International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2013): 6.14 | Impact Factor (2013): 4.438

Ultrasonic Study of Binary Mixture of Acetic Acid and Toluene

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Abstract: ***Ultrasonic velocity (U) and density (ρ) for binary liquid mixtures of acetic acid with toluene have been measured at 3 MHz ultrasonic frequency at 303K. From this data, acoustic parameters such as adiabatic compressibility (β_{ad}), acoustic impedance (Z), relative association (RA) and intermolecular free length (Lf) are calculated. The result is interpreted as per molecular interaction between the mixtures.***

Keywords: Acetic acid, ultrasonic velocity, toluene.

1. Introduction

Acetic acid is an organic compound with molecular formula CH_3COOH (CH_3CO_2H or $C_2H_4O_2$). It is colorless and polar liquid. When it is diluted is also called glacial acetic acid. Vinegar is roughly 3-9% acetic acid by volume, making acetic acid the main component of vinegar apart from water. Acetic acid has a distinctive sour taste and pungent smell. Its polarity index and dielectric constant is 6.2. It is used as solvent and reagent in formation of esters. It is a weak acid as compared to mineral acids.

Toluene is colorless, water insoluble liquid with the smell associated with paint thinner. It is a mono substituted benzene derivative. It consists of a $–CH_3$ group attached to a phenyl group. Its IUPAC systematic name is methyl-benzene. It is an aromatic hydrocarbon. Its polarity index is 2.4 and dielectric constant is 2.38. It is non polar solvent, $-CH_3$ group is electron donating group.

In the present study, ultrasonic velocity and density of binary mixture of acetic acid and toluene has been calculated and used to determine the acoustic parameters, adiabatic compressibility (β_{ad}) acoustic impedance (Z) relative association and intermolecular free length (Lf) in order to explain the intermolecular interactions in these mixtures.[1]

$C_6H_5CH_3 + CH_3\text{-}COOH \rightarrow C_6H_4\text{-}CH_3\text{-}CO\text{-}CH_3$

2. Experimental

Chemical used are obtained from Spectro Chem, Sd-fine, Molychem, Mumbai. The density of the pure components and their mixtures were measured by using DMA 35 portable vibrating density meter, Anton paar Autria (Europe) having accuracy of density 0.001 g/cm^3 [2] and viscosity by LVDL V-pro II Brook field viscometer (USA) [3]. Ultrasonic sound velocities were measured using multifrequency ultrasonic interferometer F-05 for liquids at 3 MHz for the systems (Toluene + Acetic acid). [4, 5]

From the measured values of density (ρ) and ultrasonic velocity (U), acoustic parameters like adiabatic compressibility (β_{ad}), intermolecular free length (Lf), acoustic impedance (Z) and relative association (RA) were calculated using the following relations.

$$\beta_{ad} = \frac{1}{\rho U^2} \quad (1)$$

$$L_f = K(\beta_{ad})^{1/2} \quad (2)$$

$$Z = U\rho \quad (3)$$

$$R_A = \frac{\rho_s}{\rho_0}\left(\frac{U_0}{U_s}\right)^{1/3} \quad (4)$$

Where, k is temperature – dependent constant.

The values of excess adiabatic compressibility ($\Delta\beta_{ad}$), excess intermolecular free length (ΔLf) and excess acoustic impedance (ΔZ) are shown in table 2 and calculated using following relation.[6]

$\Delta Y = Y_m – (X_1Y_1 + X_2Y_2)$ (5)

3. Tables and Figures

Table 1: Toluene + acetic acid
(The values of density (ρ), ultrasonic velocity (U), adiabatic compressibility (β_{ad}), intermolecular free length (Lf), acoustic impedance (Z) and relative association (RA), viscosity (η) of the binary liquid mixture of toluene + acetic acid at 30^{0}C.)

