



## Evaluation of Thermodynamical Acoustic Parameters of Binary mixture of DBP with Toluene at 308K and at Different Frequencies

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### Abstract

Ultrasonic investigation of molecular interactions in a binary mixture of Di-n-butyl phthalate (DBP) with toluene is carried out at different frequencies (1MHz, 3MHz, 5MHz and 7MHz) at temperature 308K. The experimental measured values of density ( $\rho$ ) and ultrasonic velocity ( $U$ ) of the binary mixture has been used to compute the different acoustic parameters like isentropic compressibility ( $\beta$ ) intermolecular free length ( $L_f$ ), acoustic impedance ( $Z$ ), their excess values, Rao's constant ( $R_m$ ), Wada's constant ( $W$ ), relative association ( $R_A$ ), available volume ( $V_a$ ), molar volume ( $V_m$ ) etc. These acoustic parameters and their excess values are used to access and explain the nature and strength of molecular interaction of DBP with toluene.

**Keywords:** Binary mixture, ultrasonic velocity, acoustic impedance, isentropic compressibility, intermolecular free length and molar volume.

### Introduction

At the present scenario of industrial growth, there is a great demand of data on the physical and chemical properties of various types of compounds. Ultrasonic velocity in a medium is fundamentally related to the binding forces between the constituent molecules. Ultrasonic velocities of liquid mixture are of considerable importance in studying intermolecular interaction between component molecules and used to compute various physical and chemical parameters which have wide applications in several industrial and engineering processes<sup>1-5</sup>. In the present study, density and ultrasonic velocity of binary mixture DBP and toluene measured at 308K at frequencies 1MHz, 3MHz, 5MHz and 7MHz. These measured values are used to calculate different parameters like impedance ( $Z$ ), compressibility ( $\beta$ ), intermolecular free length ( $L_f$ ), Rao's constant ( $R_m$ ), Wada's constant ( $W$ ), relative association ( $R_A$ ), available volume ( $V_a$ ), molar volume ( $V_m$ ) etc. The excess parameters of ultrasonic velocity ( $U^E$ ), molar volume ( $V^E$ ), acoustic impedance ( $Z^E$ ), isentropic compressibility ( $\beta^E$ ), intermolecular free length ( $L_f^E$ ) are computed, which are highly useful in understanding the nature and strength of molecular interactions, internal structure and the aggregation behavior.

### Material and Methods

The mixtures of DBP and toluene were prepared by mixing the calculated values. The mass measurement was made using an electronic balance. The accuracy of density measurement is 0.5%. The velocity of sound was measured by using interferometer with frequencies 1MHz, 3MHz, 5MHz and 7MHz (Model MS 82, Mittal enterprise, India) at constant temperature 308K which was controlled by using temperature bath jacket with an accuracy of 0.01K.

The following relations are used to compute different parameters in the binary liquid mixture<sup>2-4</sup>.

The acoustic impedance ( $Z$ ) is given as

$$Z = \rho U \quad (1)$$

Where  $U$  and  $\rho$  are the ultrasonic velocity and density respectively.

The adiabatic compressibility ( $\beta$ ) is obtained from equation

$$\beta = 1/\rho U^2 \quad (2)$$

Intermolecular free length was calculated by the formula

$$L_f = K \beta^{1/2} \quad (3)$$

Where  $K$  is Jacobson's constant and it is temperature dependent.

Molar Sound velocity/ Rao's constant ( $R_m$ ) is given by the formula:

$$R_m = (V/\rho)U^{1/3} \quad (4)$$

Wada's constant ( $W$ ) can be calculated by the formula:

$$W = (M_{\text{eff}} \beta^{-1/7})/\rho \quad (5)$$

Where  $M_{\text{eff}}$  is mass of the binary mixture.

The relative association ( $R_A$ ) is given by the formula:

$$R_A = (\rho/\rho_1)(U_1/U)^{1/3} \quad (6)$$

Where  $\rho_1$ ,  $U_1$  is the density and ultrasonic velocity of DBP respectively.

Molar Volume ( $V_m$ ) is given as

$$V_m = (X_1 M_1 + X_2 M_2) / \rho \quad (7)$$

Available Volume ( $V_a$ ) is given as

$$V_a = V (1 - U/U_\infty) \quad (8)$$

Where  $U_\infty = 1600$  m/sec.

The excess values have been calculated from the following relation

$$A^E = A_{exp} - (X_1 A_1 + X_2 A_2) \quad (9)$$

Where  $X_1$  and  $X_2$  are mole fractions of DBP and toluene respectively.

Interaction parameter ( $\chi$ ) is given by

$$\chi = (U_{exp}/U_{ideal})^2 - 1 \quad (10)$$

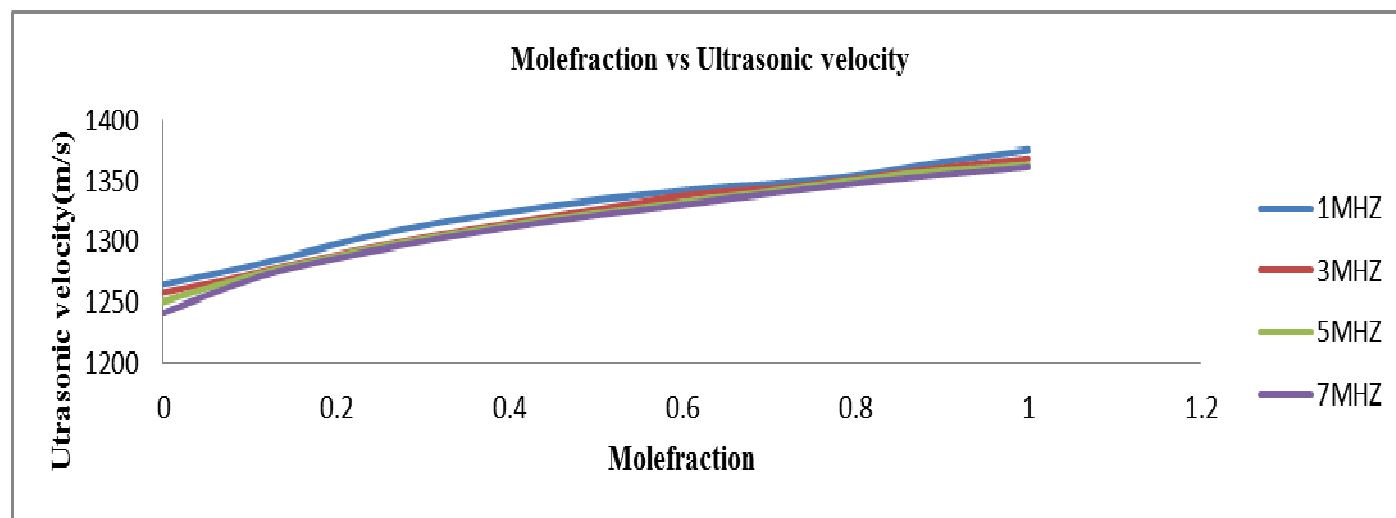
## Results and Discussion

DBP is a polar liquid and hence can interact with non-polar liquid toluene. In pure DBP, there are usual dispersive interactions as well as dipole-dipole interaction between the

