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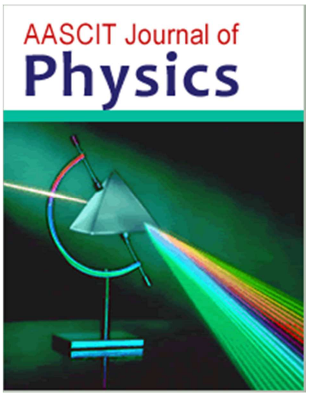

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Ultrasonic Studies on Molecular Interactions in Binary Mixtures of Benzilic Acid with Various Polar and Non Polar Solvents at 298K

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Abstract

The ultrasonic velocity (u), density (ρ) and viscosity (η) have been measured in binary liquid mixtures of Benzilic acid with polar and non-polar solvents at 298K. The experimental data have been used to calculate acoustical parameters namely, adiabatic compressibility (β), apparent molar volume (Ø), acoustic impedance (Z), intermolecular free length (L_f), and relative association (R_A) .The excess values of these parameters are also evaluated over the different concentration range .The result is interpreted in terms of molecular interaction such as dipole-dipole interaction through hydrogen bonding between components of mixtures. The dependence of excess properties of mixtures on compositions were compared and discussed in terms of the intermolecular free length and other factors affecting the solvation and self association effect. The excess values of these indicate the complexity of dipole-induced interaction in the binary liquid mixture.

1. Introduction

Ultrasonic is a flexible non-ruinous method and exceedingly helpful for examination of different properties like adiabatic compressibility, intermolecular free length and apparent volume at 298 K. The study of molecular interaction plays a vital role in the development of molecular science. Molecular interactions and structural behavior of molecules and their mixtures can be identified using ultrasonic studies. Late advancements have discovered utilization of ultrasonic studies in medication, building and farming [1-4]. The practical application of mixed solvents, rather than single solvent, in industrial and biologic processes has been recognized all over the world, as they provide a wide choice of solvent mixtures with appropriate properties [5, 6]. Ultrasonic speed together with thickness and consistency information outfit abundance of data about the association between particles, dipoles, hydrogen bonding, multi-polar and dispersive forces [7-10]. We focus in this paper the results of ultrasonic studies of binary mixture of Benzilic acid with solvents of different polarities. As a result, significant interaction through hydrogen bonding between unlike molecules in these binary mixtures is expected. Also, it is worthwhile examining the effect of intermolecular interaction between benzilic acid and various solvents. We report here the results of ultrasonic study of molecular interactions of benzilic acid at 298 K in ethanol, chloroform, acetonitrile, acetone and 1,4- dioxane binary mixtures. Ethanol is a highly polar but protic solvent. The solvent polarity decreases from ethanol to chloroform. The intermolecular interaction varies from polar solvent to non-polar solvent. The intermolecular forces responsible for the molecular interactions can be classified as long range forces and short range forces. The long range forces are the electrostatic induction and dispersion forces and they arise when the molecules come close enough together causing a significant overlap of electron clouds and are often highly directional. In the present work an attempt has been made to investigate the behavior of binary solutions of benzilic acid in different polar and non polar solvents with regard to velocity, density, adiabatic compressibility, intermolecular free length from ultrasonic measurements using standard formulae at 298 K. The values of ultrasonic parameters are plotted against concentration and the graphs obtained are explained on the basis of the various intermolecular interactions present in the system and how the interactions are affected by the nature of solvents at different concentrations. The study of excess thermodynamic functions such as excess functions such as excess adiabatic compressibility, excess velocity, excess intermolecular free length, excess acoustic impedance, and excess apparent molar volume were also calculated.

2. Experimental Procedure

Benzilic acid was synthesised by benzoin condensation followed by oxidation with Conc.HNO_3. Then benzil formed was treated with aq. KOH. The driving force for the reaction is provided by the formation of a stable potassium benzilate, which was acidified.. Solvents like ethanol, acetonitrile, chloroform, acetone and 1, 4-Dioxane (s. d. fine, India, AR) were dried over molecular sieves. All the binary mixtures were prepared by mass in a dry box and were kept in special air tight bottles. Solutions of benzilic acid in the concentration range of 0.000938-0.03 mole% with different solvents were prepared at room temperature. The densities of pure liquids and binary mixtures were measured using a simple capillary pycnometer of bulb capacity $8 \times 10^{-6} m^3$ with a graduated stem width of $5 \times 10^{-8} m^3$ divisions (Systronies India, Ltd.,). The marks on the capillary were calibrated using known densities of double distilled water. The accuracy of the density measurement was found to be ±0.001 gm/cc. The viscosities of the binary mixtures were determined using an Ostwald Viscometer (Sigma Chemicals Instruments). The ultrasonic velocities of pure solvent and the binary mixtures were measured using a single crystal variable path interferometer at 2 MHz (Mittal Enterprises, New Delhi). The accuracy in ultrasonic velocity was found to be $\underline{+}$ 0.05%. The temperature of the test liquids and their binary mixtures was maintained to an accuracy of ±0.02 in an electrically controlled thermostatic water bath.

From the measured values of density ρ, ultrasonic velocity u, the adiabatic compressibility β or K_s, intermolecular free length L_f, relative association R_A and acoustic impedance Z, have been calculated using the following standard relations.

$$\beta = K_s = 1/u^2\rho \tag{1}$$

$$L_f = K/u\rho^{1/2} \tag{2}$$

$$R_A = (\rho/\rho^\circ) \times (u^\circ/u)^{1/3} \tag{3}$$

$$Z = u\rho \tag{4}$$

where K is a temperature-dependent constant $(93.875+0.375 \times T) \times 10^{-8}$, T is the absolute temperature, Z is the acoustic impedance, β or K_s the adiabatic compressibility, L_f the intermolecular free length, R_A is the relative association, and ρ^o, ρ, u° and u are the densities and ultrasonic velocities of the solvent and solution respectively.

3. Results and Discussion

In the present investigation ultrasonic velocity measurement is used to assess the molecular interaction between benzilic acid and different polar and non polar solvents. The values of ultrasonic velocities (u), densities (ρ), adiabatic compressibility (β or K_s), intermolecular free length (L_f) of benzilic acid in different solvents and other acoustical parameters are given in Table 1.