X	Viscosity (in cps)	ρ_{mix}	U	βad (in 10^{-10})	Lf (in 10^{-11})	Z (in 10^{+6})	RA
0.000000	0.95	856.00	1266.0	7.2888	5.4461	1.0837	1.0000
0.089100	0.98	862.60	1261.0	7.2906	5.4468	1.0877	1.0090
0.171160	1.00	869.80	1241.0	7.4651	5.5116	1.0794	1.0229
0.246980	1.06	878.60	1229.0	7.5354	5.5375	1.0798	1.0366
0.317240	1.14	891.30	1186.0	7.9764	5.6972	1.0571	1.0641
0.553390	1.22	920.50	1176.0	7.8553	5.6538	1.0825	1.1021
0.736000	1.32	960.50	1135.2	8.0790	5.7337	1.0904	1.1636
0.881440	1.41	991.80	1114.8	8.1130	5.7458	1.1057	1.2088
1.000000	1.52	1036.90	1085.0	8.1923	5.7738	1.1250	1.2753

Table 2: Values of Excess Parameters
(The values of excess adiabatic compressibility ($\Delta\beta_{ad}$), excess intermolecular free length (ΔLf) and excess acoustic impedance (ΔZ) along with mole fraction (X) of acetic acid.**)**

X	$\Delta\beta$ad (in 10^{-10})	ΔLf (in 10^{-11})	ΔZ (in 10^{+6})
0.000000	0.0000	0.0000	0.0000
0.089100	-0.0787	0.0284	+0.0004
0.171160	0.0216	-0.0094	-0.0112
0.246980	0.0234	-0.0104	-0.0140
0.317240	0.4010	-0.1471	-0.0396
0.553390	0.0665	-0.0263	-0.0240
0.736000	0.1252	-0.0464	-0.0237
0.881440	0.0278	-0.0108	-0.0144
1.000000	0.0000	0.0000	0.0000

