Molecular Interaction study of Ammonium Hydroxide with Ethanol using Ultrasonic Technique at 313K and 1MHz Frequency

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Abstract: ***The density, ultrasonic velocity and viscosity at 313K temperature and 1MHz frequency have been measured in the binary system of Ammonium Hydroxide (NH_4OH) with Ethanol. When two or more liquids are mixed, there occur some changes in physical and thermodynamic properties because of free volume change, change in energy and change in molecular orientations. Thermodynamic and acoustical parameters like adiabatic compressibility, internal pressure and free volume are of considerable interest in understanding the inter-molecular interactions in binary liquid mixtures. Ultrasonic studies have been found to be useful in describing the theory of liquid state of matter. The density (ρ), ultrasonic velocity (U) and viscosity (η) can be used to study the Physico-chemical behaviour and molecular interactions in pure liquids, liquid mixtures and the solutions.From the acoustical parameters, the nature and the strength of molecular interactions in the binary system of Ammonium Hydroxide + Ethanol are discussed. The changes in the nature and degree of molecular interactions in different concentration of the binary system- Ammonium Hydroxide + Ethanol, depends upon the nature of solvent, the structure of solute molecule and extent of solution taking place in the solution. It has been observed that, weak dispersive type intermolecular interactions are confirmed in the system investigated. The nonlinear behaviour of these parameters provides the knowledge about various interactions among the molecules.***

Keywords: *Ultrasonic velocity, acoustical parameters, molecular interactions, binary mixtures, Ammonium Hydroxide (NH_4OH) and Ethanol.*

1. Introduction

The studies on thermo dynamical properties of binary &ternary mixtures are increased in recent years due to industrial applications [1, 2]. Studying molecular interaction from knowledge of variation of acoustic parameters with change in mole fraction gives an insight to understand molecular processes [3, 4]. Ultrasonic is used in many applications like Ultrasound in medical field, in industry and in the field of Research etc. [5, 6]. Ammonium Hydroxide (NH_4OH) is an alkali (solute) and Ethanol is a (solvent) used in the present study for their ultrasonic characterizations.

The solute- solvent molecular interactionand the association arises due to polar natureof the solvent [7, 8]. The natural phenomenon involves the interaction between matter & energy. Work on liquids offers direct effective information about molecular interactions [9,10].Ultrasonic parameters are directly related to large number of molecular & thermo dynamical properties[11]. Viscosity measurement covers physico-chemical properties which are susceptible to mixtures on various counts [12]. Recently Ultrasonic, dielectric, viscosity measurements are found to be helpful to study structural properties of liquids [13]. In the present study, the acoustical parameters, the nature and the strength of molecular interactions of Ammonium Hydroxide + Ethanolbinary system have been discussed in the light of their non-linear behaviour and the weak dispersive type molecular interaction.

2. Experimental Details

The liquids were of Analar grade and redistilled before use. The binary mixture of different mole fractions of two components namely Ammonium Hydroxide (NH_4OH) and Ethanol were prepared immediately before use.For ultrasonic velocity measurement, Ultrasonic Multi frequency Interferometer (Model No. F-83, Mittal, New Delhi) was used with an accuracy of $\pm 0.1 ms^{-1}$ working at fixed frequency 1MHz**.** An electronically and digitally operated constant temperature water bath has been used to circulate water through the double walled measuring cell made up of steel containing experimental solution at the desired temperature. The density of pure liquids and liquid mixtures was determined using pycknometer by relative measurement method with an accuracy of $\pm 0.1 Kgm^{-3}$. An Ostwald's viscometer was used for the viscosity measurement of pure liquids and liquid mixtures with an accuracy of $\pm 0.001 NSm^{-2}$. The temperature around the interferometer, viscometer and pycknometer was maintained within ±0.1K. All necessary precautions were taken to minimise the possible experimental errors. Using measured values of ultrasonic velocity, density and viscosity, different acoustical interaction parameters such as adiabatic compressibility (β_a), intermolecular free length (L_f) and specific acoustical impedance (Za), are calculated.