DBP molecules. By adding toluene, a non-polar liquid will primarily disrupt the dipolar interaction of the DBP component and the strength of interaction decreases. But disruption of DBP structure releases several dipoles which induce dipole moments in toluene molecules and there exist dipole induced-dipole interactions between component molecules as a result ultrasonic velocity increases which is observed in table-1 and figure 1. The values of velocity and density at different mole fraction of DBP of the mixture of DBP and toluene at 1MHz, 3MHz, 5MHz and 7MHz at 308K are presented in table-1 and figure 1. It is observed that density which is a measure of liquid-liquid interaction increases with increase in concentration of DBP indicates solvent – solvent interaction. It may be also assumed that solvent – solvent interaction bring about a bonding between them<sup>5</sup>. The ultrasonic velocity in this mixture increases with increase in concentration of DBP which indicates existence of dipole - induced dipole interaction between component molecules which is concentration dependent<sup>6,7</sup>.

**Table-1**  
**Ultrasonic velocity and density of DBP and toluene at 308K**

Mole Fraction of DBP $X_A$	Density $g/cm^3$ $\rho$	Velocity (m/s) at different frequencies			
		1MHZ	3MHZ	5MHZ	7MHZ
0	0.8628	1265	1258	1251	1242
0.0855	0.87747051	1278	1271	1269	1265
0.1442	0.89290876	1288	1281	1280	1278
0.274	0.91181853	1310	1300	1299	1297
0.4363	0.93261427	1329	1320	1318	1316
0.612	0.94873681	1343	1339	1334	1332
0.7048	0.97176901	1348	1344	1342	1340
0.8	0.99930751	1355	1352	1351	1348
0.88	1.01119079	1364	1360	1358	1354
1	1.0297	1376	1369	1364	1362



**Figure-1**  
 Ultrasonic velocity of DBP and toluene vs. Mole fraction of DBP

Further in this system ultrasonic velocity decreases with increase of frequencies which may be due to increase in agitation of molecules resulting weak dipole- induced dipole interaction.

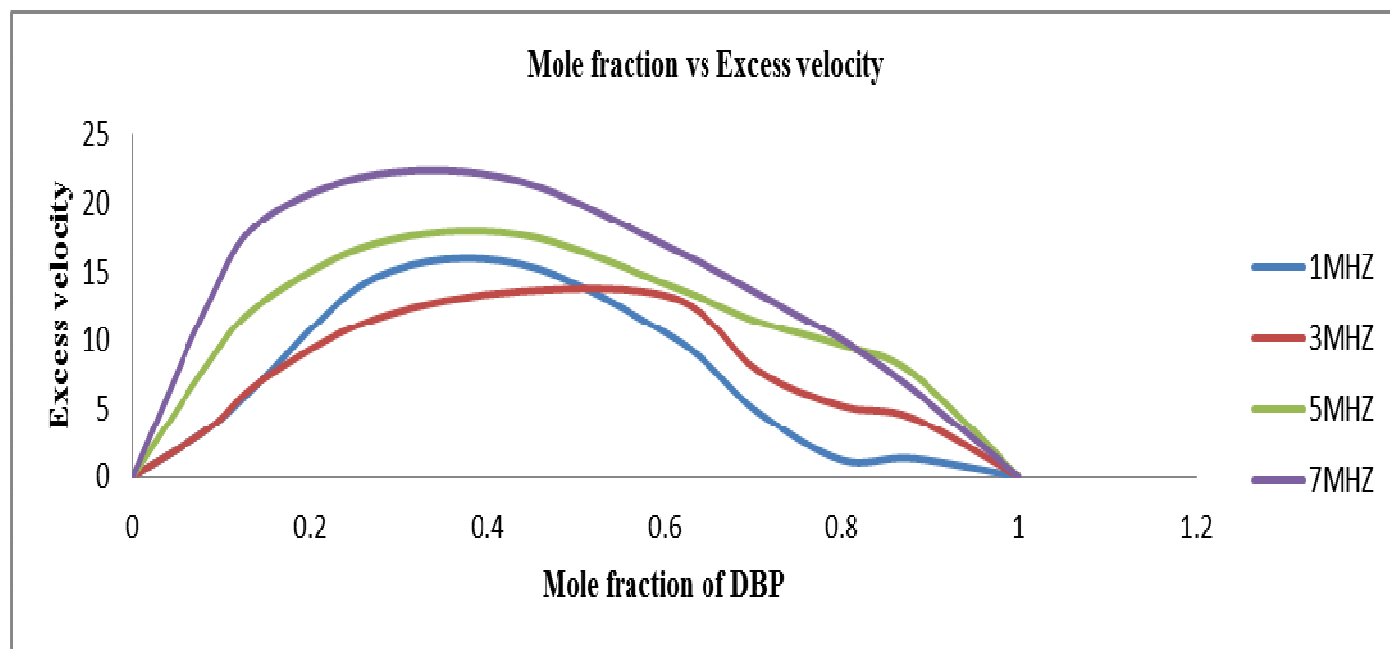
Excess velocity ( $U^E$ ) gives a better insight of molecular interaction in liquid mixture which is calculated using formula given above and is presented in table-2 and figure-2. The excess velocity shows positive deviation for the entire range of mole fraction of DBP in all frequencies. The maximum deviations are observed in the intermediate range (0.274 to 0.612 mole fraction) of concentration of DBP. Positive excess velocity indicates the presence of dipole- induced dipole interaction in entire range of mole fraction of DBP and in the intermediate concentration there may be increase in interstitial accommodation of component molecules which results more excess velocity in this range.

It is also observed from the figure-2 that positive excess velocity increases with the increase in frequencies except for 3 MHz. Moreover, here is a considerable deviation from linearity which indicates non ideal liquid mixture arising from the presence of dipole –induced dipole interactions<sup>8</sup>.

The acoustic impedance and its excess values are presented in table-3,4 and graphically in figure 3,4 respectively. It is observed from the profile that acoustic impedance of the system increases with increase in concentration of DBP. It exhibits the same trend as that of velocity graph indicating the presence of molecular interaction of unlike molecules<sup>1,9</sup>. It is also observed that acoustic impedance decreases with increase in frequencies indicating interactions become weak with increase in frequencies from 1MHz- 7MHz.

