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ACOUSTIC AND VOLUMETRIC STUDIES OF BENZOPHENONE WITH ALCOHOLS AND TOLUENE AT 303K AND ATMOSPHERIC PRESSURE

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Abstract: **The velocity of ultrasonic waves, density and viscosity of three binary liquid mixtures namely Benzophenone + 2-Butanol, Benzophenone + Allylalcohol, Benzophenone + 2-Ethoxyethanol, and three ternary liquid mixtures namely Benzophenone + Toluene + 2-Butanol, Benzophenone + Toluene + Allylalcohol, Benzophenone + Toluene + 2-Ethoxyethanol have been measured. From the precise data, some of the acoustical parameters such as adiabatic compressibility inter molecular free length, relaxation time, acoustic impedance, bulk modulus, attenuation, relative association and Gibb's free energy values are computed for the six systems at 303K and at atmospheric pressure. The performances of these parameters with composition of the mixtures have been conferred in terms of molecular interaction between solute and solvent.**

Keywords: ***Adiabatic compressibility, free length, relaxation time, attenuation and molecular interactions of binary and ternary systems.***

I. INTRODUCTION

The velocity of sound is purely one of the thermodynamic properties[1]. Many thermodynamic properties of pure liquid and liquid mixtures can be explained from sound velocity, viscosity and density data[2]. The thermodynamic data are very essential tool to understand the molecular interactions arising in the solution of solute–solvent and solute–solute mixtures.

During the past decades, the field of molecular science have been growing tremendously with the help of ultrasonic exploration of inter molecular exchanges in liquid and solid substances. The propagation of ultrasonic waves in liquid affects its physical properties and hence the physic-co-chemical behavior of the polar and non-polar liquid mixtures can be described by means of the ultrasonic waves[3]. In recent years, ultrasonic technique has become dominant tool in providing insight information regarding the behavior of pure liquids, binary and ternary mixtures [4]. Obviously, now a day, the liquid mixtures find many practical applications in the chemical, biological and industrial process on studying thermodynamic and acoustical properties of the liquid mixtures[5].

Benzophenone is an aromatic ketone which is an essential compound in natural photo chemistry and perfumery as well as in organic synthesis. Benzophenone is a white crystalline substance with rose-like odor and hence which is used as an important compound to make perfumes and as a starting material for the production of dyes, insect killer, insect repellent and drugs especially anxiolytic and hypnotic drugs. Benzophenone is used as a photo initiator of UV-curing applications in inks, varnishing, and optical fiber as well as in electronics printed circuit boards. It can act as light filters or deactivate substrate molecules that have been energized by light for the fortification of polymers and organic substances[6]. Benzophenone derivatives are used as cosmetic grades and sunscreen agents to reduce skin damage by blocking UV radiation and also in nonlinear optical materials[7].

So far, many researchers have reported that the acoustical properties of different types of ketones and their mixtures. Even though, we are fascinated to study the molecular interactions of benzophenone with its solvents because of the attractive applications of benzophenone derivatives in daily life. In this research paper, we are reported that the result of molecular interaction in binary and ternary liquid mixtures of benzophenone with various alcohols and toluene at 303K.

II. EXPERIMENTAL

A. Materials and sample preparation

The commercially available standard grades of analytical reagents had been used for the present study and quoted mass fraction cleanliness of the materials were: Benzophenone (>99%), 2-Butanol (>99.5), Allylalcohol (>99.4), 2-Ethoxyethanol (>99.5), and Toluene (>99.5) and were used for this investigation without any further distillation process. All the chemicals were procured from Sigma-Aldrich. In all systems, the mixtures were freshly prepared by changing the concentration (molarity) of benzophenone alone with fixed volume of solvents. The prepared binary and ternary mixtures, Benzophenone + 2-Butanol, Benzophenone + Allylalcohol, Benzophenone + 2-Ethoxyethanol, Benzophenone + Toluene + 2-Butanol, Benzophenone + Toluene + Allylalcohol,,

Benzophenone + Toluene + 2-Ethoxyethanol were accumulated in air tight glass bottles to avoid the evaporation.

B. Experimental details

The ultrasonic velocities in binary liquid mixtures and in ternary liquid mixtures were measured using mono quartz crystal ultrasonic interferometer (model number: F81, Mittal Enterprises, New Delhi, India) which was operated at mono frequency 2MHz with an accuracy of $0.1ms^{-1}$. The temperature of the interferometer cell was kept as invariable by circulating water from a constant temperature bath.

