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Thermo-acoustical study of binary liquid mixture containing Tri Ethyl Amine in n-Hexane at 305.15k

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ABSTRACT: *Ultrasonic velocity and absorption measurements in binary liquid mixture as a function of the concentration and concentration are useful in gaining insight into the structure and bonding of associated molecular complexes and other molecular processes occurs in these liquid mixtures. The results observed in these ultrasonic measurements have been correlated with molecular interactions in liquid mixtures with some degree of success. The absorption and velocity of sound in binary mixtures of triethylamine with n-hexane have been measured at a central frequency of 5MHz, using the interferometer. Ultrasonic absorption peaks at intermediate concentrations have been found in a binary mixture. In this work, measurements of the velocity, absorption coefficient, density, adiabatic compressibility, excess compressibility, and shear viscosity as functions of the concentration are reported. The adiabatic compressibility and excess compressibility were calculated from the velocity and the density measurements. The ultrasonic velocity (u), density (ρ) and viscosity (η) have been measured for the binary mixtures of triethylamine with n-hexane at 305.15K. From the experimental data, Adiabatic Compressibility (β), Free Length (L_f), Free Volume (V_f)), Internal Pressure (π_i), Acoustic Impedance (Z), and Cohesive Energy(H) have been calculated. In addition to that the excess values of certain above parameters are also computed. These excess parameters have been used to discuss the presence of significant molecular interactions in binary mixture. By taking measurements at several concentrations of each liquid mixture, we obtained information about the molecular association between the two different molecules in the liquid mixture. The data presented may stimulate other researchers to consider the molecular processes taking place in these liquid mixtures. Such data are valuable in building a core of basic information about these liquids, especially pyridine, which is an important liquid used currently in the extraction process for coal to analyze its compounds and in the manufacture of vitamin B6 and other drugs. In this mixture the magnitude of the peaks in variation of ultrasonic velocity and absorption was observed with change in temperature. The binary system shows a pronounced volume contraction on mixing with evolution of heat. The origin of the large ``excess'' sound absorption can be accounted for in terms of a compression relaxation and a simple molecular model based on the properties of the hydrogen bonds between like and unlike molecules in the binary liquid mixture. The compression of excess number of AB bonds in this mixture is formed at the expense of AA and BB bonds leading to a relaxation process. The absorption curves satisfactorily yield approximate values of the mean relaxation. The observed absorptions in this liquid mixture are considerably greater than would be expected from classical theory. Consequently, the experimental data appear to require a new, or at least modified, theoretical approach. The problem is discussed briefly in the light of modern theories of molecular association, liquid crystal formation, etc. These liquid mixtures are of interest to organic chemists who want to know about the type of bond and the number of each kind of molecule in the formation of complex in binary liquid mixture.*

Keywords: *Magnetic fluid, ultrasonic velocity, density, viscosity, thermo-acoustic parameters, and intermolecular interactions.*

I. INTRODUCTION

Now-a-days ultrasonic is an area of intense scientific and technological research. In view of its extensive scientific and engineering applications it attracts attention of researchers, non- destructive testing professionals, industrialists, technologists, medical practitioners, instrumentation engineers, software engineers and medical scientists. The study of ultrasonic waves in pure and liquid mixtures is useful to examine the nature of intermolecular interactions occurred in these liquids. The various acoustic parameters such as ultrasonic velocity, density, viscosity, adiabatic compressibility, free length, acoustic impedance, relaxation time, free volume and internal pressure are useful in understanding molecular structure and molecular interactions in the medium[1-3].