Table 1. *Values of density (ρ), ultrasonic velocity (u), adiabatic compressibility (β or K_s), intermolecular freelength (L_f), Relative Association (R_A) and excess functions of binary mixtures as a function of concentration mole% using various solvents at 298K.*

Solvents	Concentration for various ultrasonic parameters					
	Velocity ms^{-1}					
Non-Ideal(NI)	0.000938	0.001875	0.00375	0.0075	0.015	0.03
Ethanol	1358	1854	1412	1274	705	885
Acetonitrile	1363	1220	1601	643	1224	1124
Acetone	470	480	460	490	475	480
Chloroform	1427	701	758	1132	1427	
1,4-dioxane	1492	1420	1400	1340	1406	1368
Non-Ideal(NI)	Density Kgm^{-3}					
Ethanol	790	767	667	768	773	772
Acetonitrile	754	747	770	750	775	760
Acetone	750	710	780	760	625	750
Chloroform	1440	1443	1445	1447	1450	
1,4-dioxane	1007	1017	1010	1006	1002	1009
Non-Ideal(NI)	Adiabatic compressibility $Kg^{-1}ms^2$					

Solvents	**Concentration for various ultrasonic parameters**					
	Velocity ms^{-1}					
Ethanol	6.8632	3.8412	6.3402	8.1753	2.5165	16.409
Acetonitrile	7.1558	8.9823	5.0629	3.2188	8.6126	1.0436
Acetone	60.359	69.553	60.588	54.801	70.914	57.870
Chloroform	3.3625	1.4658	1.2105	5.4574	3.4918	
1,4-dioxane	4.4610	4.9743	5.0515	5.5356	5.0484	5.2958
Non-Ideal(NI)	Intermolecular freelength A^0					
Ethanol	5.3895	4.0043	5.6351	5.8226	10.484	8.3572
Acetonitrile	5.4933	6.1627	4.6268	11.666	6.0345	6.6312
Acetone	10.010	10.956	9.4391	9.8142	13.165	10.001
Chloroform	3.8437	7.8189	7.2333	4.8427	3.8424	
1,4-dioxane	4.3435	4.5407	4.6215	4.8381	4.6202	4.7324
Non-Ideal(NI)	Relative Association (R_A)					
Ethanol	0.8852	0.7170	0.7376	0.8791	1.0775	0.9976
Acetonitrile	0.9681	0.9953	0.9370	1.2367	1.0315	1.0405
Acetone	1.2374	1.2813	1.4931	1.6505	1.3660	1.1995
Chloroform	0.8717	1.1068	1.0800	0.9461	0.8777	
1,4-dioxane	1.0393	0.9983	1.0886	1.0385	0.8630	1.0321
	Excess Velocity					
Ethanol	258.64	754.56	315.90	182.73	-366.01	-164.78
Acetonitrile	112.58	-28.080	353.97	-590.43	-3.520	-75.435
Acetone	2.0438	-17.089	-5.3627	27.564	19.207	36.209
Chloroform	461.73	-260.25	-199.32	178.73	475.90	
1,4-dioxane	129.60	60.278	45.473	-3.489	81.184	83.053
	Excess Density					
Ethanol	-3.0452	-6.0082	-2.3456	-1.7805	15.940	6.7254
Acetonitrile	-1.2560	0.5741	-3.3651	23.615	0.3425	2.2151
Acetone	-2.6358	6.6423	-2.4056	-7.2895	9.3605	-1.4905
Chloroform	-3.9703	6.6752	4.6452	-1.8830	-3.6904	
1,4-dioxane	-0.8052	-0.2825	-0.1845	0.3356	-0.0632	0.3256
Excess Intermolecular free length						
Ethanol	-1.8008	-2.4587	-80.520	-5.8743	4.0525	2.0568
Acetonitrile	-0.4568	0.2047	-1.3025	5.6948	0.1784	0.8614
Acetone	8.358	9.208	7.7615	8.0874	11.245	8.0054
Chloroform	-1.7186	2.2355	1.6658	-0.6614	-1.5423	
1,4-dioxane	-0.3739	-0.1663	-0.0658	0.1854	0.0471	0.2854
Excess Acoustic Impedance						
Ethanol	0.1582	0.5075	0.0308	0.0713	-0.3454	-0.1885
Acetonitrile	0.0811	-0.0334	0.2887	-0.4514	0.0189	-0.0538
Acetone	0.3373	0.3366	0.3355	0.3333	0.3263	0.3194
Chloroform	0.6634	-0.3774	-0.2880	0.2595	0.6946	
1,4-dioxane	0.1169	0.0613	0.0365	-0.0180	0.0621	0.0741

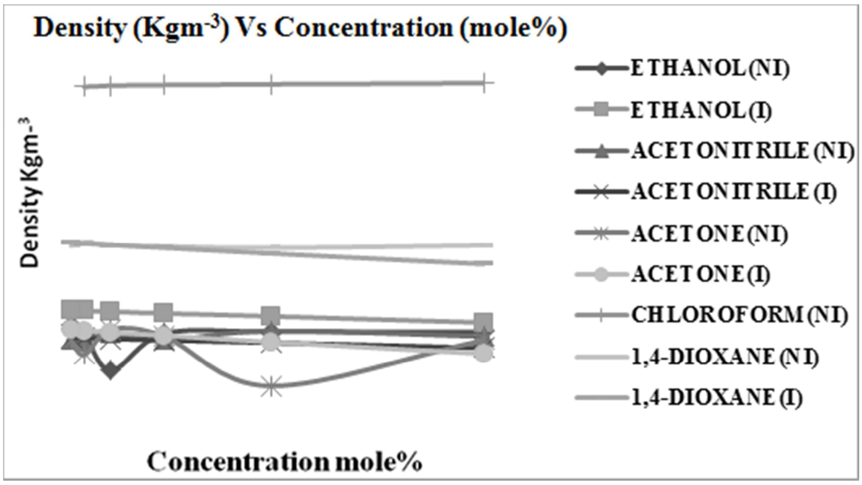

Fig. 1. *Density (Kgm^{-3}) Vs Concentration (mole %)*

Density is a measure of solvent-solvent and solute-solvent interactions. A decrease in the density of a solution with dilution is the expected trend [11, 12]. For the system of benzilic acid and different solvents under study, there is an increase in density at low concentration region for polar solvents like ethanol, acetonitrile and there is an initial decrease in density (Fig. 1) for non-polar solvents viz chloroform.