The density of the binary liquid mixtures and ternary liquid mixtures were measured using specific gravity bottle made of borosil glass which had single capillary and a bulb of volume 25ml. The capillary which had graduated marks and uniform bore. A well-fitting glass cap was used to close it always. The marks on the capillary were calibrated by using double distilled water. The densities of liquid mixtures were measured by using the relation $\rho = (w/w_w)\,\rho_w$.Where "w" is the weight of the liquid mixture; "ρ_w" is the density of water. The measurements were repeated for three times and the results reported here are the mean values.

The relative method has been used to determine the viscosity of pure liquids and liquid mixtures. In order to perform, we have used the Ostwald's viscometer. The viscosity of liquid mixtures were determined using the following relation $\eta = \eta_w(\rho_s t_s/\rho_w t_w)$.Here, "$\eta_w$" ,"$\rho_w$" and "$t_w$" are viscosity, density and time flow for the double refined water respectively. "ρ_s" and "t_s" are density and time flow of the liquid systems. The measurements were repeated for three times and the average values are taken in account.

C. Theoretical equations

From the experimental data of density, viscosity and ultrasonic velocity, various acoustical parameters are worked out using standard equations given below:

Adiabatic compressibility: $\beta_{ad} = (\rho u^2)^{-1}$

Bulk modulus: $K = \rho u^2$

Acoustic Impedance: $Z = \rho u$

Intermolecular free length: $L_f = k_f/(\rho u)^{1/2}$

Jacobson's constant $k_f = (93.875+0.375T) \times 10^{-8}$

Where T is an absolute temperature.

Relaxation time: $\tau = 4\eta / 3\rho u^2$

Relative association: $(RA) = \rho/\rho_o \times [v_o/v]^{1/3}$

Where ρ, ρ_o , v_o , and v are the density of solution, density of the solvent, speed of ultrasonic in solvent and speed of ultrasonic in solution respectively.

Gibb's free energy: $\Delta G = (K_B T) \log [(K_B T\tau)/h]$.

Where K_B is the Boltzmann's constant $(1.3806\times10^{-23}Jk^{-1})$, h is the plank's constant $(6.63 \times 10^{-34}$ JS), T is the absolute temperature and $\boldsymbol{\tau}$ is the relaxation time.

Attenuation: $(\alpha/f^2) = 8\pi^2\eta/3\rho u^3$

Where α is the absorption co-efficient, f is the frequency, η is shear viscosity,ρ is density and v is speed of sound in dispersion.

III. RESULT AND DISCUSSION

The experimentally observed values of velocity of ultrasonic (u), density (ρ) and viscosity (η) were utilized to work out different acoustical parameters such as adiabatic compressibility (β_{ad}), intermolecular free length (L_f), relaxation time (τ), acoustic impedance (Z), and Gibb's free energy (ΔG) of binary and ternary liquid mixtures are listed in **Table 1** and **Table 2**. In this present investigation, In order to understand the occurrence of molecular interactions among the different species, the ultrasonic velocity values have been used and played in a major role[8]. Moreover, the study of acoustical parameters is much important to assess the physic-co-chemical behavior and molecular interactions between the solvent - solvent and solute – solvent liquid mixtures[9].

From the **Table1**, it is revealed that the density and viscosity of binary as well as ternary liquid mixtures were identified to be increased with increasing concentration of benzophenone. it is occurred because of presence of benzophenone molecules in solution which turns the medium into thicker[10]. Likewise, the cohesive force between the liquid layers is increased by increasing the number of solute particles in liquid mixtures. Hence, the co- efficient of viscosity increases in all systems. The densities and viscosities of benzophenone + 2-ethoxyethanol and benzophenone +toluene +2-ethoxyethanol mixtures were found to be greater than other ketone+alcohol and ketone + toluene + alcohol mixtures. This may be due to the higher chain length of 2-ethoxyethanol.

The **Figure 1** reveals that the velocity of ultrasonic waves increases in all six systems with increasing concentration of benzophenone. This may be due to the association of very sturdy dipole-dipole interaction between the fundamental molecules. Hence this behavior can be endorsed to study the intermolecular interaction in the system[11] and many researchers have been proposed earlier that the ultrasonic velocity depends upon the increase or decrease of inter molecular free length. That is, the ultrasonic velocity in any liquids and liquid mixtures should be increased by decreasing the intermolecular free length and vice-versa[12] and the present investigation confirms that the same reason of increasing ultrasonic velocity in all liquid mixtures.