Recent development in science and technology for non – destructive technique are spectacular and holds significant possibilities for better new applications in molecular structure, molecular interactions, medicines and underwater acoustics. Development of sensors, electronic instrumentation and computer software added sophistication to the experimental and theoretical agreement of different ultrasonic parameters [4-7]. Thermodynamics studies of binary liquid mixtures have attracted much attention of scientists. These physico-

chemical analyses are used to handle the mixtures of hydrocarbons, alcohols, aldehydes, ketones etc. The measurement of ultrasonic speed enables us to the accurate measurement of some useful acoustic and thermodynamic parameters and their excess values [8-13]. These excess values of ultrasonic velocity, adiabatic compressibility, molar volume and viscosity in binary liquid mixture are useful in understanding the solute-solvent interactions. The study of molecular association in binary liquid mixture having alcohol as one of component is of particular interest since alcohols are strongly self associated liquids having three dimensional network of hydrogen bonding and can be associate with any other group having some degree of polar attraction [14-16]. The variation in ultrasonic velocity gives information about the bonding between molecules and formation of complexes at various concentration and temperature through molecular interactions [17-19]. In order to have clear understanding of intermolecular interaction between component molecules of an attempt has been made to study the ultrasonic behaviors of triethylamine in benzene at different temperature. Thermo-acoustic parameters are the essential sources of information for better understanding of non-ideal behavior of complex binary liquid system [20-22.]

II. EXPERIMENTAL DETAILS

The chemicals triethylamine and n-hexane used were of analytical grade and obtain from Merck chemicals private Ltd. (Purity 99.5%). The densities of pure components and binary mixtures were measured by hydrostatic sinker method with an accuracy 1 part in10^{+5}. Special attention was given to avoid the vaporization of solution. Comparing their density with literature values checked the purity of chemicals. The mixtures of various concentrations in mole fraction were prepared. The ultrasonic velocities in pure liquids and their mixtures have been measured by ultrasonic interferometer supplied by Mittal Enterprises, New Delhi at a central frequency of 5 MHz with accuracy ± 0.01 m/s. The viscosity of pure and mixture is measured by an Ostwald/s Viscometer with accuracy ± 0.001 $Nm^{-2}s$. The temperature of pure liquids and their mixtures is maintained constant temperature water bath with an accuracy of ± 0.01K.

III. THEORYTICAL ASPECT

The adiabatic compressibility (β) has been calculated from sound velocity 'u' and the density (ρ) of the medium using the relation

$$\beta = \frac{1}{u^2 \rho} \qquad (1)$$

Intermolecular free length (L_f) has been determined by the equation.

$$L_f = K_T \sqrt{\beta} \qquad (2)$$

Where K_T is a Jacobsen's constant.

The free volume L_f in terms of ultrasonic, velocity (u) and the viscosity (η) of a liquid is

$$V_f = \left(\frac{M_{eff}\, u}{k\eta} \right)^{3/2} \qquad (3)$$

Where M_{eff} is the effective molecular weight

$$M_{eff} = \sum m_i x_i \qquad (4)$$

In which mi & xi are the molecular weights and mole fraction of individual constituents respectively and K is a temperature dependent constant equal to 4.28×10^9 for all liquids in MKS system.

Specific acoustic impedance (Z) is determined from equations,

$$Z = u \cdot \rho \qquad (5)$$

Where 'u' and 'ρ' are the ultrasonic velocity and density of the mixture respectively.

IV. RESULTS AND DISCUSSION

Ultrasonic velocity (*u*), density (*ρ*), viscosity(*η*) and other related thermodynamic parameters are evaluated for binary mixture triethylamine(TEA) in n-hexane over whole concentration at 301.15 K, 305.15 K . In the binary liquid systems under investigation, the variation of ultrasonic velocity (*u*), density (ρ), viscosity (*η*), Adiabatic Compressibility (*β*), Acoustic Impedance (*Z*), and molar volume (V_m) are shown in Fig-I, Fig-II, Fig-III, Fig-IV, Fig-V and Fig-VI. The variation of these acoustic parameters indicate the existence of molecular interaction between solvent and solute optimum at specific concentration and it may leads to formation.

Table-1: Ultrasonic parameters for binary liquid mixture containing Triethylamine in n-hexane at 301.15K.