In the case of polar solvents, the increase in density is more significant. This can be attributed to the formation of intermolecular interactions between the solvent molecules by the addition of the solute which reaches a maximum. Increase in density with concentration is due to the shrinkage in the volume which in turn is due to the presence of solute molecules. In other words, the increase in density may be interpreted to the structure-maker of the solvent due to the added solute. Similarly, the decrease in density with concentration indicates structure-breaker of the solvent. It may be also true that solvent-solvent interactions bring about a bonding, probably H-bonding between them. So, size of the resultant molecule increases and hence there will be decrease in density. In the case of ethanolic solutions, there is found to be a continuous increase in the density of the solution with an increase in concentration. This is attributed to the presence of strong intermolecular attraction such as dipole–dipole attraction and hydrogen bonding. In the case of acetonitrile the increase in concentration results in the preferential formation of intermolecular hydrogen bonding between the solute molecules, forming a well-arranged structure, leading to an increase in the volume of the solution, which leads to a decrease in density. An increase in concentration allows for a closer approach of solvent and solute molecules, and stronger association between solute and solvent molecules. As the polarity of the solvent decreases, there is a decrease in density. The initial sharp decrease in density can be explained on the basis of a sudden increase in the volume of the solution with the addition of benzilic acid.

The ultrasonic velocity is found to be the lowest at low concentration and the increase in ultrasonic velocity with increase in concentration is the expected trend [13]. Fig 2 shows the plots of ultrasonic velocity versus mole fraction. It is evident from the values that ultrasonic velocity of benzilic acid linearly increasing with concentrations and increase in the polarity of solvent likes ethanol, acetonitrile and acetone. This linear increase suggests that there are strong solute-solvent interactions in the liquid mixture. An opposite trend is observed in the adiabatic compressibility. The interactions are concentration dependent. At low concentrations, the number of hydrogen bonds formed may be less and at higher concentrations, it may be more due to solute-solute interactions. A similar explanation for the decrease in compressibility with concentration of the liquid mixtures has been suggested by Fok and Moore [14].

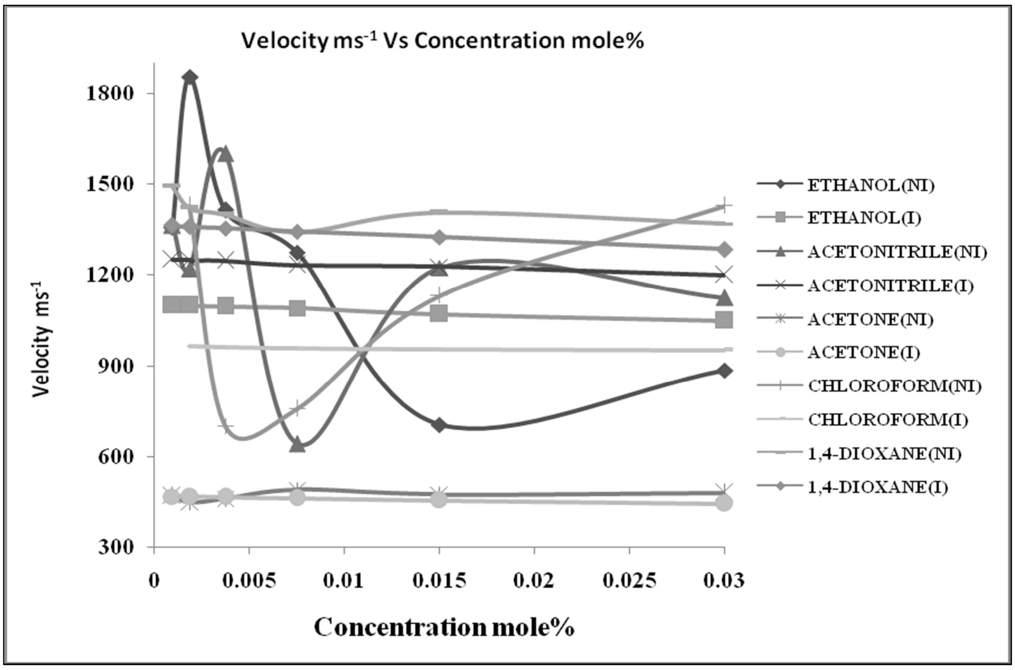

Fig. 2. *Velocity ms^{-1} Vs Concentration mole%*

The increase in velocity and decrease in compressibility were attributed to formation of hydrogen bonds between solute and solvent molecules. The maximum in ultrasonic velocity is observed at 0.001875 mol% concentration. This is due to the replacement of weaker intermolecular attraction between solvent molecules by the strong intermolecular interactions. This indicates that the solvent–solvent interaction is replaced by solute–solvent interaction. For non polar solvents there is a decrease in velocity by increasing the concentration due to weak solvent - solute interactions.

The adiabatic compressibility generally decreases with increase in concentration [12]. Compressibility is the measure of the ease with which a system can easily be compressed. i.e., the larger the compressibility the easier it can be compressed because of more free space between the components [15]. A gradual and almost linear decrease in adiabatic compressibility was observed as concentration of solute increased. Due to electrostriction, the solvent molecules within the primary solvation shell of electrolytic solution are rendered incompressible moreover increasing concentration of ions results in more solvent molecules to engage in incompressible solvation spheres thereby decreasing the adiabatic compressibility [16]. Adiabatic compressibility (β) is found to be decreased with increasing concentration of benzilic acid. It is primarily the compressibility that changes with structure which leads to change ultrasonic velocity. The change in adiabatic compressibility in liquid mixtures indicates there is a definite contraction on mixing and the variation may be due to complex formation. The decrease in value of compressibility (β) also indicates a domination contribution from structure-breaking effect. A high value of adiabatic compressibility for low concentration indicates a positive ion-solvent interaction, and at the same time the network of hydrogen bonding formed by the solvent molecules is not much disturbed. Adiabatic compressibility reaches a minimum at 0.001875 mol% beyond this concentration, there is an increase in the adiabatic compressibility with an increase in concentration (Fig. 3).