It is also identified clearly that the ultrasonic velocities increases in all systems with the increasing concentration of benzophenone. Meanwhile, the adiabatic compressibility and intermolecular free length (L_f) show the opposite trend. From the **Figures 2 and Figure 3**, the both parameters are found to be decreased in all six systems with

different concentration of benzophenone persist. It is found that the decrease in adiabatic compressibility and intermolecular free length with increasing the concentration of benzophenone pointed out the considerable molecular interaction between benzophenone and alcohol molecules forming hydrogen bonding through dipole-dipole interaction. Moreover, the strength of intermolecular forces may be increased by changing the concentration of benzophenone thereby which can bring the molecules to a closely packing structure. Hence the adiabatic compressibility and intermolecular free length of liquid system drop off.

Whenever the liquid or liquid mixture is exposed by ultrasonic which can produce a compressive force per unit area because ultrasonic purely is a mechanical wave. From **Table 2**, it is obtained that the bulk modulus increases in all six systems against the different concentrations. Hence, It is confirmed that the one of the reason of decreasing adiabatic compressibility and intermolecular free length of liquid mixtures.

The liquid alcohols are associated with three dimensional network of hydrogen bond[13] and which can make the interaction with any of other group having same degree of polar attractions[14]. The alcohols are having hydroxyl group (O-H) and aromatic ketones such as benzophenone having carbonyl groups (C=O). When they are used to prepare liquid mixtures, there may be a molecular interaction between them by hydrogen bond formation through dipole-dipole interaction. Further, the aromatic groups can produce possible interaction between the π electrons cloud and hydroxyl group. Hence, some of the intermolecular complexes may be produced from these interactions and thereby, the velocity of ultrasonic waves increases with increasing concentration of benzophenone. This type of interactions created by the π electrons are too weak than the interaction produced by the hydrogen bond[15].

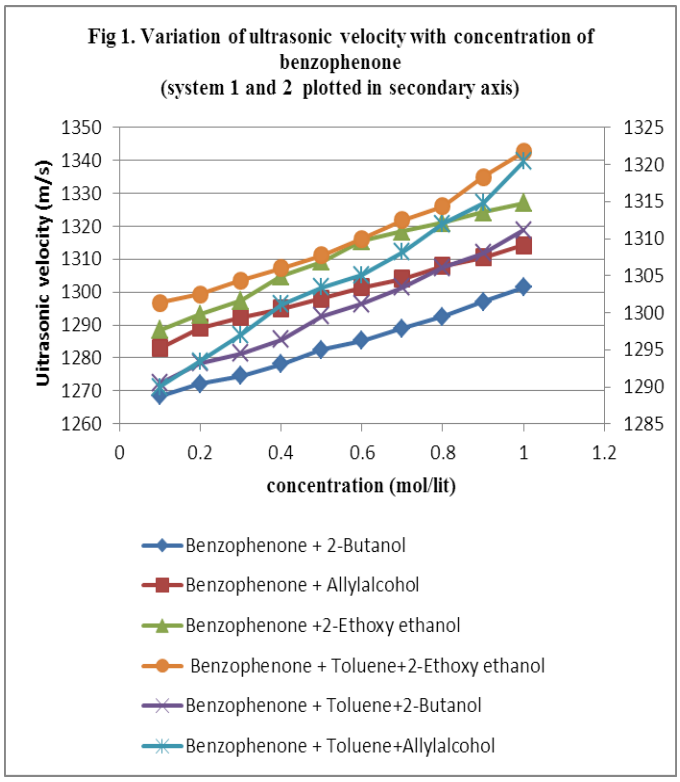
In the case of ternary mixtures, the observed ultrasonic velocities were found to be greater than binary mixtures against different concentration of liquid mixtures. Hence, it is identified that, there were very strong molecular interaction produced by adding of toluene with alcohols and bezophenone. It may be due to the withdrawal of π electrons from the toluene ring by carboxyl group of aromatic ketone such as benzophenone and which acts as electron-acceptor towards π electrons of toluene ring[16].This observation brings out that the presence of multi type of interaction like dipole-dipole interaction through hydrogen bond formation between benzophenone and alcohols and donor-acceptor character between toluene and benzophenone in binary and ternary liquid mixtures.

The acoustic impedance is one of the parameter can be used to understand the internal and elastic properties of the medium[17]. The **Table 2** indicates that the variation of acoustic impedance with concentration. The acoustic impedance increases in all six systems with increasing concentration of benzophenone with different alcohols and toluene. Hence this shows the similar trend as increasing ulrasonic velocity in all liquid systems. The increasing of acoustic impedance also helps to confirm that the existence of molecular interactions of dipole-dipole interaction through hydrogen bonding formation between solute and solvent in liquid mixtures[18]. From the **Table 2**, it is found that the acoustic impedance of benzophenone + 2-ethoxyethanol and benzophenone +toluene +2-ethoxyethanol mixtures were found to be greater than other ketone+alcohol and ketone + toluene + alcohol mixtures. This may be due to the strong intermolecular interactions between benzophenone, toluene and 2-ethoxyethanol.

