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Thermo Acoustic Studies of Molecular Interactions in Binary Liquid Mixtures of Citral and Toluene at Temperature Range from 303.15K to 318.15K

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***Abstract*: The study of propagation of ultrasonic waves in liquids and liquid mixtures is very much useful for investigative the nature of intermolecular interactions in chemical systems. The ultrasonic velocity (U), density (ρ) and viscosity (η) measurements have been carried out for the binary mixtures of Citral with toluene at temperature range from 303.15K to 318.15K. From the measured values of ultrasonic velocity, density and viscosity, the thermo dynamic parameters such as internal pressure (πi), free volume (V_f), Molar volume (V_m) and acoustical parameters such as adiabatic compressibility (β), inter molecular free length (L_f), acoustic impedance (z), relaxation time (τ) and their excess parameters have been calculated. The results were interpreted in terms of molecular interactions among the components of mixtures.**

Keywords: Ultrasonic velocity, density, viscosity, adiabatic compressibility, free volume, internal pressure, molecular interactions

INTRODUCTION

Ultrasonic analysis of liquid mixtures consisting of polar and non-polar components is of considerable importance in understanding intermolecular interaction between the constituent molecules and they find applications in several industrial and technological processes [1, 2].

In the recent years the ultrasonic studies find extensive applications as ultrasonic velocity in liquids and liquids and liquid systems. Intermolecular interaction in various binary liquid mixtures at different temperatures has been studied by several authors [3-6]. The study of pure liquids and their properties cannot be altered continuously within a practical range by varying the concentration till an optimum value of some desired parameter is attained. This is only possible by considering the liquid mixtures and solutions which find direct applications in numerous chemical industries and technological processes. Further such studies are useful in understanding the intermolecular interactions between the component molecules and more insight in to the structure and bonding associated molecular complexes and further molecular processes. Since ultrasonic velocity is fundamentally related to the bonding forces between the constituents of the medium [7], so it is highly sensitive to the structure and interactions present in the liquid system. The measurement of ultrasonic velocity of sound in liquids enables determination of some useful acoustic and thermodynamic parameters that are found to be extremely sensitive to molecular interactions. Hence these measurements are helpful to study the strength of molecular interactions in liquid mixtures. The thermodynamic studies of binary liquid mixtures have attracted much attention of research scholars and scientists, and experimental data on number systems are available from review and publication [8-12]. Ultrasonic investigation of liquid mixtures consisting polar and non polar components is of considerable importance in understanding intermolecular interaction between the component molecules and they find applications in a number of industrial and technological processes. Many investigations [13-18] have been employed in the task of collecting more and more data and explaining in terms of the properties of pure liquid.

Acoustic parameters provide a better approaching into molecular environments in liquid mixtures, it seemed important to study molecular interactions which prompted the authors to carry out the present investigations in binary liquid mixtures of toluene with Citral using ultrasonic technique. An attempt was made as a part of the doctoral research program to find the molecular interactions among the selected organic compounds with Citral. Availability of very few published data on the said compound also attracted the authors to take up the present investigations. Citral ($C_{10}H_{16}O$), also called 3, 7-dimethyl-2, 6-octadienal, a pale yellow liquid, with a strong lemon odor [19-22], that occurs in the essential oils of plants is widely used in perfumes and in the manufacture of other chemicals. The intense lemon odor of Citral has made it a popular additive to a variety of detergents, foods, and cosmetics [23-24]. In the present study the ultrasonic speed, density and viscosity of Citral with toluene over the entire range of composition at temperatures 303.15 K, 308.15 K, 313.15 K and 318.15K were determined experimentally. From these experimental Values various physio-chemical and thermo-acoustical parameters and some of their excess values have been determined.

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MATERIALS AND EXPERIMENTS

All the materials procured are of Sigma-Aldrich AR grade and glassware used of Borosilicate make. Organic liquids Citral and toluene were procured are used directly without any purification. The densities and viscosities of the liquid compounds were measured with specific gravity bottle and Ostwald viscometer pre calibrated with 3D [25] water of Millipore to nearest mg/ml. The time taken for flow of viscous fluid in Ostwald viscosity meter is measured to a nearest 0.01 sec. Borosilicate glassware, Japan make Shimadzu electronic balance of sensitivity +0.001gm and constant temperature water bath of accuracy +0.1K were used while conducting the experiments. 2MHz ultrasonic interferometer model no. F-05 with least count of digital micrometer 0.001mm of Mittal Enterprises [26] was used for calculating velocities of sound waves and all the tests were conducted as per ASTM standard [27] procedures. The 30ml of binary mixtures of Citral and toluene were prepared with variable volumes of 5ml each to conduct the experiments from which the mole fractions were calculated [28].