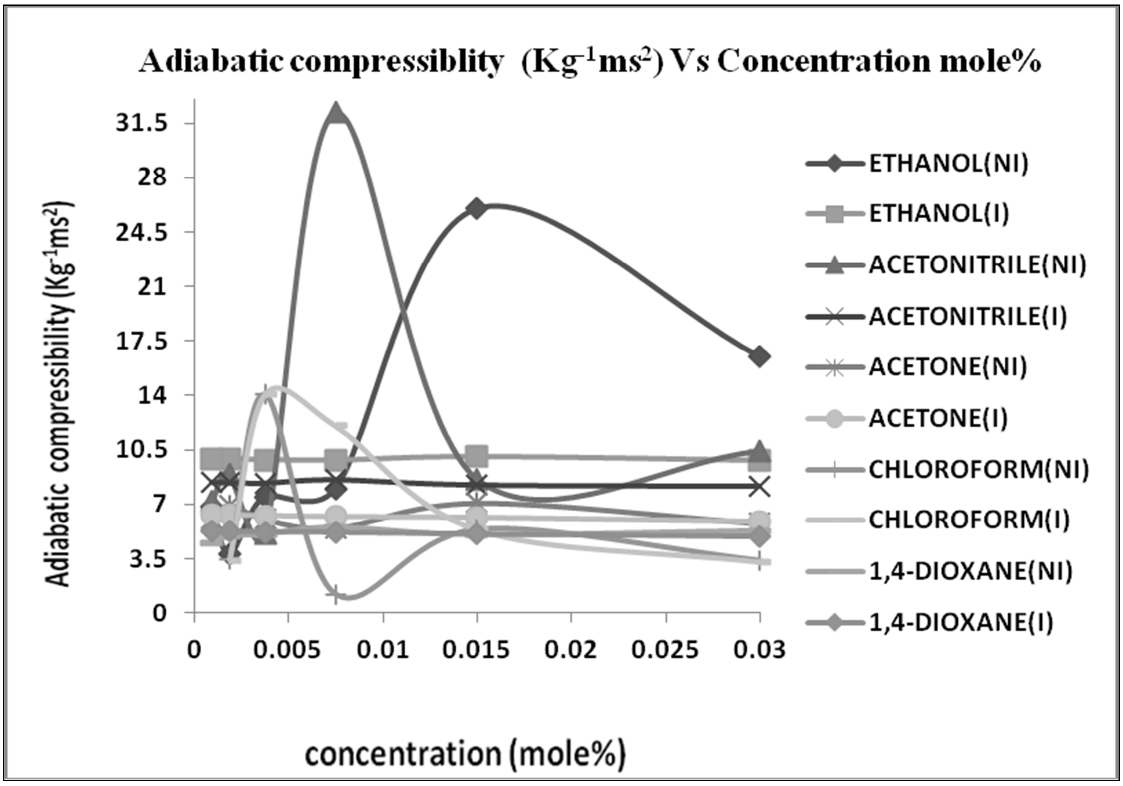

Fig. 3. *Adiabatic compressiblity ($Kg^{-1}ms^2$) Vs Concentration mole%*

This indicates that the solute/solvent interaction is replaced by comparatively stronger interaction between solute molecules, releasing the solvent molecules. Further increase in adiabatic compressibility indicates a change in the conformation /orientation of the solute molecules in solution, leading to weaker Inter-molecular interaction.

The decrease of intermolecular free length with increase in concentration is a normal trend [17]. Intermolecular free length (L_f) shows a similar behavior as reflected by adiabatic compressibility. The decrease in compressibility brings the molecules to a closer packing resulting into a decrease of intermolecular free length. As Intermolecular free length (L_f) increases, ultrasonic velocity decreases and vice-versa, shows an inverse behavior [18]. The decrease in the value of adiabatic compressibility and the free length with increase in ultrasonic velocity further strengthens the molecular association between the unlike molecules through hydrogen bonding. Therefore, intermolecular free length is one of the predominating factors for deciding the nature of variation in ultrasonic parameters in the liquid mixture. In the present study the decrease in intermolecular free length causes increase in ultrasonic velocity, decrease in adiabatic compressibility, increase in density and acoustic impedance as the concentration of benzilic acid increases (Fig. 4).

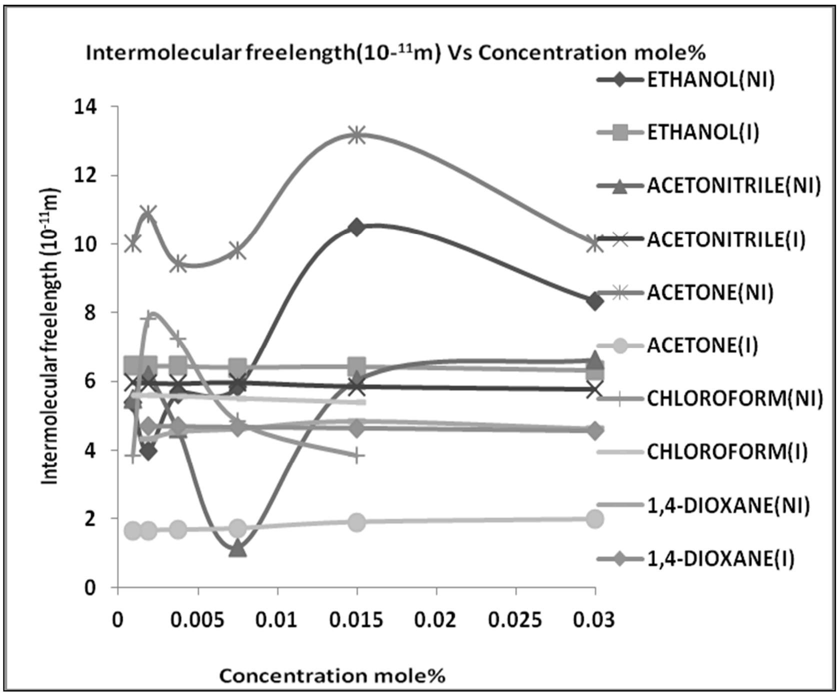

Fig. 4. *Intermolecular free length(10^{-11}m) Vs Concentration mole%*

At lower concentrations, the molecules are not close, hence the intermolecular free length will be high. As the concentration increases, the molecules come closer, thereby decreasing the intermolecular free length and hence internal pressure increases. The initial increase of free length with an increase in molar concentration shows the reduction in the degree of association among solvent molecules. This is due to the loss of dipolar association breakingup of hydrogen bonds and differences in the size and shapes of molecules in the liquid mixtures [19, 20].The stronger intermolecular interactions results in a tightly packed liquid structure and, as such, the adiabatic compressibility and intermolecular free length decreases.