Table 1: Experimental values of ultrasonic speeds (u), density (ρ) and viscosity (η) of liquids and liquid mixtures at 303K.

Mol lit^{-1}	System 1: Benzophenone+ 2-Butanol			System 2: Benzophenone+ Allylalcohol		
	u m/s	ρ kg/m^3	$\eta x10^{-3}$ Nsm^{-2}	u m/s	ρ kg/m^3	$\eta x10^{-3}$ Nsm^{-2}
0.0	1242.5	802.2	1.095	1251.4	850.5	0.7764
0.1	1268.5	811.5	1.115	1283.0	871.4	0.7830
0.2	1272.1	814.2	1.127	1289.2	874.5	0.7855
0.3	1274.5	819.2	1.132	1292.4	878.9	0.7866
0.4	1278.2	824.5	1.145	1295.0	883.1	0.7879
0.5	1282.5	827.6	1.160	1298.1	887.0	0.7890
0.6	1285.2	831.4	1.171	1301.5	891.5	0.8010
0.7	1288.9	835.1	1.180	1304.1	895.0	0.8031
0.8	1292.5	839.2	1.187	1307.9	901.5	0.8052
0.9	1297.0	844.0	1.192	1310.5	904.2	0.8074
1.0	1301.5	850.5	1.210	1314.3	907.8	0.8108
Mol lit^{-1}	System 3: Benzophenone+ 2-Ethoxyethanol			System 4: Benzophenone + Toluene + 2-Butanol		
	u m/s	ρ kg/m^3	$\eta x10^{-3}$ Nsm^{-2}	u m/s	ρ kg/m^3	$\eta x10^{-3}$ Nsm^{-2}
0.0	1254.0	929.4	1.648	1260.2	805.6	1.109
0.1	1288.5	951.6	1.752	1290.5	835.2	1.126
0.2	1293.2	955.1	1.778	1293.2	838.4	1.186
0.3	1297.4	959.4	1.802	1294.5	844.1	1.216
0.4	1304.8	962.4	1.830	1296.4	849.0	1.284
0.5	1309.2	966.4	1.851	1299.5	856.1	1.326
0.6	1315.5	969.5	1.870	1301.2	864.2	1.388
0.7	1318.4	973.4	1.895	1303.4	868.5	1.420
0.8	1321.1	976.0	1.911	1306.1	871.1	1.479
0.9	1324.3	980.4	1.936	1308.0	876.4	1.510
1.0	1327.0	985.6	1.984	1311.1	880.0	1.572
Mol lit^{-1}	System 5: Benzophenone + Toluene + Allylalcohol			System 6: Benzophenone + Toluene + 2-Ethoxyethanol		
	u m/s	ρ kg/m^3	$\eta x10^{-3}$ Nsm^{-2}	u m/s	ρ kg/m^3	$\eta x10^{-3}$ Nsm^{-2}
0.0	1258.5	861.4	0.7880	1269.3	947.0	1.662

0.1	1290.0	879.0	0.7994	1296.7	969.1	1.759
0.2	1293.4	881.5	0.8002	1299.4	973.2	1.784
0.3	1297.0	884.5	0.8015	1303.5	976.9	1.812
0.4	1301.1	889.2	0.8045	1307.2	977.4	1.835
0.5	1303.4	892.1	0.8090	1311.2	979.2	1.862
0.6	1305.1	898.4	0.8145	1316.1	981.4	1.889
0.7	1308.2	905.0	0.8190	1321.9	984.0	1.903
0.8	1312.0	909.8	0.8220	1326.1	986.1	1.936
0.9	1314.8	914.0	0.8265	1335.0	989.0	1.950
1.0	1318.5	961.4	0.7880	1341.3	947.0	1.962