THEORY AND CALCULATIONS

In order to examine the inter molecular interactions in liquid mixtures of Citral with toulene, experiments were conducted to find the density, viscosity and velocity of 2MHz ultrasonic waves for pure liquids and for binary liquid mixtures. The results of pure liquids are compared with literature values for assessment. From the experimental data of binary mixtures, the derived and excess values were calculated at various mole fractions of Citral for understanding the inter and intra molecular interactions at each temperature. The derived and excess values are calculated by using the fallowing relations.

Adiabatic compressibility (β_{ad})

Adiabatic compressibility the parameter which represents the ability to change volume of a liquid sample is

$$\beta_{ad} = (\rho\, U^2)^{-1} \qquad \text{..... (1)}$$

Intermolecular free length (L_f)

The formula for outer to outer distance between the interacting molecules

$$L_f = K\sqrt{\beta_{ad}} \qquad \text{.....(2)}$$

Molar volume of the binary liquid mixture (V_m)

The molar volume of the system at every mole fraction for the mixture is given by

$$V_m = M_{eff}/\rho_{mix} \text{ where } M_{eff} = M_1 X_1 + M_2 X_2 /(X_1+X_2) \qquad \text{.....(3)}$$

Free volume (V_f)

The free volumes of the binary mixtures have been computed using its relationship with the ultrasonic velocity and viscosity as given below

$$V_f = \left(\frac{MU}{K\eta}\right)^{\frac{3}{2}} \qquad \text{.....(4)}$$

Where k is a constant, which is independent of temperature and its value is 4.28 X 10^9 for all liquids.

Specific acoustic impedance (Z)

The ultrasonic velocity is influenced by the acoustic impedance (Z), which is given by the relation

$$Z = \rho U \qquad \text{.....(5)}$$

Excess thermodynamic parameters

With the help of excess parameters the extent of deviation from the ideal behavior of binary mixture can be estimated. The difference between the thermodynamic function of mixing for a real system and the value corresponding to a perfect solution at the same temperature, pressure and composition is called the thermodynamic excess function, denoted by Y^E.

Excess value Y^E for each parameter can compute by using the general formula

$$Y^E = Y - (Y_1 X_1 + Y_2 X_2) \qquad \text{..... (6)}$$

Where Y is the parameter under consideration, X_1 and X_2 are mole fractions of two liquids Ethyl Oleate and other organic compound under consideration respectively of the binary system, Cyclohexonone here and E represent 'excess'.

Deviation in adiabatic compressibility ($\Delta\beta_{ad}$)

The difference of the adiabatic compressibility of the mixture and the sum of the fractional contributory adiabatic compressibility's of the two liquids individually is the deviation in adiabatic compressibility. At a given mole fraction it is given by

$$\Delta\beta_{ad} = \beta_{ad} - (\beta_{ad1} X_1 + \beta_{ad2} X_2) \qquad \text{..... (7)}$$

Excess free length (L_f^E)

The excess free length can be calculated with formula

$$L_f{}^E = L_f - (L_{f1} X_1 + L_{f2} X_2) \qquad \text{..... (8)}$$

Excess acoustic impudence (Z^E)

Excess acoustic impedance can be calculated by the relation

$$Z^E = Z - (Z_1 X_1 + Z_2 X_2) \qquad \text{..... (9)}$$

RESULTS AND DISCUSSION

Velocities of 2MHz ultrasonic wave, densities and viscosities of pure Citral and toluene were measured with pre calibrated interferometer, specific gravity bottle and Ostwald viscometer respectively in the temperature range of 303.15K to 318.15K. The results were compared with available literature and shown in table.1 and table.2. The experimental values of density (ρ), viscosity (η) and speed of sound (u) for all the mixtures over the entire range of composition and at 303.15K, 308.15K, 313.15K and 318.15 K are presented in table3, table4 and table5.

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Table.1. Comparison of experimental and literature values of density (ρ), viscosity (η) and velocity (U) of 2MHz ultrasonic wave of pure Citral

Parameter	303.15K		308.15K		313.15K		318.15K	
	Expt.	Lite.	Expt.	Lite.	Expt.	Lite.	Expt.	Lite.
Density(ρ) kg/m^3	895.16	-	893.48	-	890.38	-	886.38	-
Viscosity (η) Ns/m^2	2.4638	-	2.1152	-	1.8772	-	1.6853	-
Velocity (U) m/s	1397.61	-	1380.05	-	1352.55	-	1344.75	-

Table.2: Comparison of experimental and literature values of density (ρ), viscosity (η) and velocity (U) of 2MHz ultrasonic wave for pure toluene