The decrease in adiabatic compressibility and intermolecular free length while opposite trend in acoustic impedance and molar volume with the increase in concentration of benzilic acid predict the existence of specific interactions among the components in the binary liquid mixture [21]. In the present investigation, it is observed that these acoustic impedance (Z) values increase with increasing concentration of benzilic acid. Such increasing trends of acoustic impedance further support the possibility of molecular interaction due to H-bonding between the benzilic acid (Fig. 5).

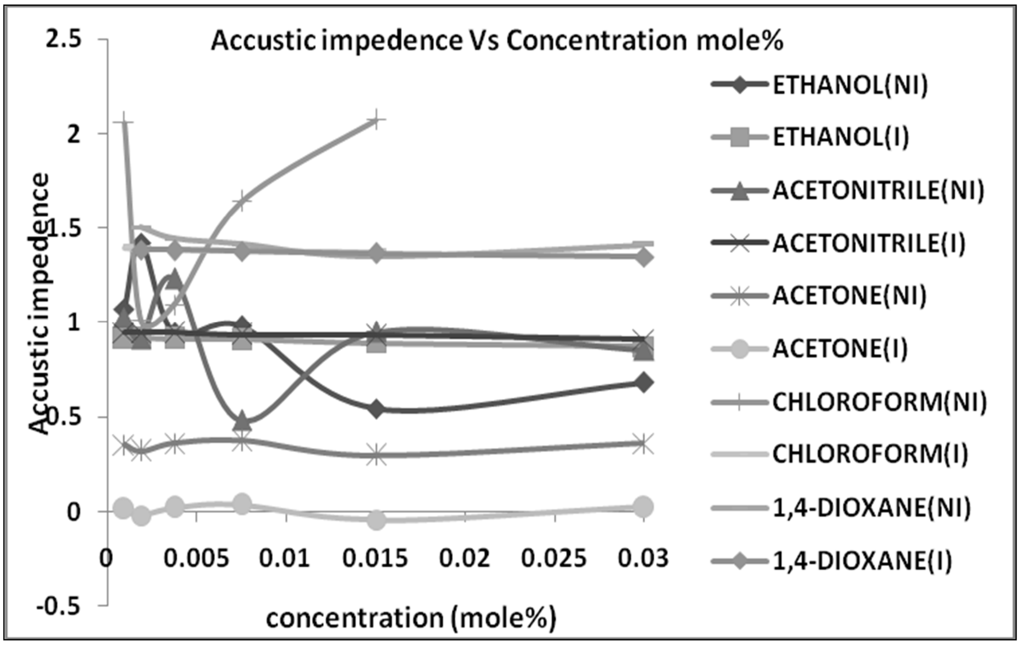

Fig. 5. *Accustic impedence Vs Concentration mole%*

Acoustic impedance (Z) of a material is the opposition exerted by the medium to displacement of the medium's particles by the sound energy. It is important to measure acoustic impedance because studies have shown that in solvent mixtures when molecular interactions occurs, acoustic impedance exhibits a non-linear variation with increasing mole fraction of solute. This was used as an essential tool to predict molecular level interactions in binary liquid mixtures. In systems of binary liquid mixtures is always much greater than either of the polar solutes in the inert solvent Literature shows that the impedance approach to explain the molecular interaction in liquid mixtures has been rather less commonly employed [22]. This is one of the reasons why the impedance approach has been adopted here, to examine the behavior of the solution regarding molecular interactions.

The relative association is the measure of extent of association of components in the medium. It is a property of understanding the molecular interaction in liquid mixtures and solutions. The relative association, R_A is influenced by two factors:

i) The breaking up of solvent/solvent interaction on addition of solute indicates higher value of R_A

ii) Solvation of solute indicates a lower value of R_A *10

The former leads to decrease and later to increase of relative association. When solute is added to solvent salvation of solute takes place and hence relative association increases. In the present study, the values of R_A increase with increase in solute concentration showing significant ion solvent interactions which increase with increase in solute concentration [23]. Relative association is found to have an initial minimum value at 0.001875 mole % for polar solvent (Fig. 6). Beyond this concentration, the R_A values increase, reaching a maximum at 0.0075 mole %. The maxima and minima are shifted to low concentration regions of 0.0075mole% and 0.001875 mole % respectively. Further, the addition of benzilic acid does not affect the existing intermolecular interactions significantly. This trend can be explained that at low concentration, the solvent/solvent interactions break down to give way to solvent/solute interactions.