**Table-2**  
**Excess Ultrasonic velocity of DBP and toluene at 308K**

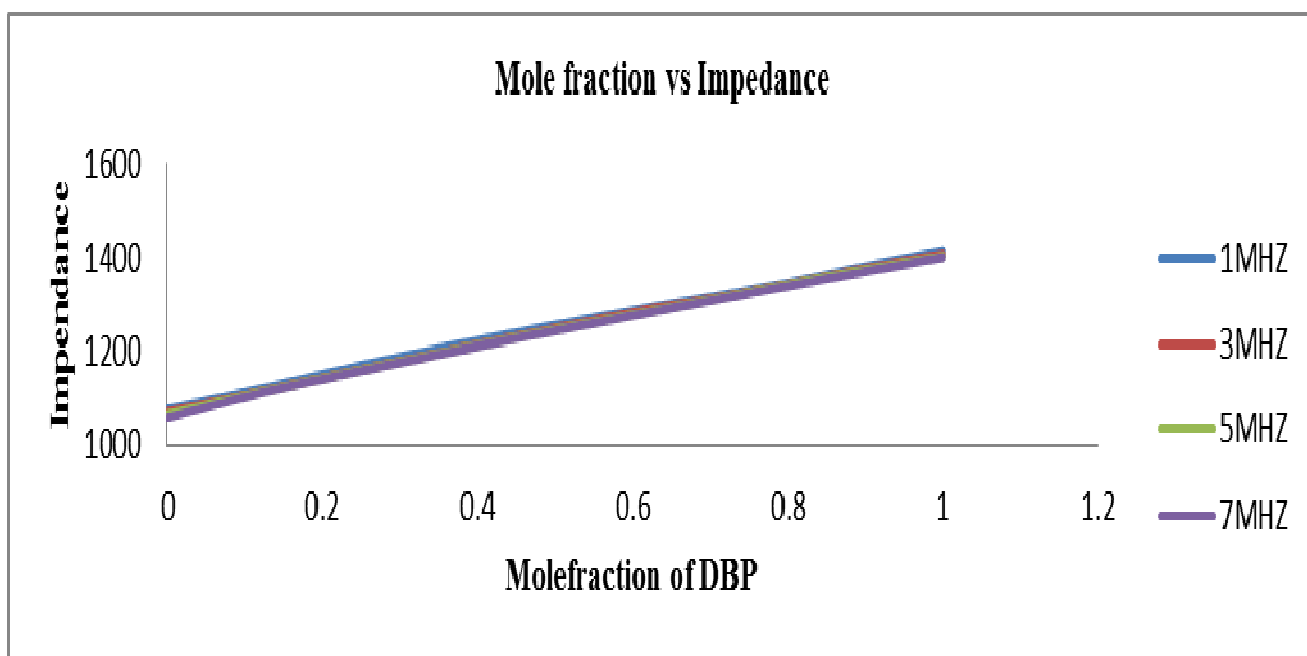
Mole Fraction of DBP $X_A$	Excess velocity at different frequencies			
	1MHZ	3MHZ	5MHZ	7MHZ
0	0	0	0	0
0.0855	3.5095	3.5095	8.3385	12.74
0.1442	6.9938	6.9938	12.7054	18.696
0.274	14.586	11.586	17.038	22.12
0.4363	15.5707	13.5707	17.6981	21.644
0.612	10.068	13.068	13.844	16.56
0.7048	4.7672	7.7672	11.3576	13.424
0.8	1.2	5.2	9.6	10
0.88	1.32	4.32	7.56	6.4
1	0	0	0	0



**Figure-2**  
**Excess ultrasonic velocity of DBP and toluene vs. Mole fraction of DBP**

**Table-3**  
**Impedance of DBP and toluene at 308K**

Mole Fraction of DBP $X_A$	Impedance at different frequencies ( $Z \cdot 10^3 \text{ kgm}^{-2}\text{s}^{-1}$ )			
	1MHZ	3MHZ	5MHZ	7MHZ
0	1079.0703	1073.0992	1067.12802	1059.45084
0.0855	1109.46302	1103.3862	1101.6499	1098.1774
0.1442	1131.50075	1125.3513	1124.4728	1122.71581
0.274	1180.86654	1171.8523	1170.95087	1169.14802
0.4363	1236.09859	1227.7277	1225.86753	1224.00733
0.612	1290.80554	1286.961	1282.15532	1280.23305
0.7048	1317.7104	1313.8003	1311.84522	1309.89016
0.8	1347.34154	1344.3585	1343.36415	1340.3811
0.88	1375.56781	1371.5339	1369.51693	1365.483
1	1416.83968	1409.6319	1404.48352	1402.42416



**Figure-3**  
**Variation of Impedance with Mole fraction of DBP**

**Table-4**  
**Excess Impedance of DBP and toluene at 308K**

Mole Fraction of DBP $X_A$	Excess Impedance at different frequencies. ( $Z^E \cdot 10^3 \text{ kgm}^{-2}\text{s}^{-1}$ )			
	1MHZ	3MHZ	5MHZ	7MHZ
0	0	0	0	0
0.0855	1.51344	1.513405	5.677986	9.402345
0.1442	3.724107	3.724075	8.698113	13.80821
0.274	9.24743	6.543132	11.38744	15.72249
0.4363	9.659511	7.799304	11.5513	14.91723
0.612	5.02038	7.903784	8.565731	10.88253
0.7048	0.580238	3.51283	6.949041	8.711721
0.8	-1.94426	2.033136	6.351728	6.551608
0.88	-0.73954	2.285912	5.516066	4.215642
1	0	0	0	0

Excess impedance is positive for entire range of composition except 0.8 and 0.88 mole fraction of DBP at 1MHz frequency. This reflects that at 1MHz both positive (polar rich region) and negative deviations are occurring and hence more than one type of interactions may be operative in the given system<sup>10</sup>. In pure DBP acoustic impedance is very high compared to toluene. In DBP, due to polarity, molecules move with high speed producing large acoustic impedance. By increasing the mole

fraction of DBP, the polarity of the mixture and acoustic impedance increases.

Table-5 and figure-5 reveal that the compressibility of the DBP and toluene mixture decreases with the increase in mole fraction of DBP for all above said four frequencies at 308 K. The non-linear decrease in compressibility exhibits the presence of molecular interaction inside the liquid mixture<sup>9</sup>.