3. Theory/Formulae

Using the experimental data of U, ρ andη, various acoustical parameters such as βa, L_f and Za were calculated by using standard equations:-

$$\beta a = 1/(U^2\rho) \quad \text{---- (1)} \quad L_f = K_T(\beta a)^{1/2} \quad \text{----- (2)}$$

$$Za = U.\rho \quad \text{---- (3)}$$

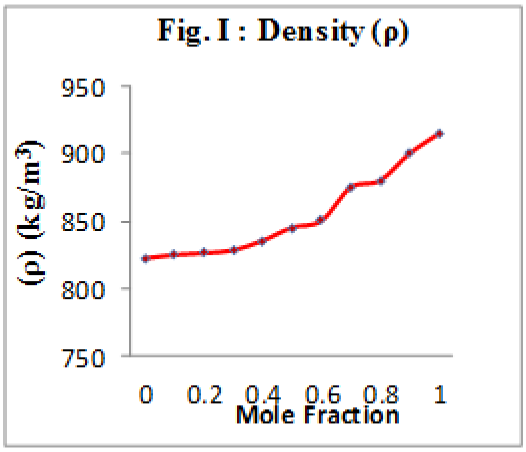
Where, K_T is the Temperature dependent Jacobson's constant in MKS system, T is the absolute temperature = 313K. After calculations, graphs were plotted for density (ρ), ultrasonic velocity (U), viscosity (η), adiabatic compressibility (βa), free length (L_f) and Acoustic impedance (Za) verses mole fraction (X) of Ammonium Hydroxide (NH_4OH) in Ethanol (Fig: I-VI).

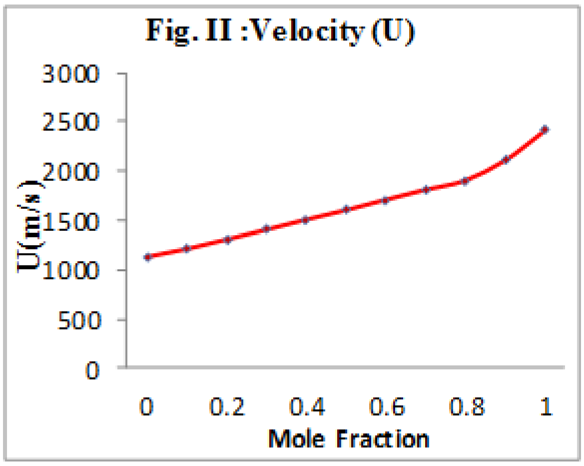
4. Tables and Graph

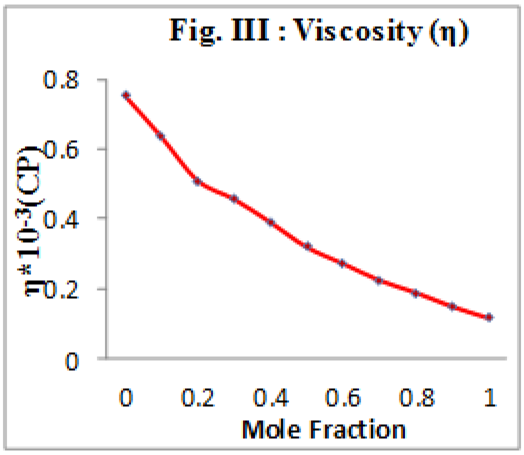
Table 1: Density (ρ), Velocity (U), viscosity (η), adiabatic compressibility (β_a), Intermolecular free length (L_f) and Acoustic impedance (Za) of Ammonium Hydroxide + Ethanol at 313K and at 1 MHz frequency.