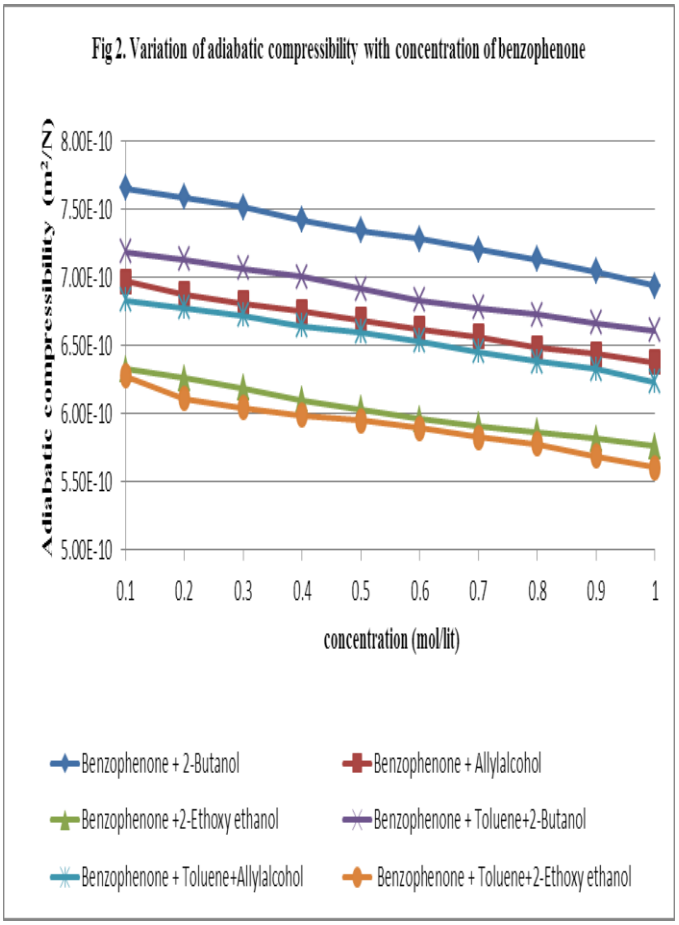


Fig 3. Variation of Inter molecular free length with concentration of benzophenone

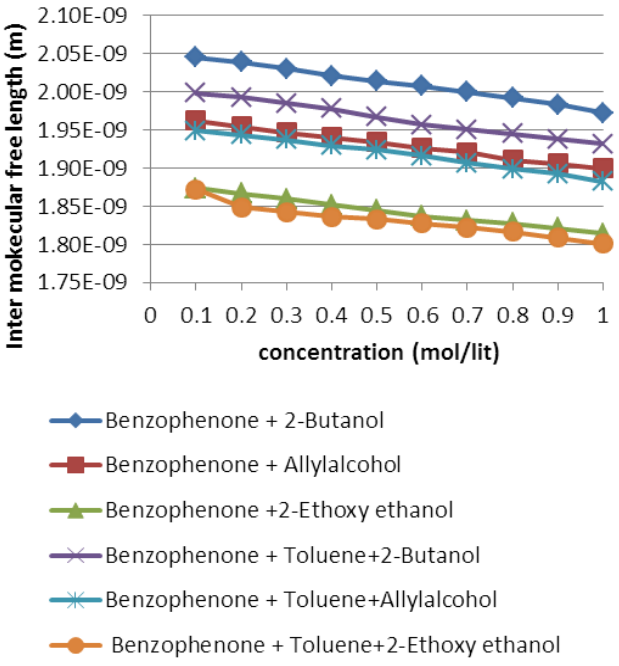


Fig 4. Variation of Relaxation time with concentration of benzophenone (system 4 and 5 plotted in secondary axis)

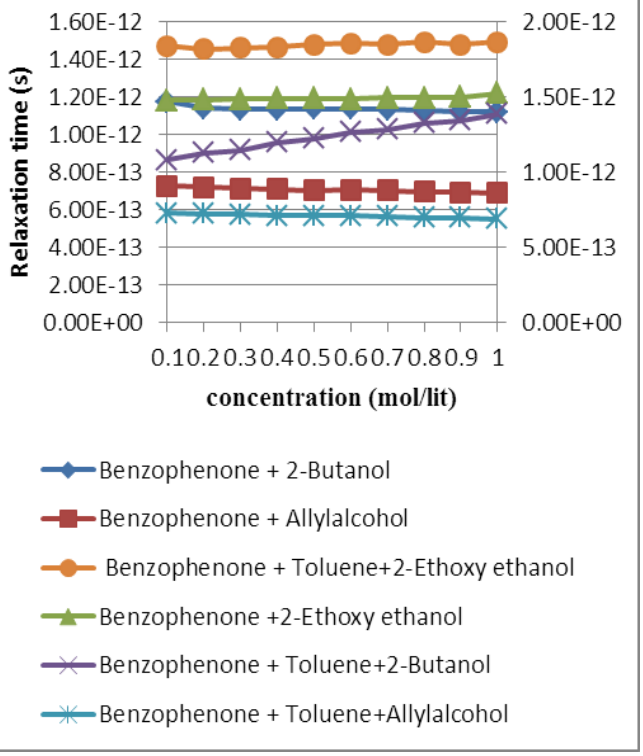
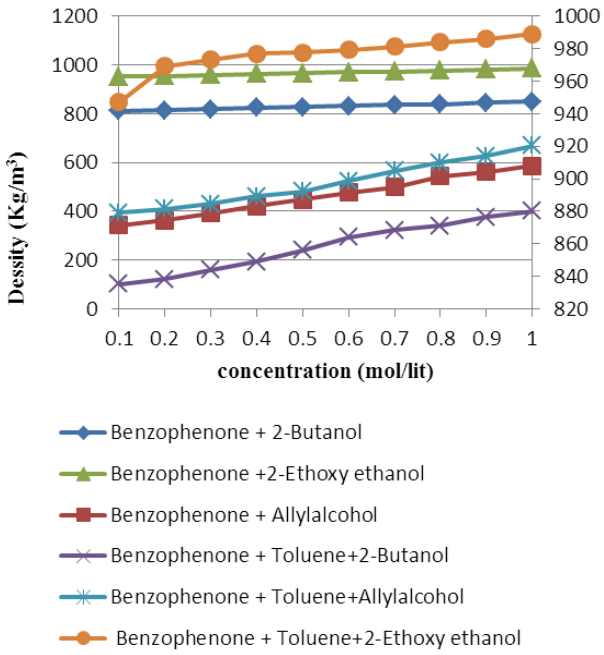