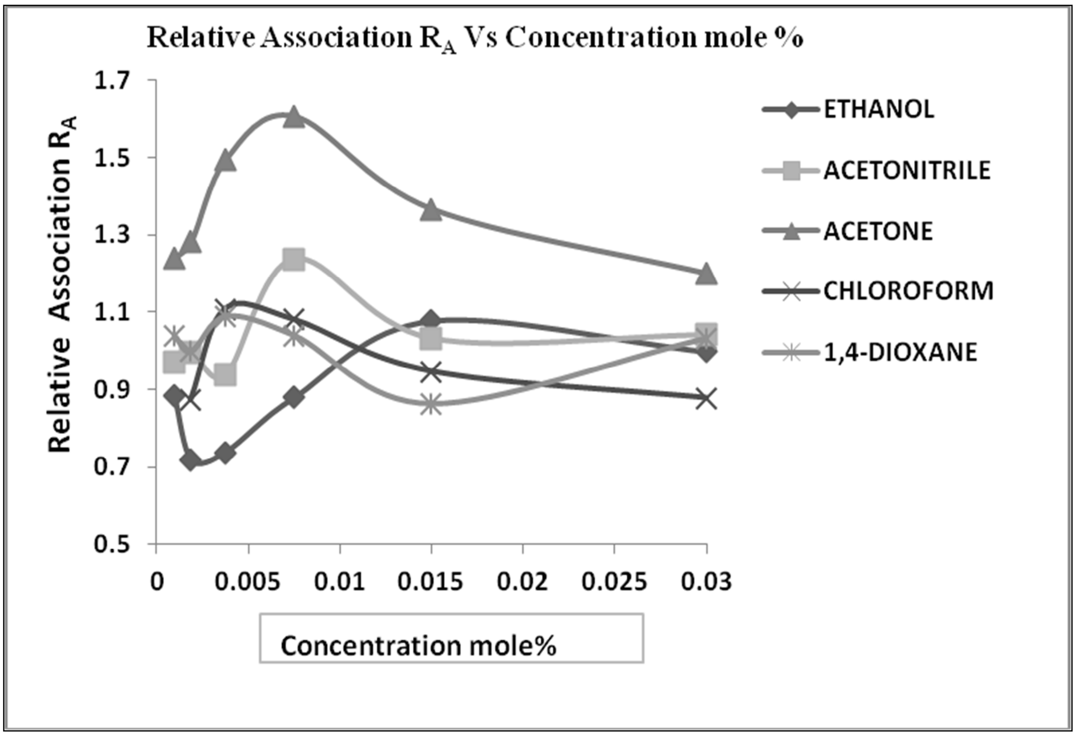

Fig. 6. Relative Association R_A Vs Concentration mole %

The decrease in free volume suggests the close packing of the molecules, which may be concluded as the increasing magnitude of the interaction [24-26]. In the concentration range of 0.0009-0.001875 mole%, there is a sharp decrease in apparent molar volume for polar solvent as the concentration increases (Fig.7).

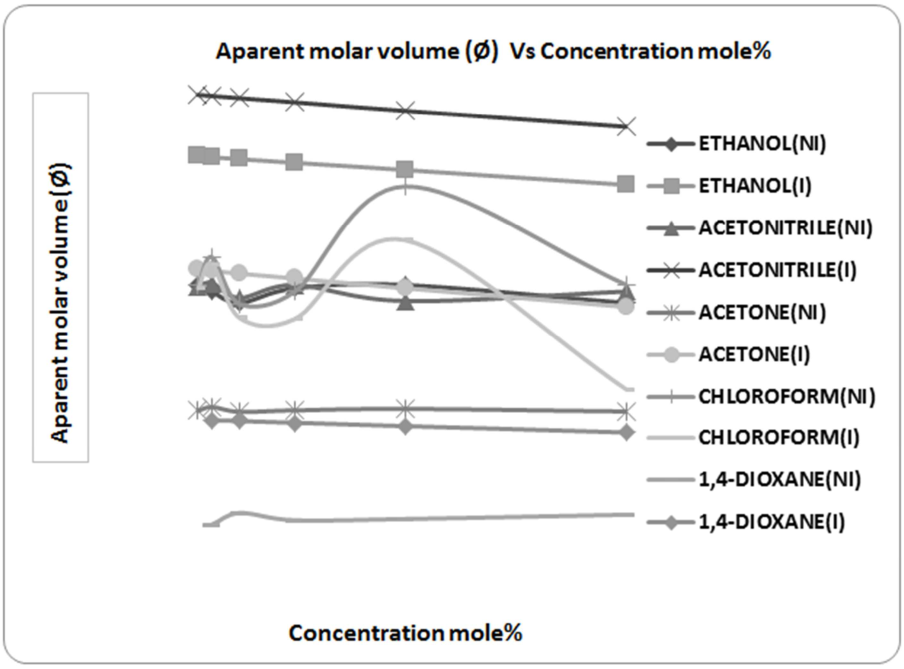

Fig. 7. *Aparent molar volume (Ø) Vs Concentration mole%*

This clearly shows that within the concentration range a significant solute-solvent interaction is taking place. Beyond this concentration range, the decrease in molar volume is not very significant. For non polar solvent there is a sharp increase in apparent molar volume at 0.00375mole %. This is explained as increase in concentration allows for close approach of solvent and solute molecules and stronger association between solute and solvent molecules. This leads to decrease in volume and an increase in the density of the solution. The strength of interaction between component molecules is well reflected in deviations observed in $K_{s,}$ ρ, u, and L_f from the expected trend. The excess parameters are found to be more sensitive towards intermolecular interactions in the binary mixture. An ideal solution should be considered as non-associated and for an ideal mixture the values of excess property is zero. For non-ideal mixtures, the difference between experimental values and ideal values is significant. Excess functions were calculated using the general formula [27].

For ideal binary mixtures:

$$Y^E = Y_{exp} - Y_{ideal} = 0 \qquad (5)$$

$$Y_{ideal} = Y_{exp} \qquad (6)$$

In general, for non-ideal mixtures

$$Y^E = Y_{exp} - Y_{ideal} \qquad (7)$$

$$Y_{ideal} = [(1-x)\, Y_1 + xY_2]$$

$$Y^E = Y_{exp} - [(1-x)\, Y_1 + xY_2] \qquad (8)$$

Where x is mole fraction of benzilic acid. Y^E is excess adiabatic compressibility or excess intermolecular freelength or excess velocity or excess density and subscrips 1 and 2 stand for ethanol, acetonitrile, chloroform, acetone , 1,4-dioxane and benzilic acid respectively.

For non ideal mixtures, depending upon the magnitude and type of intermolecular interactions or changes in concentration and orientation of solute molecules in solution, the magnitude and the sign of excess values also change.

The excess parameters are a measure of deviation from ideal behavior and are found to be highly sensitive to intermolecular interactions between component molecules of the mixture. Weak interaction between unlike molecules gives positive excess values whereas those of dipole-dipole, dipole-induced dipole, charge transfer, and hydrogen bonding between unlike molecules gives negative excess parameters.