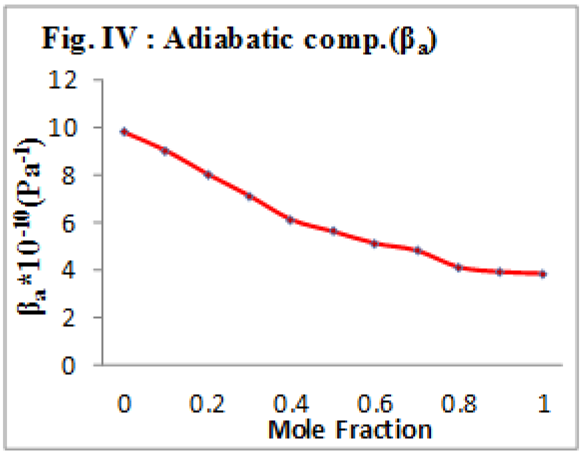
Mole fraction of NH_4OH in Ethanol	ρ (kg/m^3)	U (m/s)	$\eta*10^{-3}$ (CP)	β_a*10^{-10} (Pa^{-1})	L_f*10^{-10} (m)	$Z*10^6$ (kg/m^2s)
0.0	822.70	1130.00	0.752	9.777	0.624	0.934
0.1	824.21	1210.00	0.635	9.000	0.630	1.000
0.2	826.56	1305.66	0.510	8.010	0.645	1.100
0.3	828.63	1403.66	0.457	7.100	0.660	1.181
0.4	835.75	1505.66	0.391	6.100	0.680	1.287
0.5	845.45	1601.33	0.320	5.600	0.703	1.407
0.6	850.37	1706.00	0.273	5.101	0.725	1.524
0.7	875.12	1807.66	0.225	4.800	0.750	1.705
0.8	880.18	1903.00	0.190	4.100	0.775	1.900
0.9	900.14	2106.33	0.150	3.900	0.810	2.301
1.0	915.00	2410.00	0.117	3.829	0.907	2.778

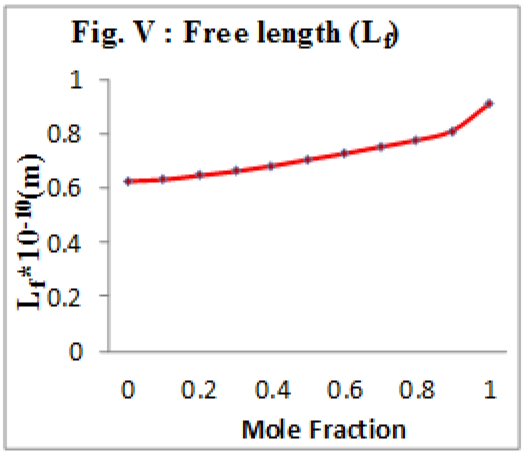
FIGURE I-VI: The variations of Velocity (U), Density (ρ), Viscosity (η), adiabatic compressibility (β_a), free length (L_f), and Specific acoustical impedance (Za) w. r. to mole fraction (X) of the system: Ammonium Hydroxide + Ethanol at 313K are shown in Fig.: I, II, III, IV, V and VI respectively.

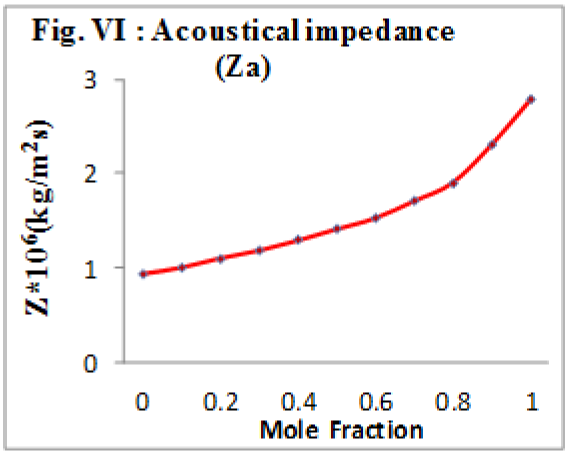












5. Results & Discussion

The experimentally determined values of density (ρ), viscosity (η), ultrasonic velocity (U) and evaluated some of the acoustical parameters such as adiabatic compressibility (βa), free length (L_f) and acoustic impedance (Za) at 313K for the system of Ammonium Hydroxide + Ethanol were listed in Table-1. The variations of density (ρ), viscosity (η), ultrasonic velocity (U), adiabatic compressibility (β_a), intermolecular free length (L_f) and acoustic impedance (Za) with respect to mole fraction (X) of Ammonium Hydroxide + Ethanol binary systems are shown in Fig.: I-VI, respectively.

From the Table-1, it has been observed that the ultrasonic velocity and density increases with increasing the mole fraction of Ammonium Hydroxide in ethanol while the viscosity decreases. This may be due to association and dipole –dipole interaction between the component molecules. In the present systems, due to thermal agitation of component molecules, the inter-molecular interaction becomes weak and this is indicated by increase in ultrasonic velocity values.