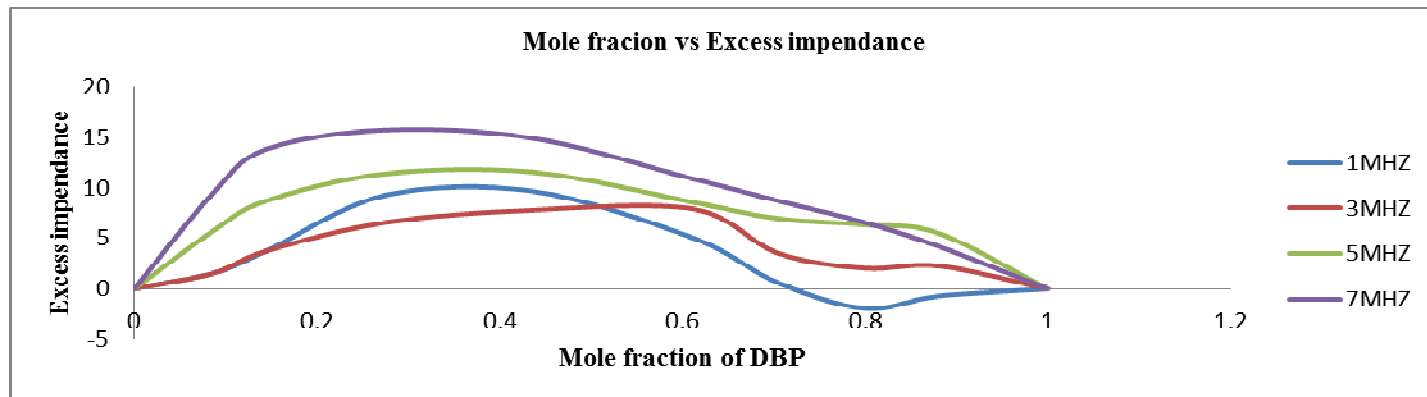


Figure-4  
 Excess Impedance of DBP and toluene Vs. Mole fraction of DBP

Table-5  
 Compressibility of DBP and toluene at 308K

Mole Fraction of DBP $X_A$	Compressibility of DBP and toluene at different frequencies ( $\beta \cdot 10^{-10} \text{ m}^2/\text{N}$ )			
	1MHZ	3MHZ	5MHZ	7MHZ
0	7.3259	7.4076	7.4908	7.5997
0.0855	7.0527	7.1306	7.1531	7.1984
0.1442	6.8617	6.9369	6.9478	6.9695
0.274	6.4644	6.5642	6.5743	6.5946
0.4363	6.0873	6.1706	6.1893	6.2081
0.612	5.7685	5.8030	5.8466	5.8642
0.7048	5.6298	5.6633	5.6802	5.6972
0.8	5.4775	5.5018	5.5099	5.5345
0.88	5.3297	5.3611	5.3769	5.4087
1	5.1293	5.1819	5.21998	5.2353

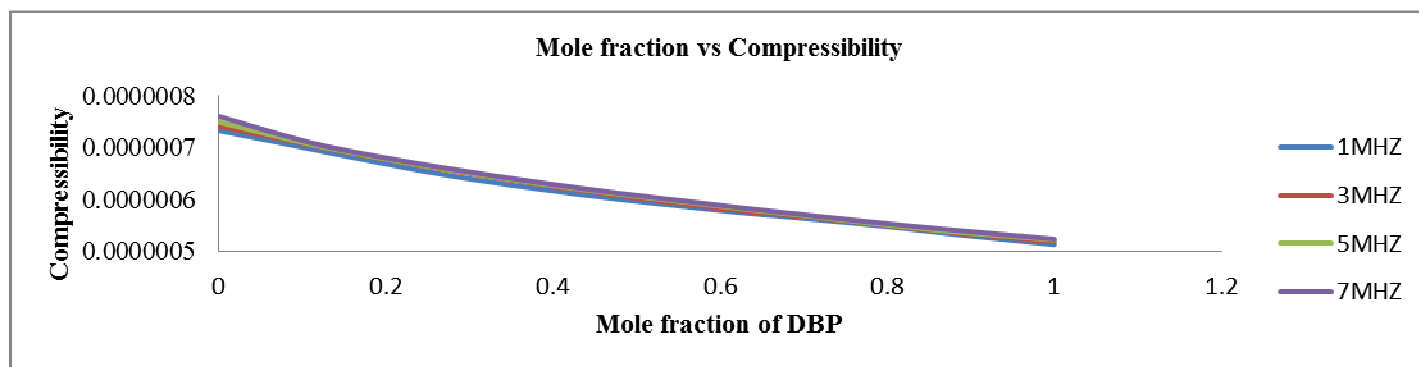


Figure-5  
 Compressibility of DBP and toluene vs. mole fraction of DBP

The strength of interaction between the component molecules is well reflected in the excess value of isentropic compressibility which is shown in table-6 and figure-6.

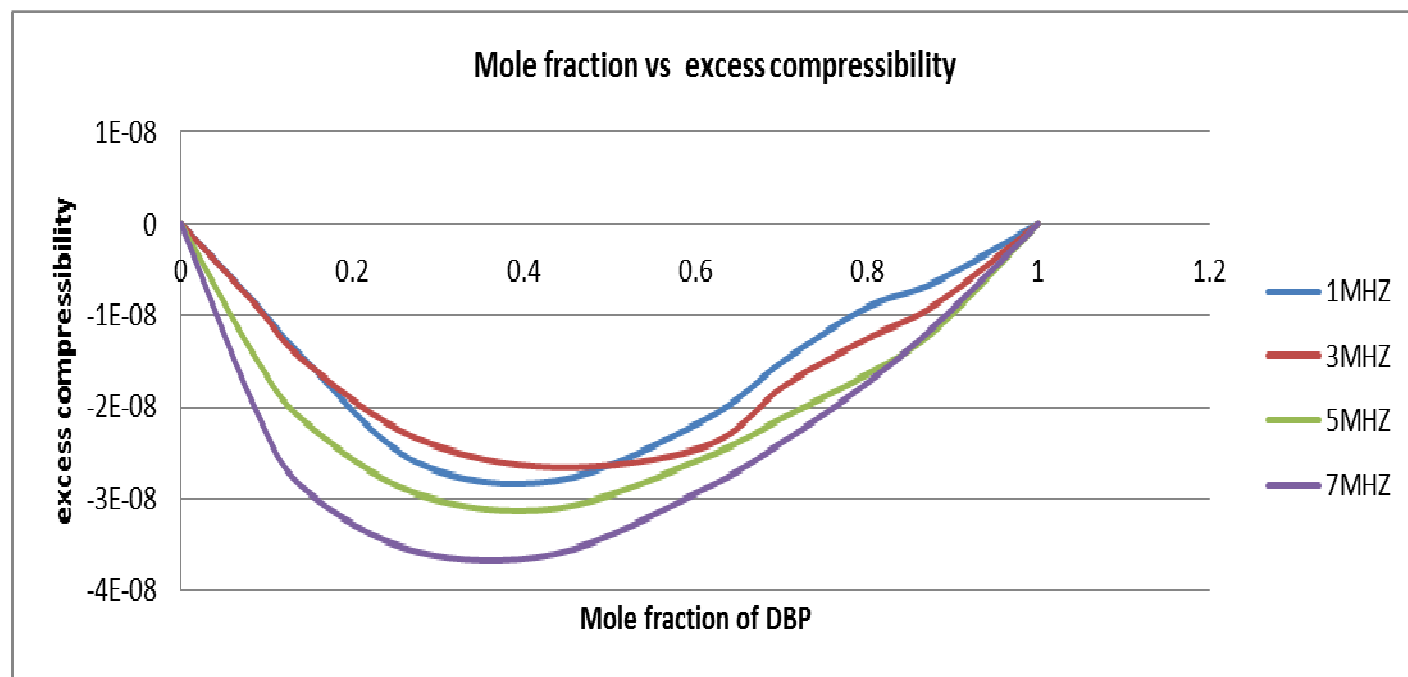
Excess compressibility ( $\beta^E$ ) is negative for entire range of composition in all four frequencies indicating strong molecular interactions in liquid mixture and it is due to dipole –induced dipole interaction<sup>8</sup>. The real values depend upon the relative strength of opposing effects (dispersive forces and dipole – induced dipole forces). However, maximum deviation is observed in between 0.2 and 0.6 mole fraction of DBP and increases in higher frequencies. It is also considered that negative excess compressibility may be due to closed packed