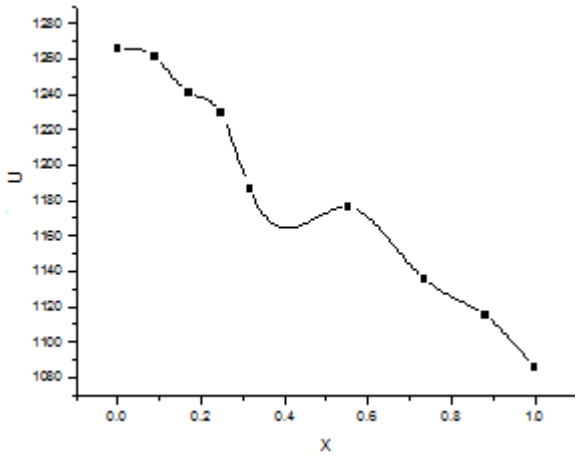

Figure 1

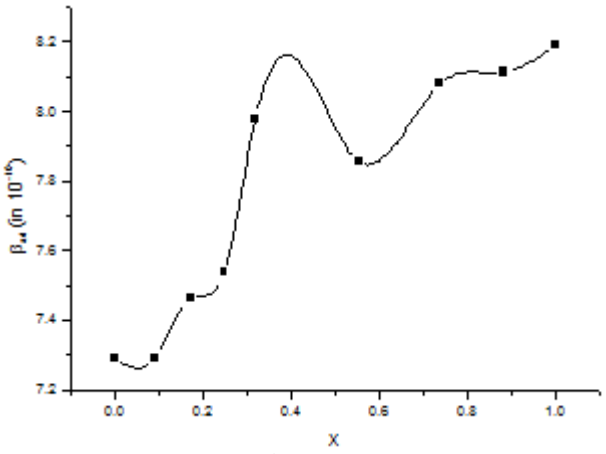

Figure 2

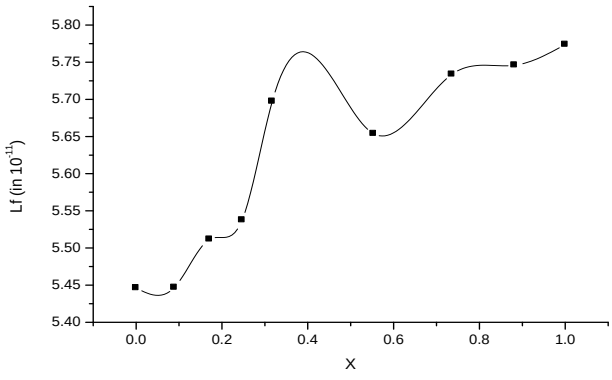

Figure 3

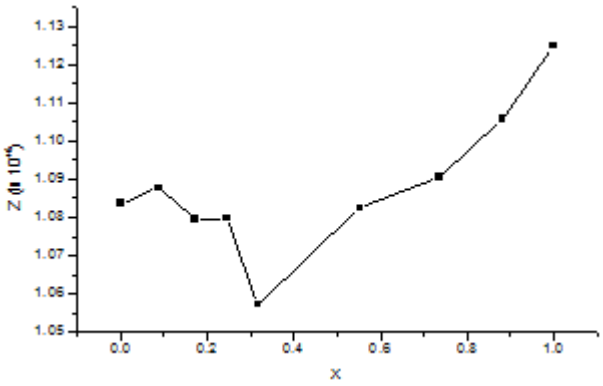

Figure 4

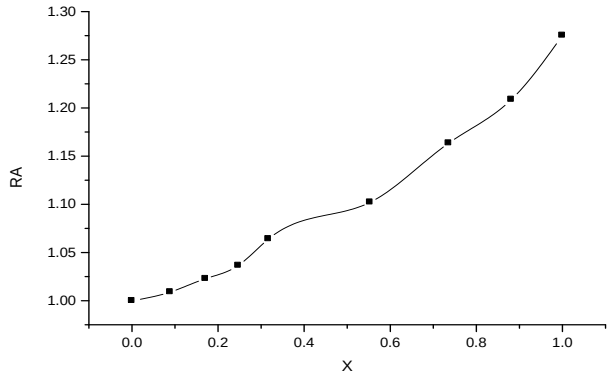

Figure 5

4. Results and Discussion

Values of density (ρ), ultrasonic velocity (U), acoustic compressibility (β_{ad}), intermolecular free length (Lf), acoustic impedance (Z), and relative association (RA) along with mole fraction of acetic acid in toluene are listed in the table (1). The excess parameter of acoustic compressibility, intermolecular free length, and acoustic impedance along with mole fraction of acetic acid in toluene listed in table (2). Also the graphical representation for above said parameter against mole fraction (X) of acetic acid is depicted in figures 1, 2, 3, 4 and 5.

Ultrasonic velocity in medium is depends upon binding forces between the molecules. [7] From the table (1) it is clear that in the system toluene + acetic acid the ultrasonic velocity decreases with increasing mole fractions of acetic acid. The decrease in velocity and increase in compressibility were attributed to the formation of hydrogen bonds between solute and solvent molecules [2].

In fig. (1), it is found that ultrasonic velocity decreases by increasing the mole fraction of acetic acid it is due to decrease in mobility of the solvent (toluene). Decrease in ultrasonic velocity may be attributed to the solute-solvent interaction.

In fig. (2), adiabatic compressibility increases by increase in mole fraction it means there is formation of hydrogen bonds between solute and solvent molecules. [8] Minima in β_{ad} due to there are definite contraction on maxima and variation observed is due to complex formation. [9]

In fig. (3), as mole fraction increases the intermolecular free length also increases. This is due to lose packing of the molecules inside the shield which may be brought by weakening of molecule interaction. Free length depends upon intermolecular attractive and repulsive forces. Its graphical nature same as adiabatic compressibility. [10]

In fig. (4), as mole fraction increases the acoustic impedance decreases. The decrease in specific acoustic impedance indicates significant interaction between the mixing components. The acoustic impedance increases from 0.317240 mole fraction, due to the possibility of molecular interaction between unlike molecules [1]. The acoustic impedance value of pure acetic acid and toluene is greater than acoustic impedance values of its mixtures. At 0.317240 mole fraction the value of acoustic impedance is minimum. [11]

In fig (5), the relative association increases due to increase in mole fraction of acetic acid, proves stronger dipole - induced dipole interaction between unlike molecules which results in contraction of volume. This indicates significance solute-solvent interaction. [12]- [14]

As mole fraction increases the viscosity increases, it means acetic acid is more viscous from table (1). From table (2), the negative values of excess acoustic impedance, shows there is weak molecular interaction existing between unlike molecules. [4] Most of values of excess intermolecular free lengths are negative. It shows sound waves cover long distance due to decrease in intermolecular free length. It means dominant nature of hydrogen bond interaction between unlike molecules. [15] Values of excess adiabatic compressibility shows that weak molecular interaction between unlike molecules of components liquid. [1]

5. Acknowledgement

K.D. More is very thankful to Dr. G. M. Kalamse (Reg. Director, YCMU Nanded) for availing me a research Lab. of Science College, Nanded.