Fig 5. Variation of density with concentration of benzophenone (system 3,4,5 and 6 plotted in secondary axis)



The variations of relaxation time with increasing molarities of benzophenone in binary and ternary mixtures have been identified. The relaxation time shows non-linearly decreasing trend with increasing concentration in binary system 1 and 2 and in ternary system 5 and shows non-linearly increasing trend in binary system 3 and ternary system 4 and 6. This non-linear variation is occurred which may be due to the specific interaction between the unlike molecules present in the system and intermolecular force with the addition of solute in solvent[19].

From the **Table 2**, it is observed that the variation of relative association (RA) with concentration. The relative association is a valuable parameter can be used to identify molecular interaction through bond breaking and forming.

If relative association decreases with increasing concentration indicates the breaking up solute molecules in solution[20] but in our present investigation, the relative association increases with increasing concentration of benzophenone in six systems. It may be due to the formation of H-bond in liquid mixtures.

From **Table 2**, it is found that the variations of Gibb's free energy with increasing concentration of benzophenone in binary and ternary mixtures have been identified. Since the Gibb's free energy computation depends on the temperature and relaxation time, The Gibb's free energy shows non-linearly decreasing trend with increasing concentration in binary system 1 and 2 and in ternary system 5 and shows non-linearly increasing trend in binary system 3 and ternary system 4 and 6. The decreasing of Gibb's free energy in system 1,2 and 5 shows that the requirement for

small time for making the re-arrangement of molecules in the mixture and decreasing the energy that leads to dissociation. The Gibb's free energy increases nonlinearly in system 3, 4 and 6 due to the more association of molecules. The non-linear attenuation co-efficient effect has been identified from **Table 2**. Viscosity measurement plays an important role to calculate attenuation co-efficient. Obtaining non-linear effect in attenuation may be due to the molecular association and dissociation[21].

Table 2: The values of adiabatic compressibility (β_{ad}), Bulk modulus (k), Acoustic impedance (Z), Intermolecular free length (L_f), Relaxation time (τ). Relative association (RA), Gibb's free energy (ΔG) and attenuation(a/f^2)at 303K for the systems 1, 2, 3 ,4,5 and 6 .