Mole Fraction (x)	Ultrasonic velocity u (m/s)	Viscosity $\eta\times10^{-3}$ (Nsm^{-2})	Adiabatic Compressibility $\beta_a\times10^{-10}$(m^2n^{-1})	Acoustic Impedance Z(Kgm^{-2} s^{-1})	Molar Volume $V\times10^3$(m^3)
0.0	940.0	0.3460	0.1737	0.6122	132.32
0.1	956.7	0.3497	0.1662	0.6286	133.43
0.2	968.3	0.3535	0.1602	0.6444	134.00
0.3	989.5	0.3639	0.1519	0.665	134.92
0.4	1001.2	0.3693	0.1469	0.6796	135.80
0.5	1010.1	0.3775	0.1432	0.6909	136.96
0.6	1032.3	0.3798	0.1356	0.7142	137.57
0.7	1049.7	0.3826	0.1302	0.7312	138.79
0.8	1060.0	0.3846	0.1261	0.7474	139.25
0.9	1076.3	0.3993	0.1214	0.7647	140.30
1.0	1110.0	0.4096	0.1130	0.7969	140.93

Table-2: For binary liquid mixture containing Triethylamine in n-hexane at 305.15K.

Mole Fraction (x)	Ultrasonic velocity u (m/s)	Viscosity $\eta\times10^{-3}$ (Nsm^{-2})	Adiabatic Compressibility $\beta_a\times10^{-10}$(m^2n^{-1})	Acoustic Impedance Z(Kgm^{-2} s^{-1})	Molar Volume $V\times10^3$(m^3)
0.0	931.3	0.3144	0.1781	0.6002	133.13
0.1	943.2	0.3154	0.173	0.6127	134.99
0.2	951.3	0.3189	0.168	0.6256	135.59
0.3	965.2	0.3267	0.1618	0.6403	136.69
0.4	973.3	0.3340	0.1571	0.6536	137.26
0.5	981.3	0.3400	0.1531	0.6653	138.17
0.6	996.7	0.3430	0.147	0.6825	138.99
0.7	1005.2	0.3441	0.1433	0.6941	140.00
0.8	1011.3	0.3484	0.1397	0.7074	140.36
0.9	1023.0	0.3565	0.1353	0.7220	141.24
1.0	1034.0	0.3699	0.1311	0.7374	141.88

Table-3: For binary liquid mixture containing Triethylamine in n-hexane at 309.15K.

Mole Fraction (x)	Ultrasonic velocity u (m/s)	Viscosity $\eta\times10^{-3}$ (Nsm^{-2})	Adiabatic Compressibility $\beta_a\times10^{-10}$(m^2n^{-1})	Acoustic Impedance Z(Kgm^{-2} s^{-1})	Molar Volume $V\times10^3$(m^3)
0.0	896.7	0.2988	0.1933	0.5768	133.96
0.1	901.0	0.2986	0.1914	0.5797	136.25
0.2	906.7	0.3058	0.1865	0.5913	136.74
0.3	917.2	0.3110	0.1799	0.6059	137.25
0.4	922.0	0.3143	0.1762	0.6154	138.10
0.5	933.3	0.3223	0.1711	0.6261	139.64
0.6	938.5	0.3244	0.1663	0.6405	139.46
0.7	946.7	0.3252	0.1625	0.6499	140.84
0.8	951.5	0.3317	0.1585	0.6629	140.93
0.9	962.1	0.3387	0.1538	0.6755	141.96
1.0	970.5	0.3502	0.1496	0.6883	142.66

Table-4: For binary liquid mixture containing Triethylamine in n-hexane at 313.15K.

Mole Fraction (x)	Ultrasonic velocity u (m/s)	Viscosity $\eta\times10^{-3}$ (Nsm^{-2})	Adiabatic Compressibility	Acoustic Impedance	Molar Volume $V\times10^3$(m^3)