molecules<sup>8</sup>. Further, the graph of compressibility (figure-5) are nearly linear suggesting this system is close to ideal one<sup>11</sup>.

Intermolecular free length ( $L_f$ ) decreases with increase in mole fraction of DBP in all four frequencies which is observed from table-7 and figure-7. According to Eyring and Kincaid, the sound velocity increases if intermolecular free length ( $L_f$ ) decreases which is reflected in the present system<sup>12</sup>. The trend of variation of  $L_f$  depends on the sizes of the component molecules. For unequal sizes, it is non-linear<sup>13</sup>. Further, the intermolecular free length depends on the intermolecular forces<sup>14</sup>. In this system, the interaction is due to dipole-induced-dipole.

**Table-6**  
**Excess Compressibility of DBP and toluene at 308K**

Mole Fraction of DBP $X_A$	Excess Compressibility at different frequencies.( $\beta^E \cdot 10^{-11} \text{ m}^2/\text{N}$ )			
	1MHZ	3MHZ	5MHZ	7MHZ
0	0	0	0	0
0.0855	-0.8536	-0.8672	-1.435	-1.9915
0.1442	-1.4748	-1.4983	-2.1561	-2.8931
0.274	-2.5963	-2.3356	-2.9423	-3.5724
0.4363	-2.8026	-2.6600	-3.1073	-3.6001
0.612	-2.1309	-2.4248	-2.5444	-2.8853
0.7048	-1.4799	-1.7563	-2.10098	-2.3611
0.8	-0.9113	-1.2522	-1.6414	-1.7366
0.88	-6.3205	-8.7897	-1.1556	-1.1032
1	0	0	0	0



**Figure-6**  
**Excess compressibility of DBP & toluene Vs. mole fraction of DBP**

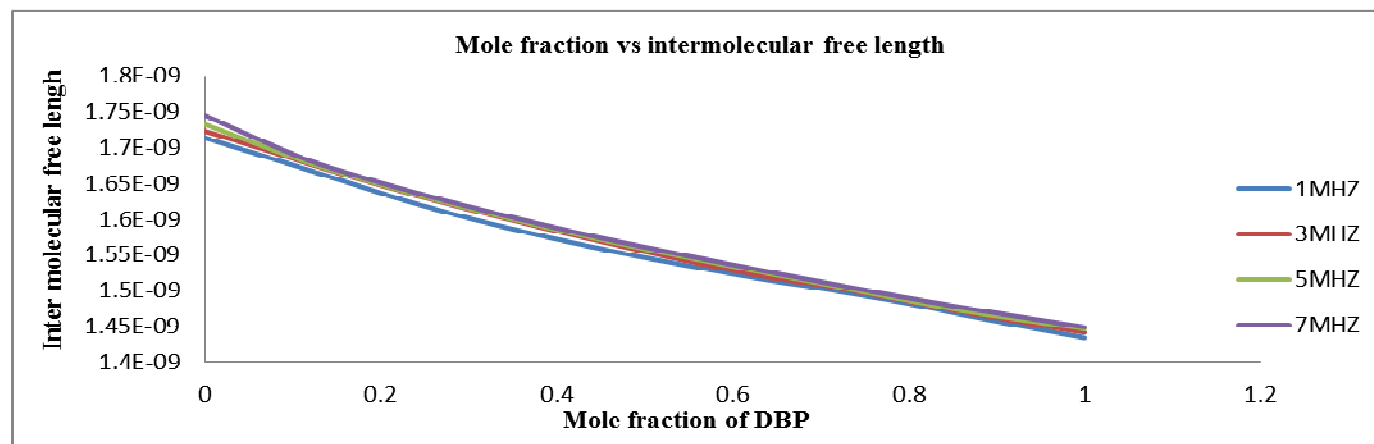
The effect of frequency as it is evident from the profiles that when frequency increases, the interactions of the molecules decrease. Hence, intermolecular free length increases with increase in frequency.

Computed values of excess free length are presented in table-8 and graphically in figure-8. Excess inter molecular free length in this system is negative in all the four frequencies for entire

range of mole fraction of DBP. According to Kannappan et al the negative values of excess free length indicate that ultrasonic waves cover long distances due to decrease in intermolecular free length describing dipole -induced dipole interaction which makes the system less compressible as observed in compressibility<sup>14</sup>. At higher frequencies, increasing negativity indicates the weakening of interaction between unlike molecules.