System 1: Benzophenone+ 2-Butanol				
Mol lit^{-1}	**β_{ad} X 10^{-10} m^2N^{-1}**	**k ($x10^9$ Nm^{-2})**	**Z Kg m-2 s^{-1}**	**L_f $X10^{-9}$ m**
0.0	8.078	1.238	996733	2.078
0.1	7.669	1.305	1029387	2.045
0.2	7.595	1.317	1035743	2.038
0.3	7.523	1.330	1044070	2.030
0.4	7.426	1.347	1053875	2.021
0.5	7.355	1.361	1061397	2.014
0.6	7.288	1.373	1068515	2.007
0.7	7.212	1.387	1076360	2.000
0.8	7.139	1.401	1084666	1.992
0.9	7.041	1.419	1094668	1.983
1.0	6.944	1.440	1106925	1.972
Mol lit^{-1}	**τ X 10^{-12} S**	**RA**	**(α/f^2) ($X10^{-14}Npm^{-1}s^{-2}$)**	**ΔG ($x10^{-21}$kJ mol^{-1})**
0.0	1.179	0.988	1.871	3.647
0.1	1.174	0.992	1.825	3.640
0.2	1.140	0.994	1.768	3.587
0.3	1.134	1.000	1.754	3.577
0.4	1.133	1.005	1.748	3.575
0.5	1.136	1.008	1.747	3.580
0.6	1.137	1.012	1.744	3.581
0.7	1.134	1.016	1.735	3.577
0.8	1.128	1.020	1.722	3.568
0.9	1.119	1.024	1.701	3.553
1.0	1.118	1.031	1.696	3.554
System 2: Benzophenone+ Allylalcohol				
Mol lit^{-1}	**β_{ad} X 10^{-10} m^2N^{-1}**	**k ($x10^9$ Nm^{-2})**	**Z Kg m-2 s^{-1}**	**L_f $X10^{-9}$ m**
0.0	7.518	1.331	1064315	2.011
0.1	6.973	1.434	1118006	1.962
0.2	6.889	1.453	1127405	1.954
0.3	6.812	1.468	1135890	1.946
0.4	6.755	1.480	1143614	1.940
0.5	6.698	1.494	1151414	1.933
0.6	6.621	1.510	1160287	1.926
0.7	6.567	1.522	1167169	1.920
0.8	6.489	1.542	1179071	1.910
0.9	6.434	1.552	1184954	1.906
1.0	6.379	1.568	1193121	1.899
Mol lit^{-1}	**τ X 10^{-12} S**	**RA**	**(α/f^2) ($X10^{-14}Npm^{-1}s^{-2}$)**	**ΔG ($x10^{-21}$kJ mol^{-1})**
0.0	0.777	1.043	1.224	2.890
0.1	0.727	1.060	1.118	2.771
0.2	0.721	1.062	1.102	2.753
0.3	0.714	1.067	1.090	2.737
0.4	0.709	1.071	1.080	2.724
0.5	0.703	1.075	1.069	2.710
0.6	0.707	1.079	1.071	2.719
0.7	0.703	1.083	1.063	2.709
0.8	0.696	1.090	1.049	2.690
0.9	0.693	1.092	1.043	2.683
1.0	0.689	1.096	1.034	2.672
System 3: Benzophenone+ 2-Ethoxyethanol				
Mol lit^{-1}	**β_{ad} X 10^{-10} m^2N^{-1}**	**k ($x10^9$ Nm^{-2})**	**Z Kg m-2 s^{-1}**	**L_f $X10^{-9}$ m**
0.0	6.842	1.461	1165467	1.922
0.1	6.329	1.579	1226136	1.873
0.2	6.260	1.597	1235135	1.867
0.3	6.192	1.614	1244725	1.859
0.4	6.103	1.638	1255739	1.851
0.5	6.037	1.64	1265210	1.844
0.6	5.963	1.677	1275377	1.837
0.7	5.913	1.691	1283330	1.831
0.8	5.875	1.703	1289393	1.827
0.9	5.819	1.719	1298343	1.821
1.0	5.767	1.735	1307891	1.814
Mol lit^{-1}	**τ X 10^{-12} S**	**RA**	**(α/f^2) ($X10^{14}Npm^{-1}s^{-2}$)**	**ΔG ($x10^{-21}$kJ mol^{-1})**
0.0	1.503	1.145	2.364	4.08932E
0.1	1.478	1.162	2.262	4.059
0.2	1.484	1.165	2.263	4.065
0.3	1.487	1.169	2.261	4.070
0.4	1.489	1.170	2.251	4.072
0.5	1.489	1.174	2.244	4.072
0.6	1.486	1.176	2.227	4.068
0.7	1.493	1.180	2.233	4.077
0.8	1.495	1.182	2.232	4.080