Parameter	303.15K		308.15K		313.15K		318.15K	
	Expt.	**Lite.**	**Expt.**	**Lite.**	**Expt.**	**Lite.**	**Expt.**	**Lite.**
Density(ρ) kg/m^3	857.65	857.70[31] 857.30[34] 857.53[35]	852.19	852.60[34]	848.90	847.90[34] 848.14[35]	841.20	840.28[31]
Viscosity(η) Ns/m^2	0.5465	0.5170[29] 0.5314[30] 0.5204[33] 0.5240[34] 0.5200[35]	0.5139	0.5083[30] 0.5068[31] 0.4980[34]	0.4883	0.4833[30] 0.4662[31] 0.4750[34]	0.4655	0.4630[30] 0.4379[31] 0.4379[32]
Velocity(U) m/s	1276.3	1283.7[35]	1265.6		1242.5	1241.1[35]	1223.2	1221.0[32]

Table.3: Ultrasonic Velocity (U), Density (P), Viscosity (H), Adiabatic Compressibility (β_{ad}), Inter Molecular Free Length (L_f), Molar Volume (V_m), Rao's Constant(R), Wada's Constant (W) for Binary Mixture Of Citral and Toluene at different temperatures.

Mole fraction (X_1)	**Mole fraction (X_2)**	**Velocity m/sec (U)**	**Density Kg/m^3 (ρ)**	**Viscosity Nsm^{-2} (η)**	**Ad. Comp. 10^{-10} N^{-1}.m^2 (β_{ad})**	**Int. Mol. Free length 10^{-10} m (L_f)**	**Mol. Vol. (V_m)**	**Rao's Constant (R)**	**Wada's Constant (W)**
T= 303.15 K									
0.0000	1.0000	1276.3	857.65	0.5465	7.1579	5.5515	107.43	5.4091	8.1101
0.1122	0.8878	1296.52	863.902	0.866	6.8862	5.4451	114.45	5.7931	8.6884
0.24	0.76	1316.74	870.154	1.1855	6.6283	5.3422	122.46	6.2305	9.3472
0.3871	0.6129	1336.96	876.406	1.505	6.3835	5.2426	131.68	6.7334	10.105
0.5582	0.4418	1357.18	882.658	1.8245	6.1508	5.1462	142.39	7.3177	10.985
0.7595	0.2405	1377.4	888.91	2.144	5.9296	5.0528	155.00	8.0052	12.02
1.0000	0.0000	1397.62	895.162	2.4635	5.719	4.9622	170.06	8.8259	13.257
T=308.15 K									
0.0000	1.0000	1265.6	852.19	0.5139	7.3260	5.6705	108.12	5.42847	8.13502
0.1126	0.8874	1284.67	859.07	0.7807	7.0532	5.5639	115.13	5.80944	8.70975
0.2409	0.7591	1303.74	865.95	1.0475	6.7939	5.4607	123.11	6.24297	9.3638
0.3882	0.6118	1322.81	872.83	1.3143	6.5475	5.3607	132.29	6.74079	10.1149
0.5593	0.4407	1341.88	879.71	1.5811	6.3129	5.2638	142.94	7.31845	10.9866
0.7603	0.2397	1360.95	886.59	1.8479	6.0896	5.1699	155.46	7.99694	12.0104
1.0000	0.0000	1380.02	893.47	2.1147	5.8769	5.0788	170.39	8.8053	13.2303
T=313.15 K									
0.0000	1.0000	1242.5	848.9	0.4883	7.63045	5.8423	108.54	5.4161	8.1192
0.1126	0.88734	1260.84	855.81	0.7197	7.35025	5.7341	115.58	5.7954	8.69176
0.2409	0.75907	1279.18	862.72	0.9511	7.08380	5.6292	123.59	6.227	9.34331
0.3883	0.6117	1297.52	869.63	1.1825	6.8302	5.5275	132.79	6.7225	10.0915
0.5593	0.44061	1315.86	876.54	1.4139	6.5888	5.4289	143.47	7.2975	10.9596
0.7604	0.23958	1334.2	883.45	1.6453	6.3588	5.3333	156.03	7.9727	11.9792
1.0000	0.0000	1352.54	890.36	1.8767	6.1395	5.2406	170.99	8.777	13.1939
T=318.15 K									
0.0000	1.0000	1223.2	841.2	0.4645	7.9452	6.018	109.53	5.4373	8.1463
0.1131	0.8869	1243.5	848.73	0.6679	7.6203	5.8936	116.57	5.8184	8.7217
0.2418	0.7582	1263.7	856.26	0.8713	7.313	5.7736	124.58	6.2516	9.3755
0.3894	0.6106	1284	863.79	1.0747	7.0224	5.6577	133.76	6.7482	10.125
0.5605	0.4395	1304.2	871.32	1.2781	6.7471	5.5457	144.41	7.3235	10.994
0.7613	0.2387	1324.5	878.85	1.4815	6.4863	5.4374	156.9	7.9978	12.012
1.0000	0.0000	1344.7	886.38	1.6849	6.2389	5.3327	171.75	8.7994	13.223

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Table.4.Freee Volume (V_f), Acoustic Impedance (Z), Internal Pressure(Π),Gibb's Energy (G^E), Enthalpy(H) and Relaxation Time(T) for binary mixture of Citral and Toluene at different temperatures.