			$\beta_a \times 10^{-10}(m^2n^{-1})$	$Z(Kgm^{-2}\ s^{-1})$	
0.0	831.2	0.2860	0.2261	0.5320	134.63
0.1	837.0	0.2870	0.2226	0.5365	136.78
0.2	844.2	0.2880	0.2161	0.5479	137.39
0.3	857.0	0.2955	0.2073	0.5626	138.13
0.4	864.0	0.2986	0.2028	0.5706	139.56
0.5	869.5	0.3083	0.1978	0.5813	140.12
0.6	881.2	0.3115	0.1899	0.5975	140.37
0.7	887.0	0.3127	0.1863	0.6049	141.76
0.8	893.3	0.3153	0.1808	0.6189	141.70
0.9	905.2	0.3231	0.1747	0.6321	142.75
1.0	912.5	0.3362	0.1702	0.6435	143.47

weak hydrogen bonded complex in binary liquid mixture. This conclusion is further supported by thermodynamic studies [11, 16] on a similar system by IR and NMR [18-24]. Beyond this optimum concentration, addition of solute (triethylamine) in a solvent (n-hexane) tries to break this weak complex structure and tends towards the values of pure components

.

V. CONCLUSION

The acoustic data of Ultrasonic velocity (u), viscosity (η), Adiabatic Compressibility (β), Acoustic Impedance (Z) and molar volume (V_m), of Triethylamine in Benzene over the whole concentration range may suggest the existence of a strong intermolecular interaction.

Figure -I: Variation of Ultrasonic Velocity with mole fraction for binary liquid mixture containing Triethylamine in n-hexane at 301.15K, 305.15K, 309.15K, 313.15K.

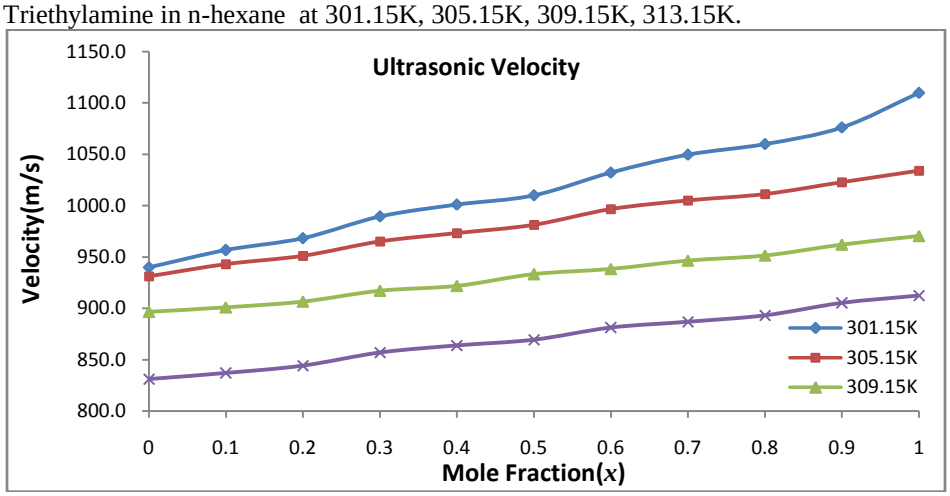


Figure -II: Variation of Density mole fraction for binary liquid mixture containing Triethylamine in n-hexane at 301.15K, 305.15K, 309.15K, 313.15K.

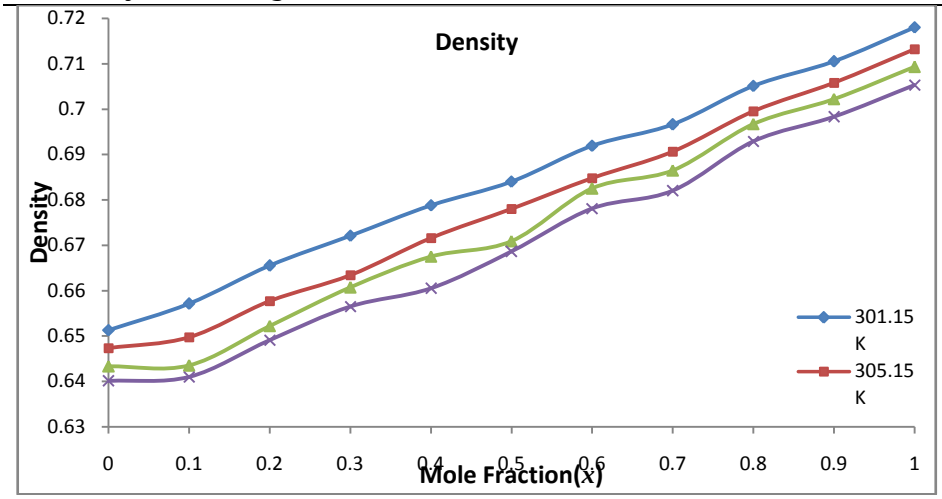


Figure-III: Variation of Viscosity with mole fraction for binary liquid mixture containing Triethylamine in n-hexane at 301.15K, 305.15K, 309.15K, 313.15K.

