominant factor in determining the variations of ultrasonic velocity (U) in the liquids. As free length L_f increases, U decreases and vice-versa, showing an inverse behaviour. The interdependence of L_f and U has been evaluated from model given by Eyring and Kincaid as shown in equation 3. The intermolecular free length is the distance between the surfaces of the neighbouring molecules, and it is calculated by the relation,

$$L_f = K_t(\beta_{ab})^{\frac{1}{2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

Excess parameters:

The excess parameters of the samples can be calculated by using the general relation of the excess property and it is given by the relation as,

$$A_m^E = A_{12} - (x_1M_1 + (1-x_1)M_2) \quad \ldots\ldots\ldots\ldots\ldots 5$$

Where x_1, 1-x_1, and M_1, M_2 are the mole fractions and molecular weights of the components 1 and 2 respectively.

3. RESULTS AND DISCUSSION

Table 1: Experimental Observations.

Mole fraction of Nitromethane	Density (Kg/m^3)	Ultrasonic Velocity (m/s)	Viscosity (10^{-3}Ns/m^2)
0.0000	791.3	1143.92	0.99
0.1049	835.5	1152.83	0.71
0.2086	874.3	1162.64	0.65
0.3112	885.9	1164.68	0.62
0.4128	911.6	1172.45	0.58
0.5132	941.5	1180.60	0.52
0.6127	0981.5	1194.87	0.51
0.7110	1011.7	1206.26	0.45
0.8083	1034.2	1219.32	0.49
0.9047	1053.9	1229.51	0.51
1.0000	1105.5	1255.17	0.55

Table 1 shows the experimental observed values of density, ultrasonic velocity and Viscosity for the binary liquid mixture of Ethanol in Nitromethane. All the studied values are observed at 313K. From the table the values of Density and Ultrasonic Velocity are increases whereas the Viscosity is decrease as the concentration of the Nitromethane is increases. The variation in the observed values shows the simply molecular interactions occurs between two substances. Also the Fig. 1, 2 and 3 shows the Excess Density, Excess Velocity and Excess Viscosity as a function of mole fraction of NM.

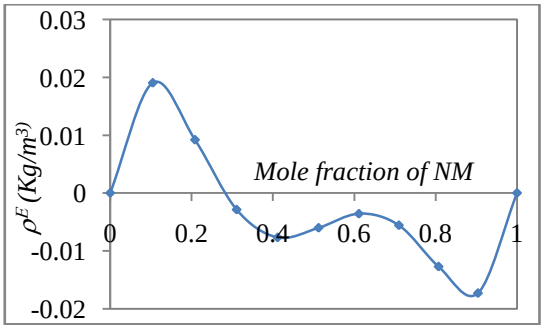

Fig.1 *Excess Density as a function of Mole fraction of NM at 313K.*

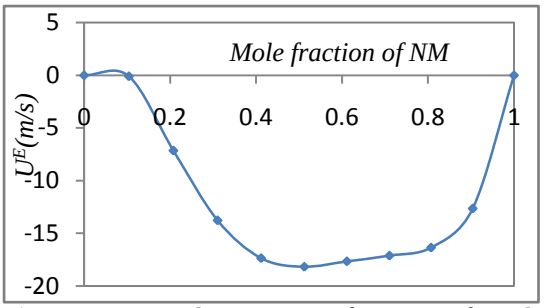

Fig.2 *Excess Velocity as a function of Mole fraction of NM at 313K.*

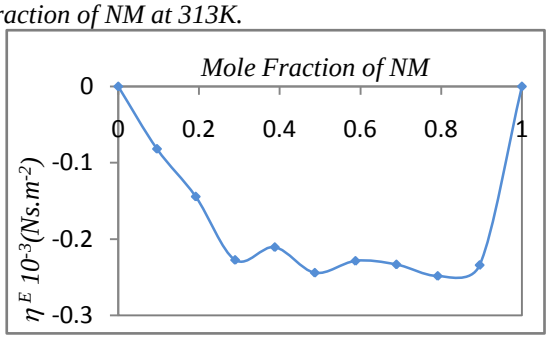

Fig.3 *Excess Viscosity as a function of Mole fraction of NM at 313K.*

The behaviour of binary systems under investigation has been qualitatively examined using the excess functions. As mentioned earlier, in pure the molecules associated through hydrogen bond, mixing of ethanol with Nitromethane will induce the rupture of hydrogen bonds in the liquids with subsequent increase in β^E and L_f values, However, due to simultaneous formation of hydrogen bonds between OH groups of unlike molecules there is a compensating effect resulting in an overall decrease in β^E and L_f values with concentration of Nitromethane, as seen from Fig. 4, 5 and 6 respectively