Mole fraction (X_1)	Mole fraction (X_2)	Free Volume (V_f)	Acoustic Impedance (Z)	Internal pressure (π)	Gibb's Energy (G^E)	Enthalpy (H)	Relaxation time (τ)
T=303.15 K							
0.0000	1.0000	3.5636	1.0946	314.6222	0.1070	33.8008	0.5215
0.1122	0.8878	2.0335	1.1201	363.6351	0.1086	41.6213	0.7951
0.24	0.76	1.4538	1.1458	388.7432	0.1096	47.6086	1.0477
0.3871	0.6129	1.1719	1.1717	397.9796	0.1103	52.4069	1.2809
0.5582	0.4418	1.0206	1.1979	395.5756	0.1109	56.3284	1.49629
0.7595	0.2405	0.9402	1.2244	384.1749	0.1114	59.55	1.6950
1.0000	0.0000	0.9062	1.2511	365.6112	0.1118	62.1794	1.8785
T=308.15 K							
0.0000	1.0000	3.859	1.0785	310.1111	0.1087	33.5296	0.5019
0.1126	0.8874	2.344	1.1036	351.1441	0.1101	40.4286	0.7341
0.2409	0.7591	1.726	1.1289	371.8874	0.1111	45.7866	0.9488
0.3882	0.6118	1.414	1.1545	378.7824	0.1118	50.1111	1.1473
0.5593	0.4407	1.245	1.1804	375.3762	0.1124	53.6596	1.3308
0.7603	0.2397	1.155	1.206	363.9415	0.1128	56.5815	1.5004
1.0000	0.0000	1.118	1.2330	346.0798	0.1132	58.9691	1.6570
T=313.15 K							
0.0000	1.0000	4.0529	1.0547	309.2372	0.1105	33.5647	0.4968
0.1126	0.88734	2.5751	1.0790	344.9551	0.1118	39.8683	0.7053
0.2409	0.75907	1.9386	1.1035	362.6315	0.1127	44.8159	0.8983
0.3883	0.6117	1.6102	1.1283	367.7373	0.1134	48.8317	1.0769
0.5593	0.44061	1.4294	1.1534	363.3881	0.1140	52.1361	1.2421
0.7604	0.23958	1.3341	1.1787	351.6197	0.1144	54.8618	1.395
1.0000	0.0000	1.2975	1.2042	333.8856	0.1148	57.0901	1.5363
T=318.15 K							
0.0000	1.0000	4.267	1.0289	306.9601	0.1123	33.6225	0.4920
0.1131	0.8869	2.8223	1.0553	337.9783	0.1135	39.3989	0.6786
0.2418	0.7582	2.1726	1.0820	352.8087	0.1144	43.9519	0.8495
0.3894	0.6106	1.831	1.1090	356.2043	0.1151	47.6468	1.0062
0.5605	0.4395	1.6426	1.1363	350.9509	0.1156	50.6810	1.1497
0.7613	0.2387	1.5453	1.1640	338.8996	0.1160	53.1734	1.2812
1.0000	0.0000	1.5121	1.1919	321.3855	0.1163	55.1994	1.4015

Table.5*:* Excess Velocity, Excess Adiabatic Compressibility ($\Delta\beta_{ad}$), Excess Inter Molecular Free Length (L_f^e), Excess Impedance (Z^E), Excess Molar Volume (V_m^E), Excess Free Volume(V_f^E), Excess Viscosity (ΔH),Excess internal pressure (Π^E), Excess Gibbs Energy(ΔG^E), Excess Enthalpy (H^E) for binary mixture of Citral and toluene at different temperatures.