In order to know the nature of interactions between the component molecules of the binary liquid mixture, it is of interest to discuss the same in terms of the excess values of acoustical parameters rather than the actual values. It is learnt that dispersive forces are responsible for weak interaction between unlike molecules. This leads to positive excess values of adiabatic compressibility, intermolecular free length, molar volume and available volume and negative excess values of velocity and acoustic impedance. The attractive forces are responsible for strong interaction between unlike molecules which leads to negative excess values of adiabatic compressibility, intermolecular free length, molar volume and available volume and positive excess values of velocity and acoustic impedance. Non-ideal liquid mixtures show considerable deviation from linearity from their physical properties with respect to mole fraction and these have been interpreted as the presence of both strong and weak interactions.

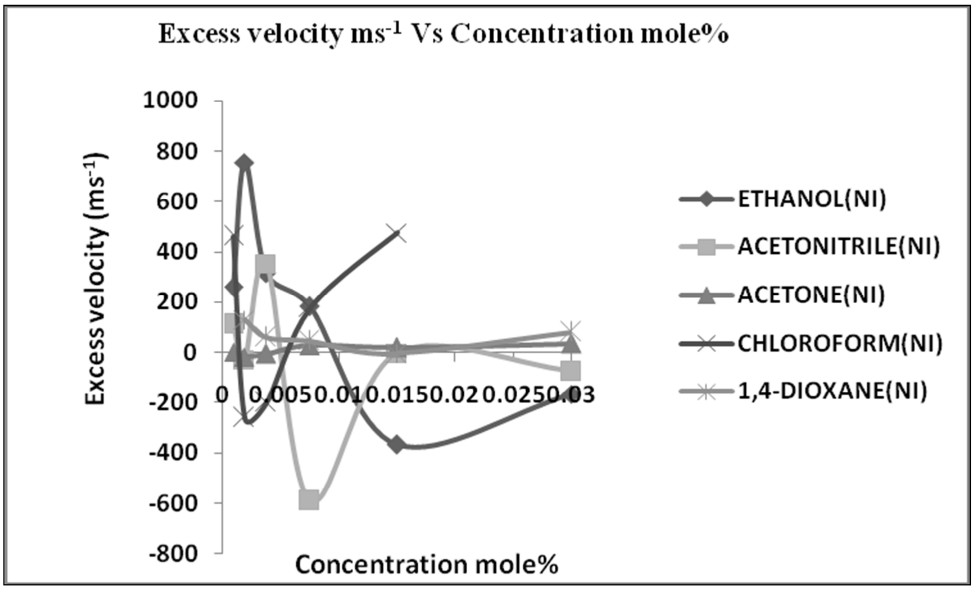

Fig. 8. *Excess velocity ms^{-1} Vs Concentration mole%*

Fig. 8 shows that the values of excess velocity are positive for the mole fraction of benzilic acid between 0.000938 to 0.0075 and negative for the mole fraction of benzilic acid between 0.015 to 0.03 for all concentration. The positive values of excess velocity indicate the presence strong molecular interactions at lower concentration of benzilic acid. The negative values of excess velocity indicate the presence dispersive forces between unlike molecules in the binary mixture.

The negative values of some thermo-acoustic parameters like excess compressibility indicate a strong intermolecular interaction in the constituent molecules due to presence of hydroxyl group of binary liquid mixture and it may lead to the formation of weak complex in the liquid mixture at particular concentration. β_E values are negative which suggest the presence of hydrogen bonding interaction between the components of the liquid mixtures. However, β_E values are positive which suggest the absence of hydrogen bonding.

The positive values of excess adiabatic compressibility, excess intermolecular free length, indicate weaker interactions between solute and solvent molecules, resulting from the disruption of molecular association (Figs.9 and 10).

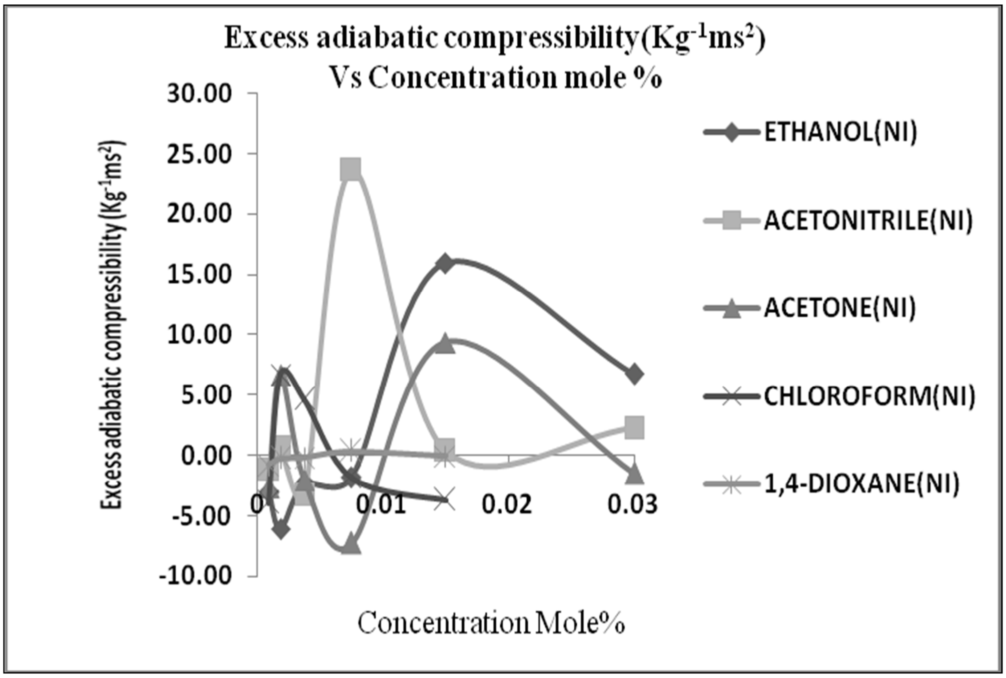

Fig. 9. *Excess adiabatic compressibility(Kg^{-1}ms^{2}) Vs Concentration mole %*