0.9	1.501	1.186	2.235	4.086
1.0	1.524	1.192	2.264	4.114
System 4: Benzophenone + Toluene + 2-Butanol				
Mol lit^{-1}	**β_{ad} X 10^{-10} m^2N^{-1}**	**k ($x10^9$ Nm^{-2})**	**Z Kg m-2 s^{-1}**	**L_f $X10^{-9}$ m**
0.0	7.816	1.279	1015217	2.059
0.1	7.189	1.390	1077825	1.998
0.2	7.132	1.402	1084218	1.992
0.3	7.069	1.414	1092687	1.985
0.4	7.008	1.426	1100643	1.977
0.5	6.927	1.445	1112501	1.967
0.6	6.834	1.463	1124497	1.956
0.7	6.777	1.475	1132002	1.950
0.8	6.729	1.486	1137743	1.945
0.9	6.669	1.499	1146331	1.938
1.0	6.610	1.512	1153768	1.931
Mol lit^{-1}	**τ X 10^{-12} S**	**RA**	**(α/f^2) (X10^{-14} $Npm^{-1}s^{-2}$)**	**ΔG ($x10^{-21}$kJ mol^{-1})**
0.0	1.155	0.972	1.809	3.611
0.1	1.079	1.000	1.649	3.487
0.2	1.127	1.003	1.719	3.567
0.3	1.146	1.010	1.746	3.596
0.4	1.199	1.015	1.825	3.679
0.5	1.222	1.023	1.855	3.714
0.6	1.264	1.032	1.916	3.775
0.7	1.283	1.037	1.941	3.802
0.8	1.327	1.039	2.003	3.862
0.9	1.342	1.045	2.024	3.883
1.0	1.386	1.048	2.083	3.940
System 5: Benzophenone + Toluene + Allylalcohol				
Mol lit^{-1}	**β_{ad} X 10^{-10} m^2N^{-1}**	**k ($x10^9$ Nm^{-2})**	**Z Kg m-2 s^{-1}**	**L_f $X10^{-9}$ m**
0.0	7.333	1.363	1083568	1.993
0.1	6.831	1.462	1133910	1.948
0.2	6.780	1.474	1140132	1.943
0.3	6.723	1.487	1147196	1.937
0.4	6.648	1.505	1156938	1.929
0.5	6.604	1.515	1162763	1.924
0.6	6.536	1.530	1172501	1.916
0.7	6.455	1.548	1183921	1.907
0.8	6.388	1.566	1193657	1.899
0.9	6.323	1.580	1201727	1.892
1.0	6.233	1.604	1215032	1.882
Mol lit^{-1}	**τ X 10^{-12} S**	**RA**	**(α/f^2) (X10^{-14} $Npm^{-1}s^{-2}$)**	**ΔG ($x10^{-21}$kJ mol^{-1})**
0.0	7.704	1.046	1.207	2.874
0.1	0.728	1.060	1.113	2.773
0.2	0.723	1.062	1.103	2.761
0.3	0.718	1.064	1.091	2.747
0.4	0.712	1.069	1.08	2.732
0.5	0.710	1.072	1.076	2.730
0.6	0.709	1.079	1.072	2.725
0.7	0.705	1.086	1.062	2.713
0.8	0.699	1.090	1.051	2.700
0.9	0.697	1.095	1.046	2.694
1.0	0.689	1.101	1.030	2.674
System 6: Benzophenone + Toluene + 2-Ethoxyethanol				
Mol lit^{-1}	**β_{ad} X 10^{-10} m^2N^{-1}**	**k ($x10^9$ Nm^{-2})**	**Z Kg m-2 s^{-1}**	**L_f $X10^{-9}$ m**
0.0	6.241	1.602	1262318	1.846
0.1	6.281	1.592	1227974	1.872
0.2	6.117	1.636	1259248	1.849
0.3	6.040	1.653	1268566	1.842
0.4	5.991	1.669	1277003	1.836
0.5	5.959	1.680	1281566	1.832
0.6	5.895	1.696	1288725	1.827
0.7	5.831	1.715	1297312	1.821
0.8	5.779	1.730	1304882	1.816
0.9	5.690	1.757	1316443	1.808
1.0	5.609	1.782	1327831	1.801
Mol lit^{-1}	**τ X 10^{-12} S**	**RA**	**(α/f^2) (X10^{-14} $Npm^{-1}s^{-2}$)**	**ΔG ($x10^{-21}$kJ mol^{-1})**
0.0	1.383	1.202	2.148	3.937
0.1	1.472	1.137	2.239	4.052
0.2	1.453	1.162	2.206	4.028
0.3	1.461	1.166	2.210	4.037
0.4	1.465	1.169	2.211	4.043
0.5	1.477	1.169	2.221	4.057
0.6	1.484	1.169	2.224	4.066
0.7	1.479	1.170	2.207	4.060
0.8	1.491	1.172	2.218	4.075
0.9	1.479	1.173	2.185	4.060
1.0	1.491	1.174	2.190	4.074

IV. CONCLUSION

The experimental observation of ultrasonic velocity, density and viscosity and their variation indicates the presence of molecular interaction in binary and ternary liquid mixture of benzophenone with alcohols and toluene. The direct parameters like adiabatic compressibility, acoustic impedance, inter molecular free length, ultrasonic relaxation time, relative association, Gibb's free energy and attenuation were also confirmed that the existence of molecular interaction in the systems.

It has been identified that the molecular interactions in the ternary mixtures of system 4 and system 6 were stronger than that of the binary mixtures of system 1 and 2. Hence, a competitive mechanism established in H-bond formation and dipole-dipole interaction between the solute and solvent used in this present investigation.

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