**Table-7**  
**Intermolecular free length of DBP and toluene at 308K**

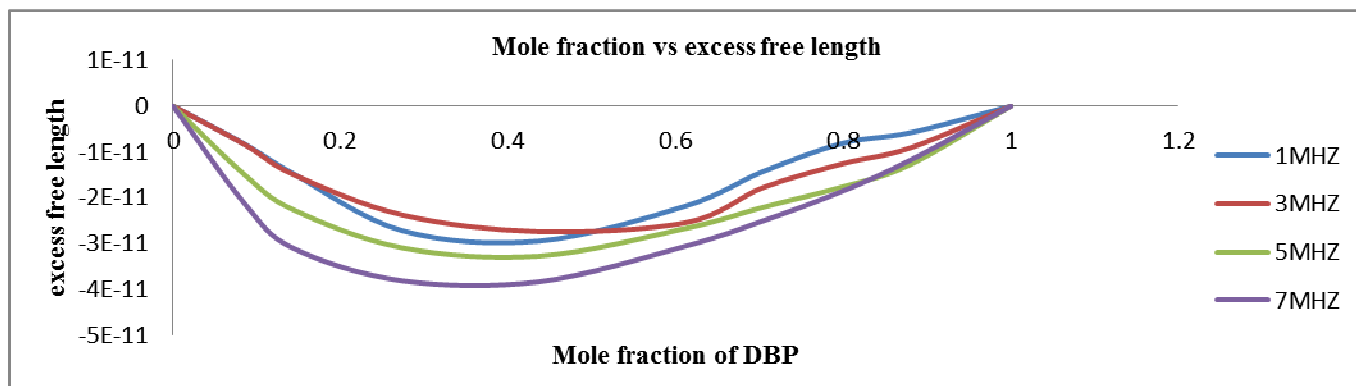
Mole Fraction of DBP $X_A$	Intermolecular free length at different frequencies.( $L_f * 10^{-11}$ m)			
	1MHz	3MHz	5MHz	7MHz
0	1.7135	1.72299	1.7326	1.7452
0.0855	1.6812	1.6905	1.6931	1.6985
0.1442	1.6583	1.6673	1.6686	1.6713
0.274	1.6096	1.6219	1.6232	1.6257
0.4363	1.5619	1.5726	1.57494	1.5773
0.612	1.5205	1.525	1.5307	1.5330
0.7048	1.5021	1.5065	1.5088	1.5110
0.8	1.4816	1.4849	1.486	1.4893
0.88	1.4615	1.4658	1.4679	1.4723
1	1.4337	1.4411	1.4464	1.4485



**Figure-7**  
**Intermolecular free length of DBP and toluene Vs. Mole fraction of DBP**

**Table-8**  
**Excess Intermolecular free length of DBP and toluene at 308K**

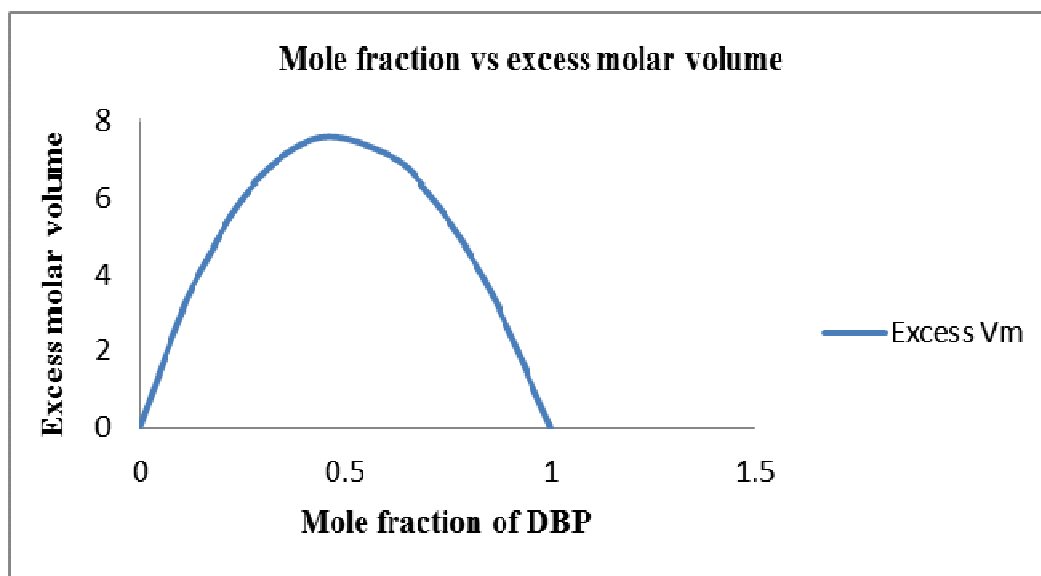
Mole Fraction of DBP $X_A$	Excess Intermolecular free length at different frequencies.( $L_f^E * 10^{-13}$ m)			
	1MHz	3MHz	5MHz	7MHz
0	0	0	0	0
0.0879	-0.8331	-0.8423	-1.5026	-2.1331
0.1804	-1.4841	-1.50002	-2.2709	-3.1145
0.2937	-2.7255	-2.3809	-3.1005	-3.8197
0.4183	-2.9516	-2.7443	-3.2794	-3.8405
0.5149	-2.1817	-2.5463	-2.6718	-3.0593
0.6529	-1.4257	-1.7769	-2.2091	-2.5045
0.8179	-0.80801	-1.2565	-1.7617	-1.8524
0.8891	-0.58295	-0.91263	-1.2771	-1.1815
1	0	0	0	0



**Figure-8**  
 Variation of Excess Intermolecular free length with Mole fraction of DBP

**Table-9**  
 Available volume ( $V_a$ ) of DBP and toluene at 308K

Mole Fraction of DBP $X_A$	Available Volume			
	1MHZ	3MHZ	5MHZ	1MHZ
0	22.67971443	23.15362	23.6275234	24.2368291
0.0855	25.10618262	25.65197	25.8079082	26.1197863
0.1442	26.46233144	27.05604	27.1408528	27.3104831
0.274	28.82407645	29.81801	29.9174035	30.1161902
0.4363	31.60142205	32.65092	32.8841366	33.1173574
0.612	34.46139324	34.99776	35.6682125	35.9363945
0.7048	36.00470258	36.57621	36.8619574	37.147709
0.8	37.13875826	37.59352	37.7451053	38.1998656
0.88	37.44901043	38.08374	38.4011039	39.0358329
1	37.84709813	39.02982	39.8746212	40.2125418



**Figure-9**  
 Excess molar volume DBP and toluene Vs. Mole fraction of DBP



Available volume ( $V_a$ ) is presented in table -9 for mixture DBP and toluene shows that  $V_a$  increases with the increase in mole fraction of DBP. Further, when frequency increases the available volume decreases which reflects the presence of molecular interaction. Molar volume of the mixture have an increasing trend with mole fraction of DBP and excess volume is positive over entire range of mole fraction. The positive excess volume indicates the expansion of volume and this may be due to relative strength of dispersive force over weak dipole

-induced dipole attractive force. Further, expansion in volume may be due to steric hindrance of component molecules, unfavorable geometric fitting and electrostatic repulsion<sup>15</sup>.