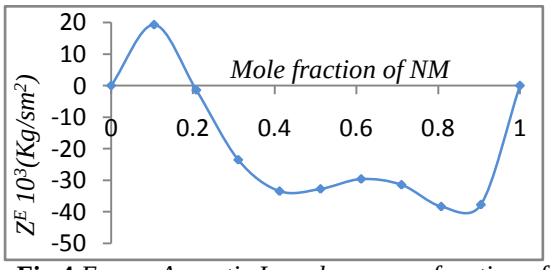

Fig.4 *Excess Acoustic Impedance as a function of Mole fraction of NM at 313K.*

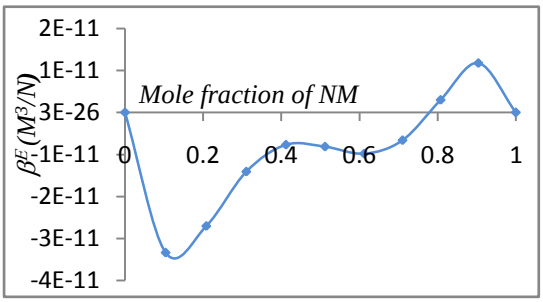

Fig.5 *Excess adiabatic compressibility as a function of Mole fraction of NM at 313K.*

The non-linear nature of specific acoustic impedance reveals the information about the intermolecular association. The fig.4 shows negative deviation of excess acoustic impedance which indicates presence of weak molecular interaction between the molecules of the binary liquid mixture. Fig. 5 shows the values of the Excess adiabatic compressibility, the negative values of β^E indicates the mixture is less compressible than the corresponding ideal mixture [7]. The values of β^E can be explained on the basis of the complex formation between Ethanol with NM molecules through hydrogen bonding between oxygen atom of ethanol and hydrogen atom of hydroxyl group in Nitromethane. According to the *Fort and Moore et al* [8] which suggests that different molecular sizes in the liquid mixtures generally mix and cause to decrease in volume gives negative β^E values. The graph for β^E negative values indicates that the molecular interactions are weaker in the present system where as the positive values shows dominant forces.

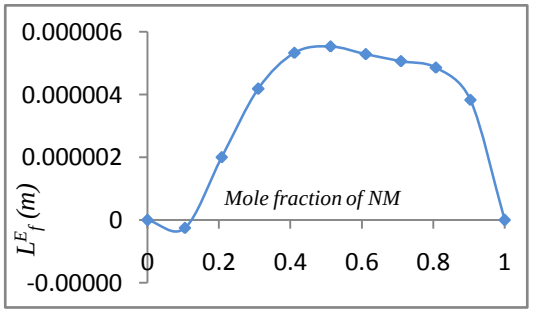

Fig.6 *Excess molecular free length as a function of Mole fraction of NM at 313K.*

Fig.6 shows the excess molecular free length. The deviation in excess intermolecular free length L_f^E is the measure of the intermolecular distance. The positive deviation in the liquid mixture suggests that the molecule in the liquid becomes less compact and hence the density and velocity decrease.

4. CONCLUSIONS

In the present work, the densities, viscosities and speed of sound at 313.15 K have been measured over the entire range of composition of Nitromethane with Ethanol. From these measured physico-chemical data, various excess properties have been calculated. These data were fitted to Redlich–Kister type polynomial equation to derive results and used to interpret molecular interactions between the component molecules.

All the studied parameters of the present system of Nitromethane+Ethanol show non linear deviations indicating the occurrence of the intermolecular interactions in the system and the result concludes that, the molecular interactions in the present system are weak in nature.

ACKNOWLEDGEMENT:

All the authors are heartily acknowledge Dr. Anita G. Murugkar, Associate Professor, Department of Physics, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad, for providing the Infrastructural and Instrumental facility, for the completion of the present work. Also we are grateful for her guidance and advice at every stage to complete the work.

REFERENCES:

[1] H. Kellay, D. Bonn and J. Meunier, *"Prewetting in a Binary Liquid Mixture"* Physical Review Letters Vol-17, 1993(16), 2607-2610.

[2] J.N.Ramteke, *"Ultrasonic study of molecular interaction in binary liquid mixture containing α - picolin in ethanol at 301.15 K and 305.15K"* Adv. Appl. Sci. Res., 2012, 3(3):1832-1835

[3] A.Ali, A Yasmin & A.K.nain,*"Study of intermolecular interactions in binary liquid mixtures through ultrasonic speed measurement"* Indian J.of pure & appl phys, vol 40, may 2002, 315-322.

[4] Himanshu SHEKHAR, *"Explosive Characteristics and Shaped Charge Applications of Nitromethane (NM): A Review"* Central European Journal of Energetic Materials, 2012, 9(1), 87-97.

[5] Redlich O. Kister A. T. *"Algebraic representation of thermodynamic properties and the classification of solutions"* Ind. Eng. Chem. 1984, 40, 345-348.

[6] Aruna P. Maharolkar ,A. G. Murugkar, S. S. Patil P. W. Khirade *"Characterization of Dominant Hydrogen Bonded Complex Strucutres"* Asian Journal of Chemistry vol 25 No. 2 (2013), 937-940

[7] K. Narendra, C. Srinivasu, S. Fakruddin, P.Narayanamurthy, *"Excess parameters of binary mixtures of anisaldehyde with o-cresol, m-cresol and p-cresol at T = (303.15, 308.15, 313.15, and 318.15) K"* J. Chem. Therm, 43 (2011) 1604–1611.

[8] R.J. Fort and W.R. Moore, *"Adiabatic compressibilities of binary liquid mixtures"* Trans. Faraday Soc. 61 (1965) 2102–2110.