References

[1] G.R. Bedare, V.D. Bhandakkar and B.M. Suryawanshi, "Studies of acoustic and thermodynamics properties of binary mixtures at 308k," Journal of chemical and pharmaceutical Research, 4(2), pp. 1028-1032, 2012.
[2] B.G. Nemaniwar, S.S. Mokle, P.L. Kadam, "Effect of temperature on the dielectric relaxation time of binary mixture of 2-chloroaniline and 2-ethoxy ethanol in 1-4 dioxane solution losing microwave absorption data," Pakistan Journal of Chemistry, Vol. 3, No. 2, pp. 1-6, 2013.
[3] Bhupesh Nemaniwar, Potaji Kadam, "Dielectric behavour of binary mixture of 2-3 dichloro aniline with 2-methoxy ethanol using microwave X-band," Chemical Science transaction, Vol 3, No. 3, pp. 995-1000, 2014.
[4] S. Thirumaran and Deepesh George, "Ultrasonic study of intermolecular association through hydrogen bonding in ternary liquid mixtures," APRN Journal of Engineering and Applied Science, Vol. 4, No. 4, June 2009.
[5] R.S. Kawale, U.B. Tumberphale, G.A. Karhale and G.M. Kalamse, "Dielectric Behavior of thiophenol (C_6H_6S) in Benzene at 15.2 GHz microwave frequency."
[6] P.J. Singh and K.S. Sharma, "Dielectric Behaviour of ketone-amine binary mixtures at microwave frequencies." Pramana Journal of Physics, Vol. 46, No. 4, pp. 259-270, April 1996.
[7] Sahu S, Nath G and Paikaray R., "Study of molecular interactions in binary mixtures at variable frequencies using ultrasonic techniques," Research Journal of chemical sciences, Vol. 2(11), pp. 64-66, November 2012
[8] R. Patani, "Acoustical and thermo dynamical properties of PEG in non-electrolytes at 303, 313 and 323 k", et. al Archive of Physics Research, 1(4), pp. 111-118, 2010.
[9] Isht Vibhu, "Ultrasonic and infrared study of molecular interactions in ternary mixtures of 1-napthol and 2-napthol with 2-propane in benzene," et.al. Pramana Journal of Physics, Vol. 62, No. 5, pp. 1147-1155, May 2004.
[10] K. R. Ezhil Pavai and S. Renuaka, "Study of molecular interactions in ternary mixtures of propyl acetate in cyclohexane with 2-Methoxyethanol at 303, 308 and 313," International Journal of Research in Physical Chemistry, 1(1), pp. 32-37, 2011.
[11] Akanksha Dixit, Kailash C. Juglan and Ajay Sharma, "Acoustic parameter investigation of ternary mixture of n-butanol, water and acetic acid by using ultrasonic techniques," Journal of Chemical and Pharmaceutical Research, 6(10), pp. 93-104, 2014.
[12] Sunanda Aswale, Shashikant R. Aswale, Aparna B. Dhote, "Ultrasonic Studies of Aspirin by Relative association, Relaxation time and free volume," International Journal of Pharmacy and Pharmaceutical Sciences, Vol. 4.
[13] Harish Kumar and Deepika, "Thermodynamic study of binary liquid mixture of water and DMSO at 308.15k," International Journal of Chemical Science and Technology, 2(1), pp. 1-8, 2012.
[14] Zade Sachin, "Study of molecular interactions of coumaran-3-ones in polar and non-polar solvents using ultrasonic interferometer," Rasayan Journal of Chemistry, 4(3), pp. 620-629, 2011.
[15] K. Ravichandran S., "Acoustic and thermodynamic properties of cholesterol in ethanol and 1-propanol solution in different concentration at 303k," Research Journal of Chemical Sciences, Vol 1(8), pp. 12-17, Nov. 2011.