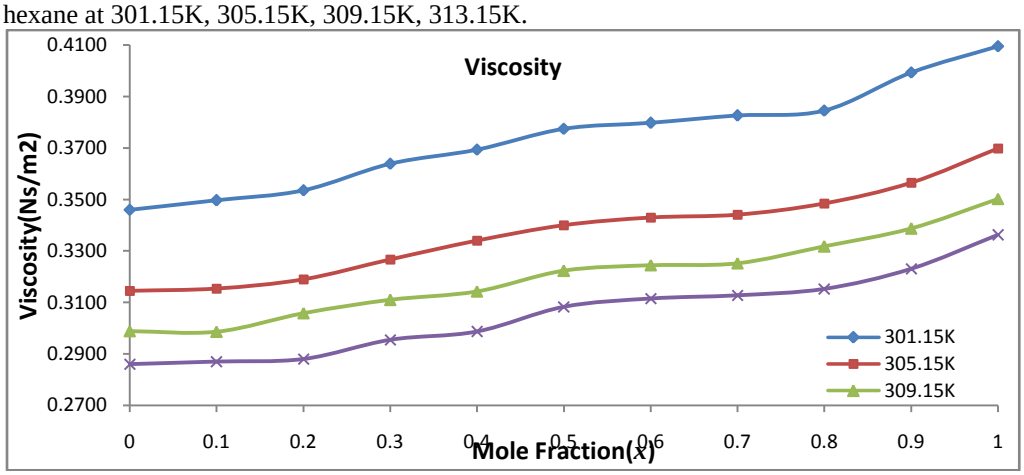


Figure-IV: Variation of Adiabatic Compressibility with mole fraction for binary liquid mixture containing Triethylamine in n-hexane at 301.15K, 305.15K, 309.15K, 313.15K.

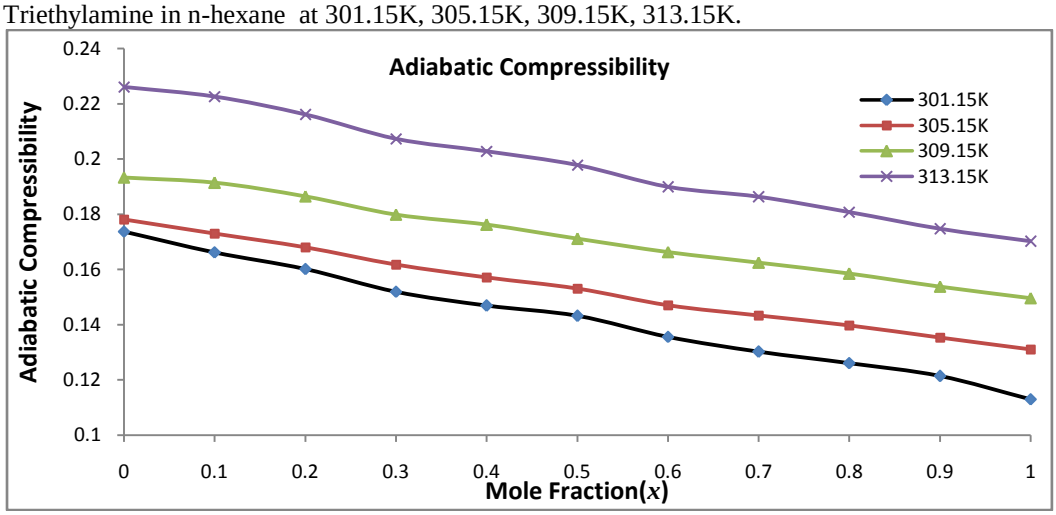


Figure-V: Variation of Acoustic Impedance with mole fraction for binary liquid mixture containing Triethylamine in n-hexane at 301.15K, 305.15K, 309.15K, 313.15K.

