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Acoustic Parameters of acetic acid in benzene at 3 MHz.

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ABSTRACT

In present study, Ultrasonic velocity (U) and density (ρ) for binary liquid mixtures of acetic acid with benzene 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 (R_A) and intermolecular free length (Lf) are calculated. The result is interpreted as per molecular interaction between the mixtures.

Keywords: Acetic acid, ultrasonic velocity, acoustic parameters.

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I. Introduction

Acetic acid is an organic compound with molecular formula CH_3COOH (CH_3CO_2H or $C_2H_4O_2$). It is colorless 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. Benzene is an important organic chemical compound with chemical formula C_6H_6. Its molecule is composed of 6 carbon atoms joined in a ring with one hydrogen atom attached to each carbon atom. Benzene is a natural constituent of crude oil. It is most elementary petrochemicals. It is a colorless and highly flammable liquid with a sweet smell. In the present study, ultrasonic velocity and density of binary mixture of acetic acid and benzene has been calculated and used to determine the acoustic parameters like 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]

II. Experimental

Chemical used are obtained from Spectro Chem, Sd-fine and 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 multi-frequency ultrasonic interferometer F-05 for liquids at 3 MHz for the systems (Benzene + 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 (R_A) 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.

III. Table (Benzene + acetic acid)

X	Viscosity (η) (in cps)	ρmix	U	βad (in 10^{-10})	Lf (in 10^{-11})	Z (in 10^{+6})	R_A
0.00000	0.70	867.70	1267.8	7.1702	5.4016	1.1001	1.0000
0.07562	0.75	870.00	1246.2	7.4013	5.4880	1.0842	1.0084
0.14727	0.84	879.70	1240.8	7.3835	5.4814	1.0915	1.0211
0.21525	0.90	880.50	1218.6	7.6480	5.5787	1.0730	1.0282
0.27984	0.99	899.20	1204.8	7.6615	5.5836	1.0834	1.0541
0.50890	1.03	925.00	1182.0	7.7379	5.6114	1.0934	1.0912
0.70000	1.15	961.20	1128.0	8.1765	5.7682	1.0842	1.1517
0.86144	1.29	998.60	1095.0	8.3518	5.8297	1.0935	1.2085
1.00000	1.52	1036.90	1085.0	8.1923	5.7738	1.1250	1.2587

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

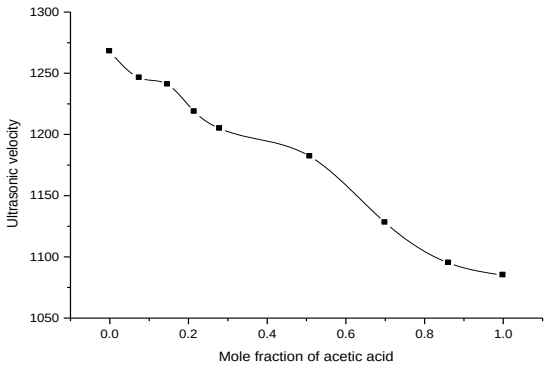

Fig. 1

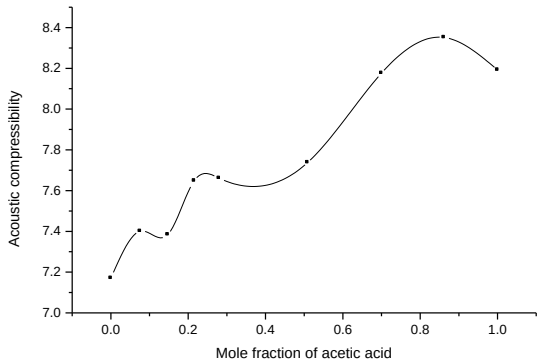

Fig. 2

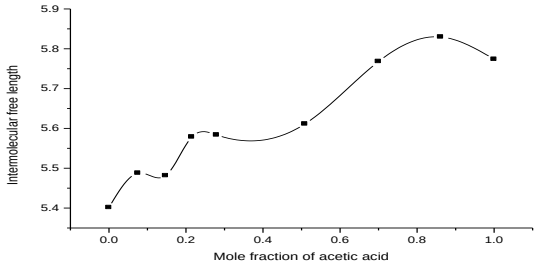

Fig. 3

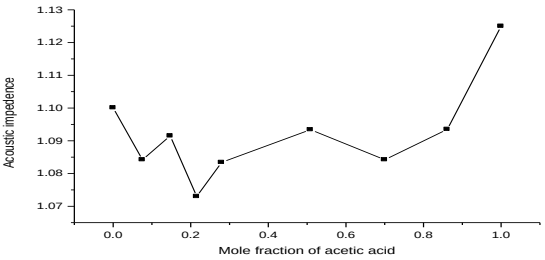

Fig. 4

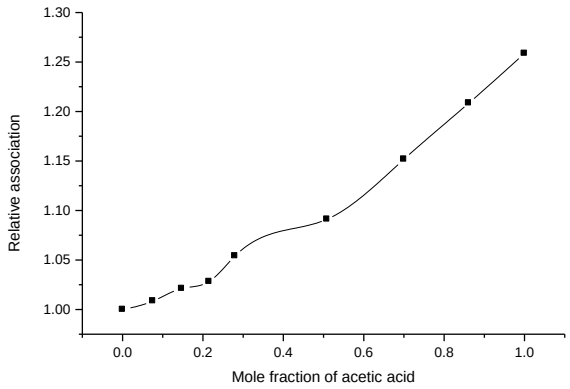

Fig. 5

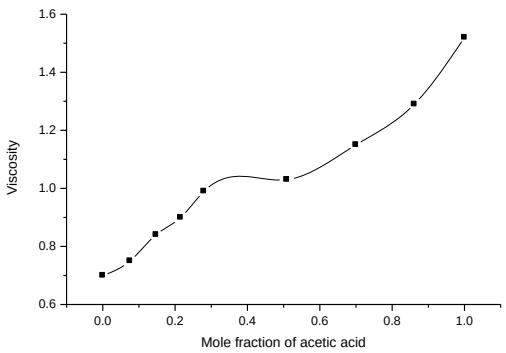

Fig. 6

IV. Results and discussion

Values of density (ρ), ultrasonic velocity (U), adiabatic compressibility, intermolecular free length (Lf), acoustic compressibility (β_{ad}), relative association (R_A) and viscosity (η) along with mole fraction of acetic acid in benzene listed in the table. Also the graphical representation for above said parameter against mole fraction (X) of acetic acid is depicted in figures 1, 2, 3, 4, 5 and 6.

Ultrasonic velocity in medium is depends upon binding forces between the molecules. [6]

From the table it is clear that in the system benzene + 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 [4]

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 (benzene). 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. [7] Minima in β_{ad} due to there are definite contraction on mixing and variation observed is due to complex formation. [8]

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. [9]

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 0.2 mole fraction, due to the possibility of molecular interaction between unlike molecules. [1] The acoustic impedance value of pure acetic acid and benzene is greater than acoustic impedance values of its mixtures. At 0.2 mole fraction the value of acoustic impedance is minimum.

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. [10]- [12]

In fig. (6), as mole fraction increases the viscosity increases, it means acetic acid is more viscous.

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