(X_1)	U^E	$\Delta\beta_{ad}$	L_f^E	Z^E	V_m^E	V_f^E	Δη	Π^E	ΔG^E	H^E
T=303.15 K										
0.0000	0.0000	0.0000	0.0000	0.0648	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.1122	6.6117	-0.1103	-0.0402	0.0648	0.0105	-1.2320	6.6117	43.293	0.0076	4.6372
0.24	11.319	-0.1842	-0.0678	0.0648	0.0206	-1.4719	11.318	61.881	0.0109	6.9959
0.3871	13.691	-0.2173	-0.0807	0.0648	0.0301	-1.3629	13.691	63.617	0.0114	7.6195
0.5582	13.160	-0.2039	-0.0764	0.0648	0.0302	-1.0597	13.160	52.492	0.0098	6.6870
0.7595	8.9539	-0.1355	-0.0511	0.0648	0.02045	-0.6049	8.9539	30.825	0.0060	4.1947
1.0000	0.0000	0.0000	0.0000	0.0648	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
T=308.15 K										
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.1126	6.1843	-0.1096	-0.0399	0.0076	-0.0123	-1.2061	0.0865	36.982	0.0069	4.0340
0.2409	10.581	-0.1830	-0.0672	0.0132	-0.0244	-1.4731	0.1480	53.113	0.0100	6.1297
0.3882	12.791	-0.2159	-0.0800	0.0160	-0.0483	-1.3804	0.1789	54.707	0.0106	6.7056
0.5593	12.285	-0.2025	-0.0757	0.0155	-0.0486	-1.0811	0.1718	45.147	0.0091	5.9017

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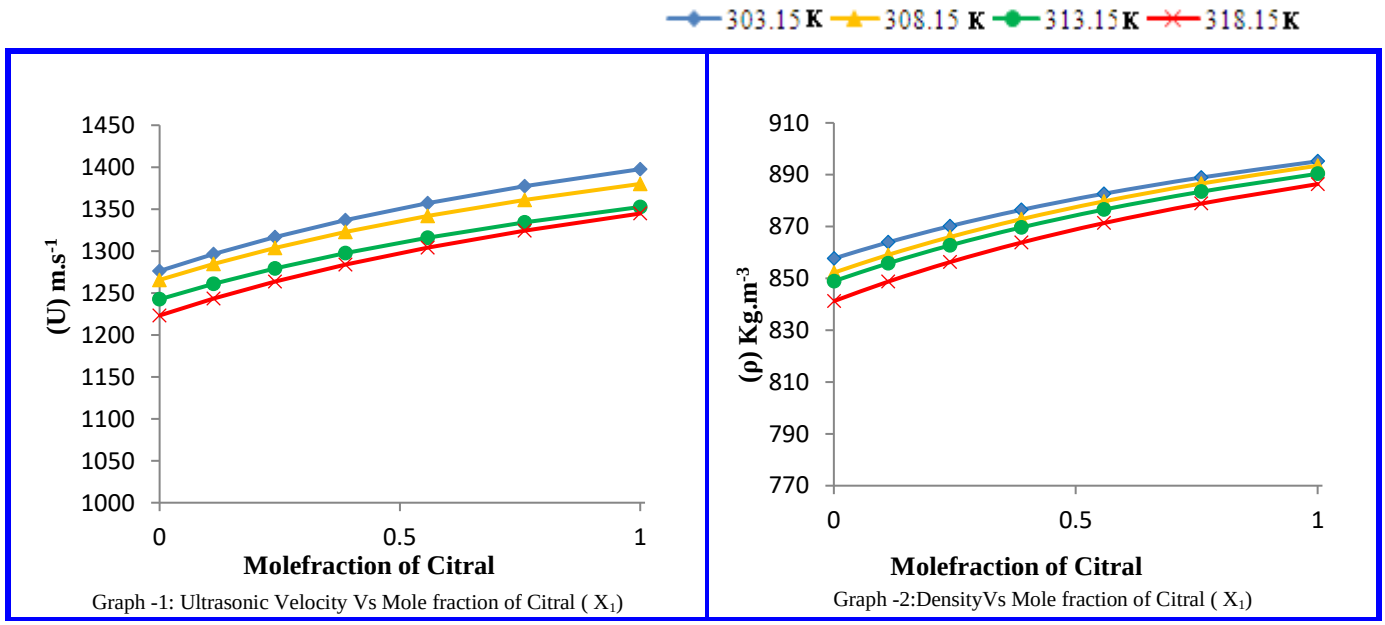
0.7603	8.3509	-0.1345	-0.0506	0.0106	-0.0276	-0.6201	0.1168	26.481	0.0056	3.7089
1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
T=313.15 K										
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.1126	5.9434	-0.1122	-0.0404	0.0074	-0.0300	-1.1673	0.0749	32.941	0.0064	3.6533
0.2409	10.168	-0.1874	-0.0681	0.0128	-0.0603	-1.4504	0.1282	47.455	0.0094	5.5833
0.3883	12.291	-0.2212	-0.0811	0.0155	-0.1204	-1.3727	0.1550	48.929	0.0100	6.1316
0.5593	11.804	-0.2076	-0.0767	0.0150	-0.1206	-1.0820	0.1489	40.362	0.0087	5.4115
0.7604	8.0235	-0.1379	-0.0513	0.0102	-0.0606	-0.6234	0.1012	23.639	0.0054	3.4079
1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
T=318.15 K										
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.1131	6.5079	-0.1319	-0.0468	0.0079	-0.0527	-1.1330	0.0653	29.386	0.0060	3.3355
0.2418	11.127	-0.2196	-0.0787	0.0137	-0.1040	-1.4283	0.1117	42.360	0.0089	5.1126
0.3894	13.441	-0.2583	-0.0934	0.0166	-0.2084	-1.3631	0.1349	43.626	0.0095	5.6222
0.5605	12.899	-0.2416	-0.0881	0.0160	-0.2085	-1.0801	0.1295	35.904	0.0083	4.9639
0.7613	8.7593	-0.1599	-0.0588	0.0109	-0.1046	-0.6244	0.0879	20.958	0.0051	3.1252
1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