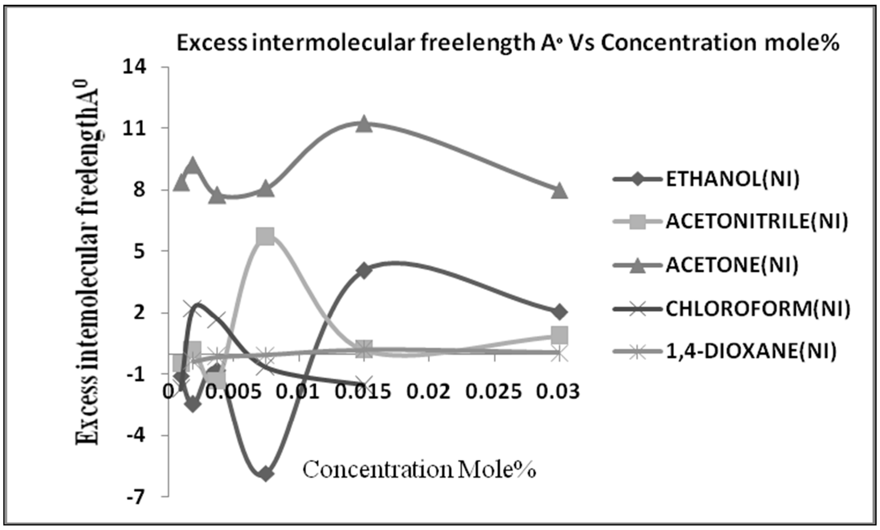

Fig. 10. *Excess intermolecular free lenghth A^0 Vs Concentration mole%*

The negative value of excess volumes shows that the existence of interactions between solute and solvent molecules is apparent. A positive excess acoustic impedance value indicates that over the concentration range of 0.000185 - 0.00375 mole% for polar solvents that significant interaction between solute and solvent is present. The negative excess adiabatic compressibility and excess intermolecular free length are attributed to the presence of intermolecular interaction between solute and solvent. This is especially true for solutions of concentration of mole fraction 0.0075-0.0015% for polar solvents and 0.000938 - 0.001875 mole% for non polar solvents. The rate of disruption of intermolecular interaction between solvent molecules is increased as the polarity of the solvent is increased. . Thus, the positive excess velocity, acoustic impedance, and negative excess Ks and L_f may be attributed to specific, strong interactions like hydrogen bonding and dipole-dipole interactions, while the negative deviations may be ascribed to weak dispersion forces in the system. Oswal and Desai [28, 29] attributed the positive excess Ks and L_f values to the large size of the solute molecules and weaker cohesive forces between unlike components of the solution, as in the present system. In (Fig. 11) at a concentration of 0.03 mol% a maximum for excess density for polar solvents indicates that solvent–solvent interactions are replaced by solvent–solute interactions. The values of excess density in all the solvents at different mole fraction are found to be both positive and negative. The nature of sign changes when the mole fraction is increased in all solvents. This is due to the weakening of the molecular interaction between the molecules.

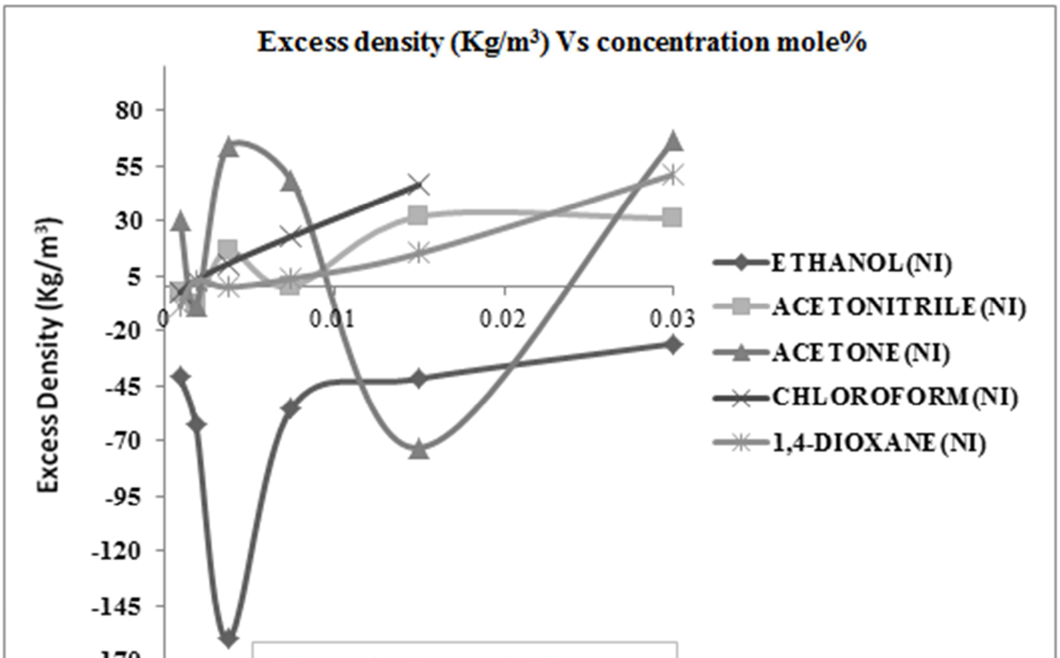

Fig. 11. *Excess density (Kg/m-^{3}) Vs concentration mole%*

4. Conclusion

The ultrasonic studies of benzilic acid is a non-destructive investigation used for probing the nature of the acoustical and molecular interaction in binary liquid mixture. The acoustic data of ultrasonic velocity (u), density (ρ), Intermolecular free-length with their excess values of benzilic acid with various solvents over the different concentrations range may suggest the existence of a strong molecular interaction in binary liquid mixture. Polar solvent is capable of taking part in intermolecular hydrogen bonding interactions which are being slowly replaced by solvent-solute interaction. This leads to the solvation of the solute particles resulting in an increase in volume and a decrease in density of the mixture. In non-polar solvents, at higher concentration the dipole induced dipole interaction increases leading to decrease in volume. The negative values of some thermo-acoustic parameters like excess compressibility indicate a strong intermolecular interaction in the constitute molecules due to presence of hydroxyl group of binary liquid mixture and it may leads to the formation of weak complex in the liquid mixture at particular concentration.

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