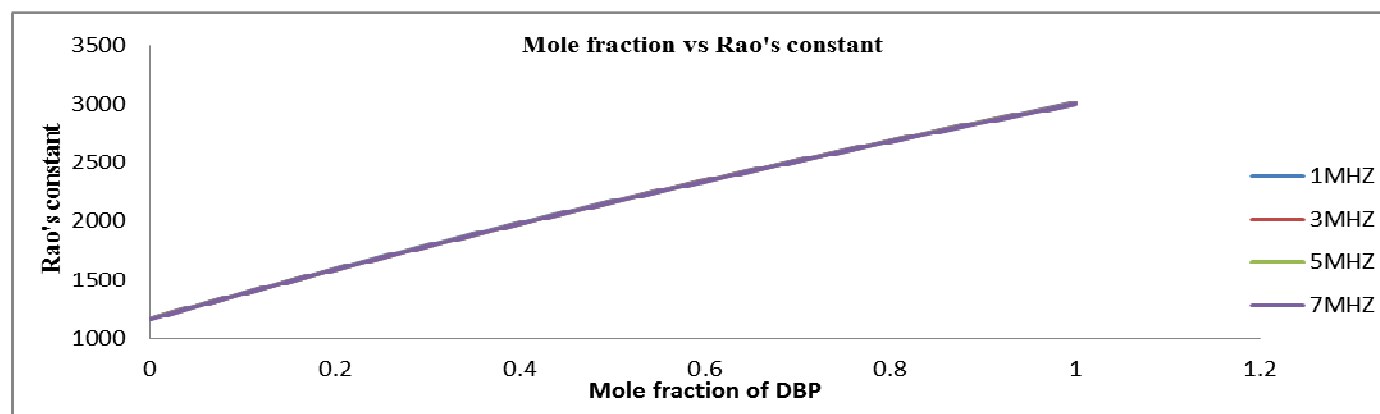
Molar sound velocity ( $R_m$ ) / Rao's constant, a factor in deciding the molecular association in liquid mixture is presented in table-11 and in graph in figure -10. In the present work, the values of  $R_m$  increase with mole fraction in DBP suggest associative nature of liquid mixture.

**Table-10**  
**Excess Molar Volume ( $V_m$ ) at 308K**

Mole Fraction of DBP	Molar volume	Excess Molar volume
$X_A$	$V_m$	$V_m^E$
0	108.321024	0
0.0855	124.751218	2.577878049
0.1442	135.704264	4.020620412
0.274	159.029387	6.316146164
0.4363	186.576662	7.568322429
0.612	214.545639	7.071195581
0.7048	228.601286	6.09181464
0.8	242.538829	4.605492664
0.88	253.891596	2.997028071
1	270.336415	0

**Table-11**  
**Rao's constant of DBP and toluene at 308K**

Mole Fraction of DBP	Rao's Constant( $R_m$ ) at different frequencies			
	1MHZ	3MHZ	5MHZ	7MHZ
$X_A$				
0	1171.50173	1169.33685	1167.164	1164.358
0.0855	1353.80177	1351.32552	1350.616	1349.196
0.1442	1476.49545	1473.81578	1473.432	1472.664
0.274	1740.0744	1735.63541	1735.19	1734.299
0.4363	2051.31479	2046.67379	2045.64	2044.604
0.612	2367.07324	2364.72086	2361.774	2360.593
0.7048	2525.27473	2522.77446	2521.522	2520.269
0.8	2683.86732	2681.88514	2681.224	2679.238
0.88	2815.70044	2812.94535	2811.566	2808.803
1	3006.8426	3001.73512	2998.076	2996.61



**Figure-10**  
**Variation of Rao's constant with mole fraction of DBP**

Further, linear variation of Rao's constant (figure-10) indicates absent of complex formation in the liquid mixture. Similar trend of variations are observed in all four frequencies. However Rao's constant decreases with increase in frequencies which is also observed in other parameters.

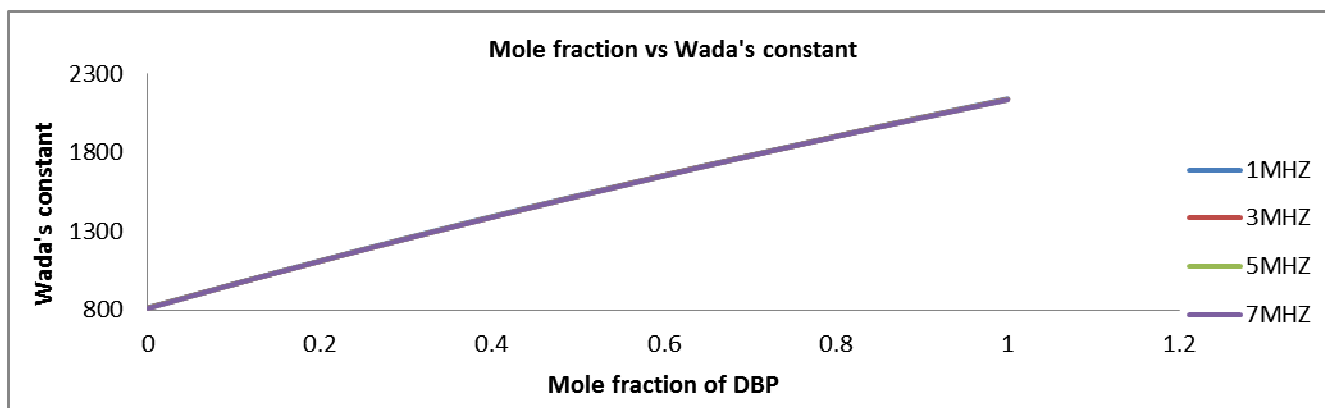
confirms again the associative nature of liquid mixture and no complex formation in the liquid mixture<sup>16</sup>. Considering the effect of frequencies, it reveals that at higher frequencies Wada's constant decreases which conforms the presence of interaction as in case of DBP and benzene<sup>17</sup>.