In order to examine the inter molecular interactions in liquid mixtures of Citral with Toluene experiments were conducted to find the density, viscosity and velocity of 2MHz ultrasonic waves for pure liquids and for liquid mixtures. The results of pure liquids are compared with literature values. The experimental values are coinciding with the values from the previous studies. The derived, excess values were calculated at various mole fractions of Citral for understanding the inter and intra molecular interactions at each temperature. Graphs were drawn for variation of the experimental and derived quantities with mole fraction of Citral at all the study temperatures as shown in graph 1 to graph 14. From the above studies it can be concluded that there exists a dipole-dipole interactions among the unlike molecules.



Graph -1: Ultrasonic Velocity Vs Mole fraction of Citral (X_1)

Graph -2:DensityVs Mole fraction of Citral (X_1)

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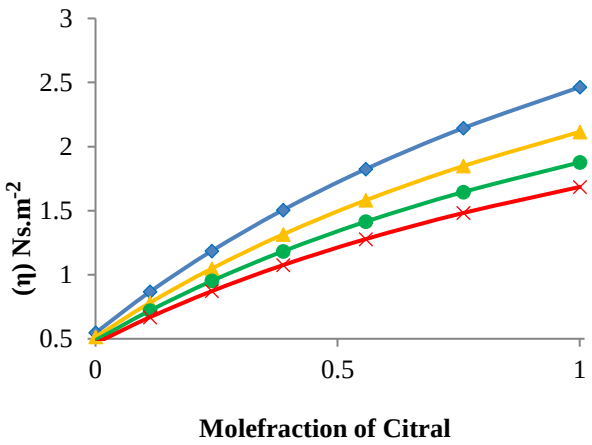
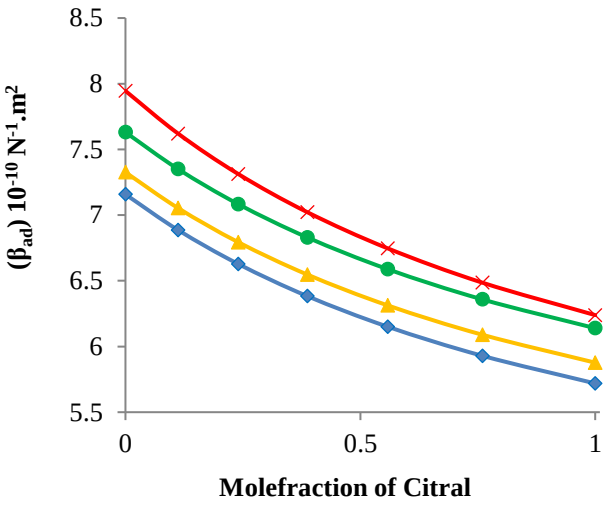
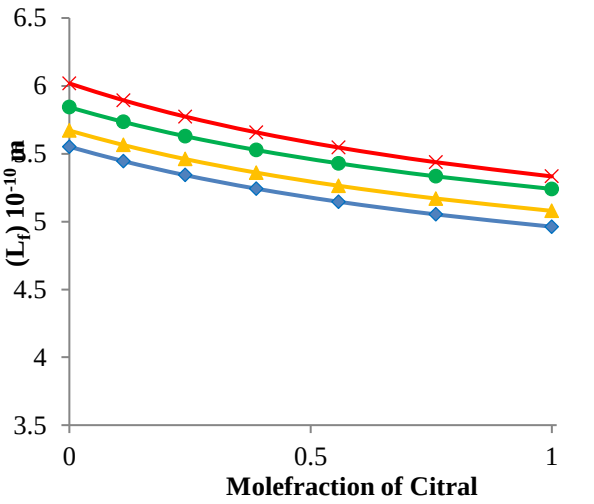