In the present investigation, it is observed that adiabatic compressibility decrease and free length increase with increase in the concentration of Ammonium Hydroxide in Ethanol. The decrease in adiabatic compressibility indicates the enhancement of the bond strength. From Fig.:-VI, it is also observed that the values of acoustic impedance increase with increase in molar concentration of Ammonium Hydroxide in Ethanol. Acoustic impedance Za is resistance part of medium of mechanical vibration. This resistance increases proportional to density of medium and ultrasonic velocity of sound in medium. This is due to increase in pressure and cohesive energy of the system because of strong interaction.

6. Conclusion

The observed increase of ultrasonic velocity indicates the solute-solvent interaction. The existence of solute-solvent type molecular interaction is favoured in the system- Ammonium Hydroxide + Ethanol, confirmed from the U, ρ, η, βa, L_f, and Za data. This provides useful information about inter and intermolecular interaction of liquid mixtures as exist in liquid systems investigated. The non-linear behaviour confirms the presence of solute-solvent, solvent-solvent, and dipole-dipole interactions. For the observed molecular interaction, hydrogen bond formations are responsible for the hetero molecular interaction in the liquid mixture.

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References-

[1] Chimankar O.P, Shriwas Ranjeeta, Tabhane V.A, Intermolecular Hydrogen bonding formation in aqueous D-Mannitol, Archives of Applied Science Research, 2010, Vol.2, Issue 6, p 285.
[2] Bhandakkar V. D. and Asole A. W. Ultrasonic study of hydrogen bonded complexes in benzene solution , Pelagia Research Library**,** Advances in Applied Science Research, 2013, 4(4): 207-213, ISSN: 0976-8610.
[3] Pitzer K.S. (1995). Thermodynamics, 3rd edition McGraw-Hill book co, NY, ISBN 0-07-05022,1-8.
[4] Srinivasulu V. & Naidu P.R. (1995). Ultrasonic behaviour of liquid mixtures of n-hexane with 1-alknaols at 303.15K, J. Pure and Appl. Ultrasonic, (17), 14-28.
[5] Bhandakkar V D, Sweta S Rode and Pratibharani A Maddi, Thermo-acoustical and nonlinear molecular interaction studies in binary liquid mixtures at 303K, Scholars Research Library, Archives of Applied Science Research, 2012, 4 (6):2546-2551, ISSN 0975-508X .
[6] Kannapan, A.N. & Rajendran, V. (1991). Molecular interaction studies in ternary liquid mixtures from ultrasonic data, Indian J. Pure and Appl. Phys., 29, 465-468.
[7] Praharaj M. K., Satapathy A., Mishra S. & Mishra, P. R. (2012). Study of thermodynamic and transport properties of ternary liquid mixture at different frequencies, J Chem. & Pharma. Research, 4(4), 1910-1920
[8] Bhandakkar V D, Bhat V R, Asole A W & Chimankar O P, Molecular Interaction Study of Binary Liquid Mixture of Tetrahydrofuran and Ethanol at 313K ,

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[9] Bhandakkar V D, Tabhane V A & Sharda Ghosh (2003). Ultrasonic study of molecular interactions in Binary Liquid mixtures: Acrolein and Cinnamaldehyde in methanol, cyclohexane & p-dioxane. Ind Jour Pure and Appli Phys, (41), 849 -854.

[10] Rajgopal, K. & Chenthilnath, S. (2010), Excess thermodynamic studies of binary mixtures of 2-methyl-2-Propanol with ketones, Indian J .Pure and Appl. Phys., 48, 326-333.

[11] V.D. Bhandakkar, O.P. Chimankar & N.R. Pawar, Ultrasonic study of molecular interactions in some bio-liquids, J. Chem. Pharm. Res., 2010, 2(4):873-877, ISSN No: 0975-7384.

[12] Bhandakkar V. D., Bhat V. R., Chimankar O. P. and Asole A. W., Thermo acoustical study of Tetrahydrofuran with ethanol using ultrasonic technique at 323K, Pelagia Research Library, Advances in Applied Science Research, 2014, 5(2):80-85, ISSN: 0976-8610,

[13] Bhandakkar V. D. and Sweta S. Rode Acoustical studies on molecular interactions in binary liquid mixtures at 303K, Pelagia Research Library, Advances in Applied Science Research, 2012, 3 (5):3223-3229, ISSN: 0976-8610.