The values of Wada's constant are presented in table-12 and figure-11. The observed values have similar type of variation as in Rao's constant. The linear variation of Wada's constant

Variation of relative association ( $R_A$ ) with mole fraction DBP are presented in table-13 and figure-12

**Table-12**  
**Wada's constant of DBP and toluene at 308K**

Mole Fraction of DBP $X_A$	Wada's constant at different frequencies.			
	1MHZ	3MHZ	5MHZ	7MHZ
0	815.00705	813.715949	812.419704	810.7455
0.0855	943.73712	942.25732	941.833453	940.9843
0.1442	1030.6319	1029.02846	1028.79888	1028.339
0.274	1218.1133	1215.4493	1215.18209	1214.647
0.4363	1441.4416	1438.64582	1438.02269	1437.399
0.612	1670.3073	1668.88441	1667.1015	1666.387
0.7048	1785.9356	1784.41984	1783.66076	1782.901
0.8	1902.258	1901.05372	1900.65187	1899.445
0.88	1999.0954	1997.41867	1996.57898	1994.897
1	2140.2637	2137.14718	2134.91412	2134.019



**Figure-11**  
**Wada's constant Vs. mole fraction of DBP**

**Table-13**  
**Relative association ( $R_A$ ) of DBP and toluene at 308 K**

Mole Fraction of DBP $X_A$	Relative Association at different frequencies.			
	1MHZ	3MHZ	5MHZ	7MHZ
0	0.851986878	0.852114	0.85266013	0.85429679
0.0855	0.864122992	0.864236	0.86363576	0.86412233
0.1442	0.872176197	0.872278	0.87144137	0.87146936
0.274	0.889903586	0.890664	0.88980666	0.88982845
0.4363	0.91381231	0.914329	0.91367591	0.91369152
0.612	0.941015271	0.940351	0.9403771	0.94038745
0.7048	0.95588134	0.955203	0.9545128	0.95452045
0.8	0.97064966	0.969717	0.96877398	0.96901805
0.88	0.98227565	0.981568	0.98085217	0.98133699
1	1	1	1	1

Relative association ( $R_A$ ) for the mixture DBP and toluene increases with the increase in mole fraction of DBP for all above said four frequencies indicates the presence of molecular interaction between unlike molecules<sup>1,9</sup>. Further, these results confirm the dipole – induced dipole chemical interaction between DBP and toluene<sup>18</sup>.

in table-14 and figure -13. It indicates the strength of interaction and used to assess the strength of molecular attraction<sup>1</sup>. Molecular interaction in the present study shows that the interaction between DBP and toluene molecules may be due to weak attractive dipole – induced dipole interaction. Its positive value also suggests the deviation from ideality which may be due to association of unlike molecules.

Molecular interaction parameter for the mixture is positive for entire mole fraction of DBP and in all frequencies is presented

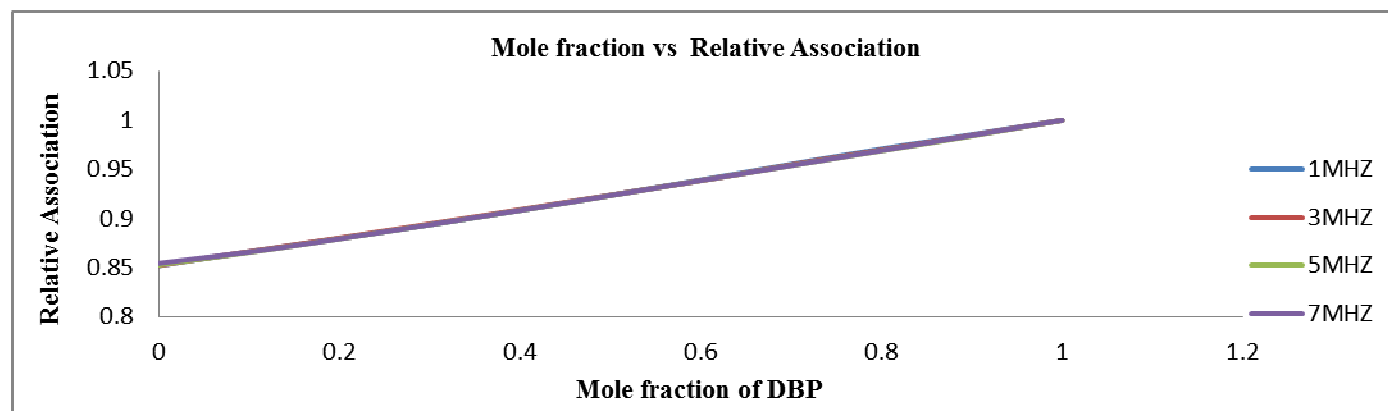


Figure-12  
Variation of relative association with mole fraction of DBP

Table-14  
Interaction Parameter of DBP and toluene at 308 K

Mole Fraction of DBP $X_A$	Interaction Parameter of DBP and toluene at different frequencies at 308K.			
	1MHZ	3MHZ	5MHZ	7MHZ
0	0	0	0	0
0.0855	0.0055149	0.00554538	0.01327252	0.020451
0.1442	0.010949	0.01100936	0.02015173	0.029913
0.274	0.0226462	0.01806577	0.02675777	0.035002
0.4363	0.0238505	0.02088316	0.02740678	0.033723
0.612	0.0151636	0.01980855	0.02108325	0.025336
0.7048	0.0071107	0.01165931	0.01714371	0.020341
0.8	0.0017736	0.00773692	0.01436462	0.015004
0.88	0.0019383	0.00638334	0.01122769	0.009521
1	0	0	0	0

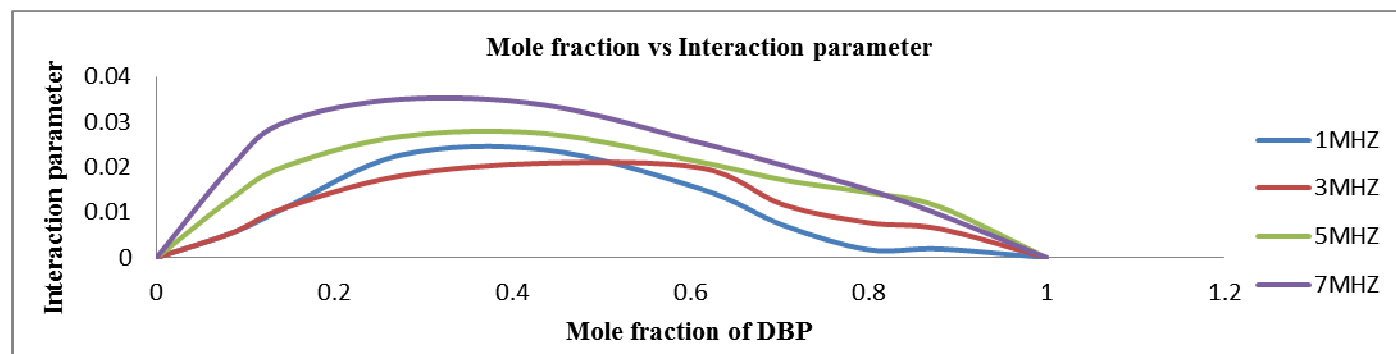


Figure-13  
Variation of Interaction Parameter with Mole fraction of DBP

## Conclusion

The ultrasonic velocity, density and other computed parameters which depend on the composition of the liquid mixture and the frequencies indicate the presence of molecular interactions. Deviation of the excess parameters from linearity and variations with frequencies shows that the extent of molecular interaction decreases with increase of frequencies. The interactions are primarily of dipole –induced dipole interaction and toluene molecules behave as structure breaker for DBP.

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