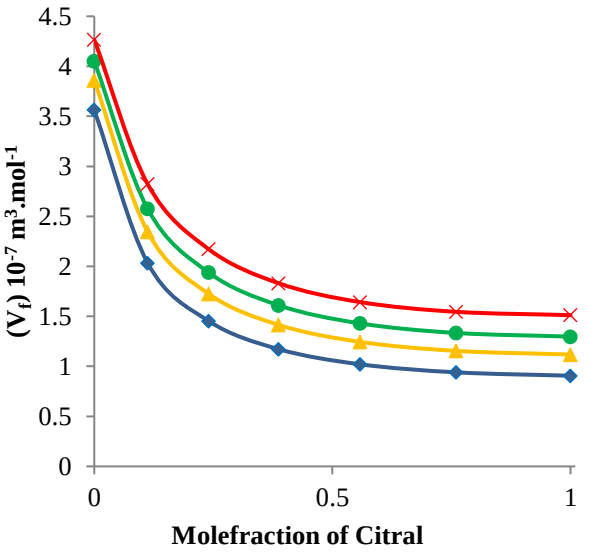
Graph-3:Viscocity Vs Mole fraction of Citral (X_1)



Graph-4: Adiabatic Compressibility Vs Mole fraction of Citral (X_1)



Graph -5: Intermolecular Free Length Vs Mole fraction of Citral(X_1)



Graph -6: Free volume Vs Mole fraction of Citral (X_1)

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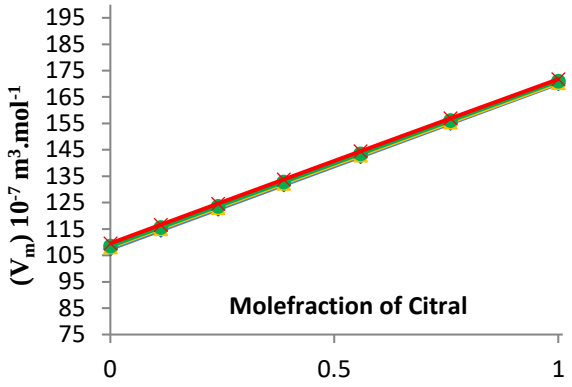
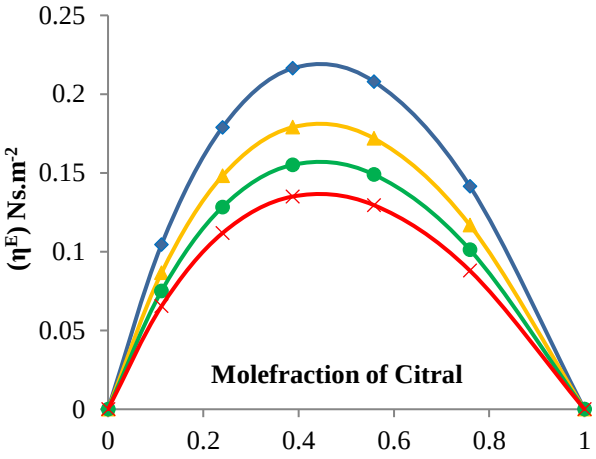
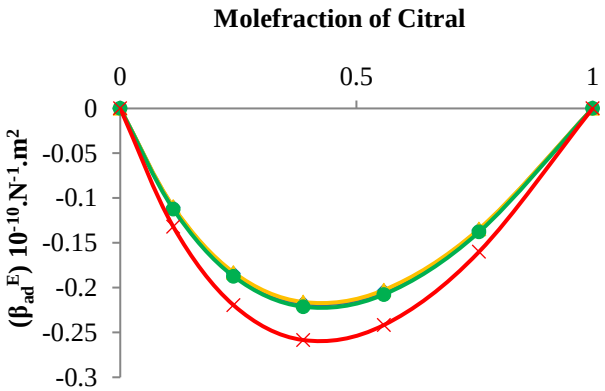


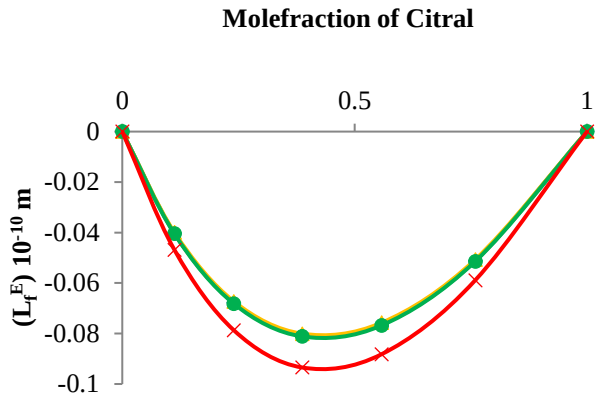
Graph -7:Molar Volume Vs Mole fraction of Citral(X_1)