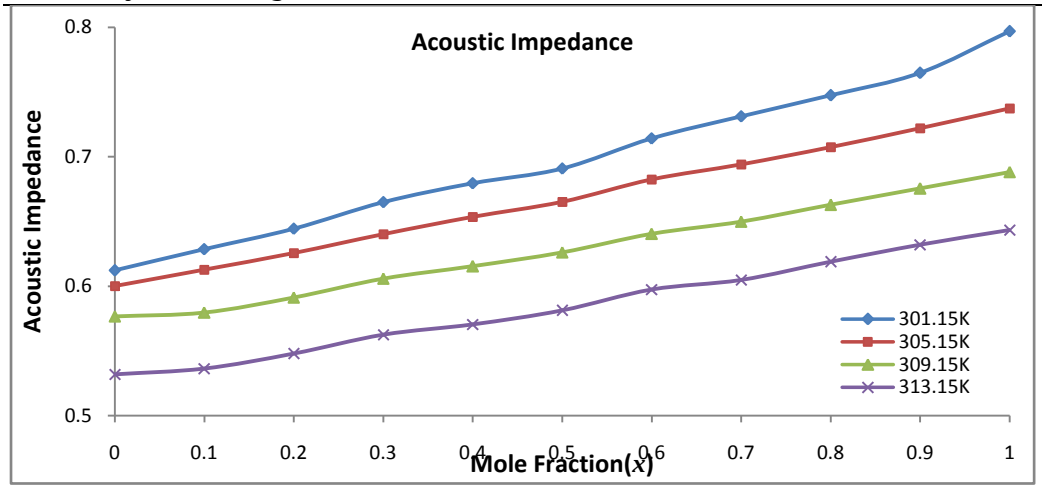
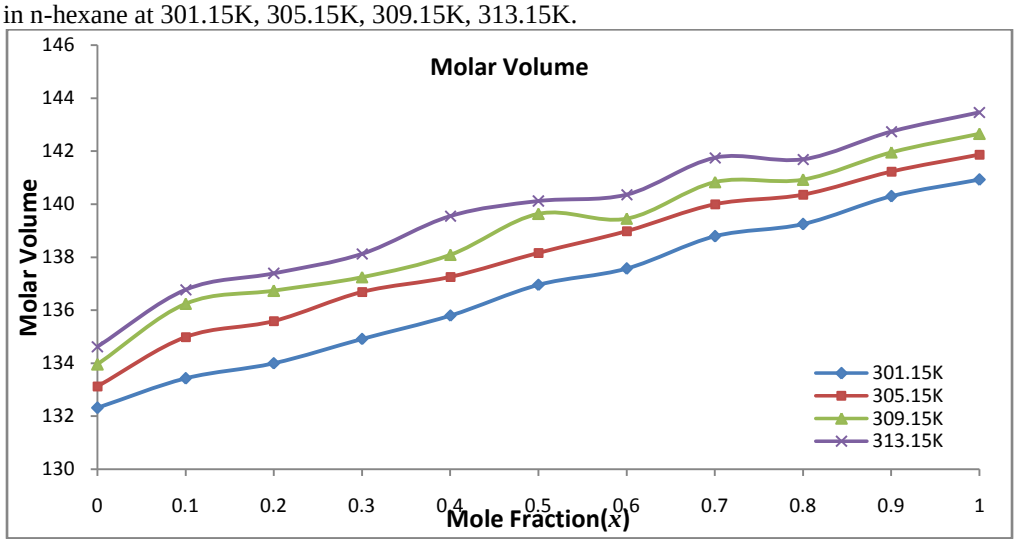


Figure-VI: Variation of Molar Volume with mole fraction for binary liquid mixture containing Triethylamine in n-hexane at 301.15K, 305.15K, 309.15K, 313.15K.



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