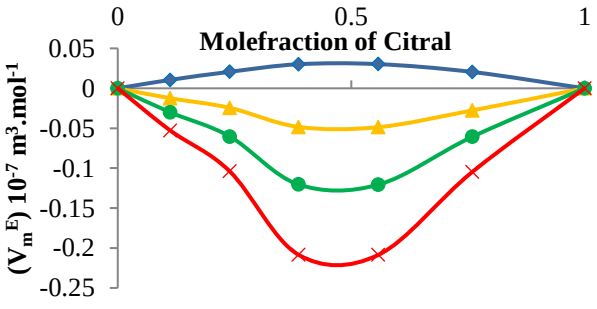
Graph -8:Deviation in Viscosity Vs Mole fraction of Citral(X_1)



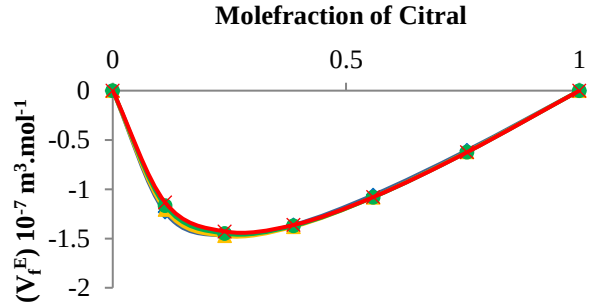
Graph -9: Excess adia. Compressibility Vs Mole fraction of Citral(X_1)



Graph -10:Excess Intermolecular Free Length Vs Mole fraction of Citral(X_1)



Graph -11:Excess Molar Volume Vs Mole fraction of Citral(X_1)



Graph -12:Excessmolar volume Vs Mole fraction of Citral(X_1)

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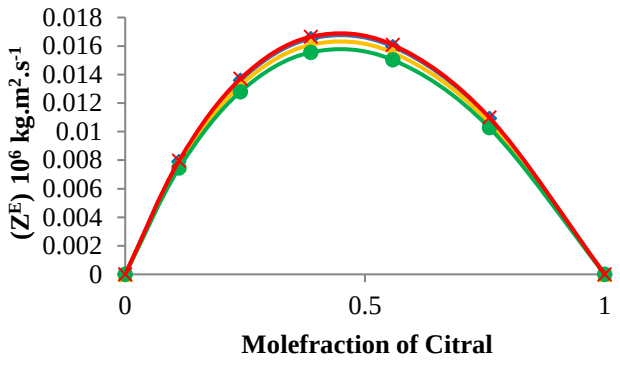
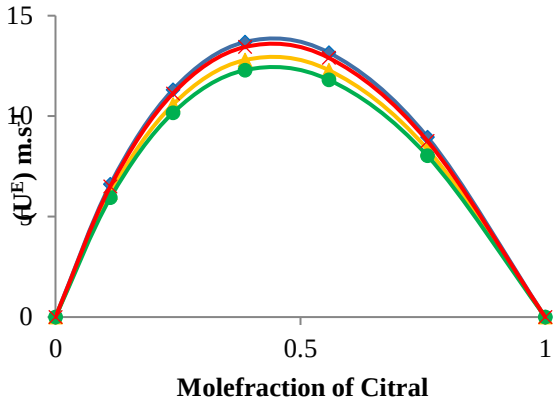


Graph -13. Excess acoustic impedance Vs Mole fraction of Citral(X_1)



Graph -14. Excess acoustic impedance Vs Mole fraction of Citral(X_1)

In the above system the experimental values are changing gradually from values of selected organic compounds toulene at X_1 is 0.0000 to the values of Citral at X_1 is 1.0000. The adiabatic compressibility, intermolecular free length, and free volume are decreases with increase in the mole fraction of Citral. Rao's constant and Wada's constant as a function of mole fraction of Citral are represented in the table3. From the figures, it is observed that Rao's constant and Wada's constant increase with increase in the mole fraction of Citral and is almost independent of temperature at particular mole fraction of Citral.

The excess quantities excess adiabatic compressibility, excess intermolecular free length, excess molar volume and excess free volumes are negative and excess viscosity, excess Acoustic impedance and excess velocities are positive. The negative values of excess parameters represent the strong interactions [36] for the present studies between Citral and Toluene which is supported by the positive values of deviation in viscosity and internal pressure. The values of excess molar volume are changing from positive to negative with increase in mole fraction of Citral (X_1) in case liquid mixture of Toulene which yields that there exists a strong dipole-dipole interactions due to the increase in concentration of the common compound Citral.

CONCLUSIONS

The miscible organic binary liquid mixture of Citral and Toulene are showing negative values of Excess molar volume (V_m^E**),** Excess adiabatic compressibility and Excess free volume (V_f^E) may give an information about the considerable interactions among the molecules of the between this binary mixture. So we concluded that interactions are exist may be due to dipole-dipole interactions.

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