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Ultrasonic studies on binary liquid mixture of o-Chlorotoulene with 2-propanol at 303.15K to 318.15K

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ABSTRACT

Density, viscosity and ultrasonic velocities for organic liquids of o-Chlorotoulene with 2-propanol were measured at different mole fractions. Among the derived quantities adiabatic compressibility, free volume, acoustic impedance and intermolecular free length and their excess values were calculated. The effect of mole fraction on the velocity of 2M Hz frequency ultrasonic wave at 303.15K to 318.15K is measured with interferometer and presented in this paper.

Key words: o-Chlrotoluene, 2-propanol, density, viscosity, velocity Interferometer.

INTRODUCTION

Studies on liquid- liquid mixtures either binary, ternary or more has significance of its own in special fields of contemporal civilized societies like chemical engineering, food processing, preparation of cosmetics, polymer paints and cleansing agents, petroleum, edible and non edible oil, preparation of bio diesel etc. Ultrasonic waves have their inclusive applications in various fields like nondestructive tests for solids and liquids in medical and engineering, food processing, pharmaceutical, polymer and chemicals, metallurgical industries etc. It will be helpful tool if these two fields were combined for conducting studies on inter and intra particulate behavior. Acoustic investigations of binary mixtures have been taking place since decades by so many scholars under various heads like acoustic, thermodynamic, molecular interactions[1-13] etc. The sound velocity is one of those physical properties that help in understanding the nature of liquid state. Using the measured values of ultrasonic velocity (u) and density (ρ),viscosity(η) the thermodynamic parameters such as adiabatic compressibility (β_{ad}) and intermolecular free length (L_f) can be computed. The intermolecular free length (L_f) is an important physical property of liquid mixtures which mainly affects the sound velocity. The intermolecular free length decreases with decreases of temperature and hence the close packing of molecules which in effect decreases the sound velocity [25-26]. The adiabatic compressibility (β_{ad}) decreases with increase of

velocity that gives insight into the structure making and structure breaking of components in binary mixtures. The excess thermodynamic parameters such as excess adiabatic compressibility (β_{ad}) and excess intermolecular free length (L_f) are very useful to understand the intermolecular interactions in binary mixtures. When negative excess functions are observed [14,19,20] complex formation is suspected more often.

MATERIALS AND METHODES

Organic liquids o-Chlrotoluene (C_7H_7Cl, 126.586g/mol) and 2-propanol (C_3H_8O, 60.1g/ml) of AR gradewere procured from Sigma-Aldrich with CAS no.111-62-6 and 95-49-8 respectively. The densities and viscosities ofthe liquid compounds were measured with pyknometer and Ostwold viscometer pre calibrated with 3D [27]water ofMillipore to nearest mg/ml. The time taken for flow of viscous fluid in Ostwold viscosity meter is measured to anearest 0.01 sec. Borosilicate glassware, Japan make Shimadzu electronic balance of sensitivity +0.001gm andconstant temperature water bath of accuracy +0.1K were used while conducting the experiments **2MHz** ultrasonicinterferometer model no.**F-05 (S.No.1314421**)[28]with least count of micrometer 0.001mm of Mittal Enterprises wasused for calculating velocities of sound waves and all the tests were conducted as per ASTM standard procedures

RESULTS AND DISCUSSION

velocity of 2MHz ultrasonic wave in pure liquids, densities and viscosities of o-Chlorotoluene and 2-propanol were calculated with pre calibrated interferometer, Pycknometer and viscosity meters respectively to nearest mg in the temperature range from 303.15K to 318.15K. The results were compared with available literature and shown in table.1 and table.2. The velocities, densities and viscosities of binary mixtures at other said temperatures were also measured. The derived quantities adiabatic compressibility, intermolecular free length and free volume also were calculated and given in table.3. The graphs for mole fraction of o-Chlorotoluene X_1 vs velocity (U), density (ρ), viscosity (η), adiabatic compressibility (β_{ad}), inter molecular free length (L_f) and free volume were drawn and presented in graphs. The structural contributions are due to the geometrical appropriate of the molecules of very dissimilar molecular sixes into each othersa structures resulting in negative/positive excess values. In the present investigation, the excess adiabatic compressibility ($\Delta\beta_{ad}$), the excess free volume(V_f^E), excess free length (L_f^E) exhibit negative values over the entire range of composition at temperatue

303.15K to 318.15K studied and given in table.4. clearly represents the presence of strong interactions[18] between o-Chloro toluene and 2-propanol.

Table1.Density, viscosity and velocity of pure compounds and comparision

Experimental and literature values of density (ρ), viscosity (η) and velocity (U) of 2MHz ultrasonic wave for pure o-Chlorotoluene

Parameter	303.15K		308.15K		313.15K		318.15K	
	Expt.	Lite.	Expt.	Lite.	Expt.	Lite.	Expt.	Lite.
Density(ρ) kg/m^3	1071.7	1072.79[21] 1072.86[22] 1072.50[23] 1072.80[24]	1067.20	1068.21[22] 1067.60[23] 1068.21[24]	1063.10	1064.21[22]	1061.6	-
Viscosity(η) Ns/m^2	0.8871	0.8870[21]	0.8186	-	0.7551	-	0.6902	-
Velocity(U) m/s	1281.2	1284.00[21] 1280.70[22] 1283.61[24]	1266.9	1262.70[23] 1265.64[24]	1249.8	-	1230.2	-

Table.2. Experimental and literature values of density (ρ), viscosity(η) and velocity (U) of 2MHz ultrasonic wave for pure Isopropyl alcohol

Parameter	303.15K		308.15K		313.15K		318.15K	
	Expt.	Lite.	Expt.	Lite.	Expt.	Lite.	Expt.	Lite.
Density(ρ)	779.5	778.20[16]	771.79	773.50[16]	769.12	770.80[16]	763.49	767.10[16]

kg/m^3		777.47[17]		773.15[17]		768.45[17]		
Viscosity(η) **Ns/m^2**	1.7675	1.7635[15] 1.7078[16]	1.5649	1.5533[15] 1.6548[16]	1.3254	1.3130[15] 1.4223[16]	1.1349	1.1624[15] 1.0607[16]
Velocity(U) **m/s**	1122.48	1115.10[15] 1133.40[16] 1132.16[17]	1113.59	1102.30[15] 1110.20[16] 1114.32[17]	1088.96	1089.00[15] 1091.10[16] 1096.18[17]	1076.43	1075.50[15] 1069.20[16]

Table3. Ultrasonic velocity *(U),* Density *(ρ)*, Viscosity *(η),* adiabatic compressibility *(β_{ad}),* inter molecular free length *(L_f),* acoustic impedance (Z) andfree volume **(V_f)** for binary mixture of o-Chlrotoluene(X_1) and 2-propanol (X_2)attemperature range from303.15K to 318.15K.

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)**	**Acoustic Impedance (Z)**	**Free Volume (V_f)**
303.15K								
0	1	1122.4	779.5	1.7675	10.182	6.6211	0.875	0.2662
0.1151	0.8849	1148.9	827.63	1.62154	9.1537	6.2779	0.9509	0.3755
0.2455	0.7545	1175.3	875.76	1.47558	8.266	5.9658	1.0293	0.5362
0.3942	0.6058	1201.7	923.89	1.32962	7.4946	5.6806	1.1103	0.7779
0.5655	0.4345	1228.1	972.02	1.18366	6.8203	5.419	1.1938	1.1523

0.7649	0.2351	1254.6	1020.1	1.0377	6.2276	5.1782	1.2799	1.7542
1	0	1281.0	1068.2	0.89174	5.7042	4.9558	1.3685	2.7686
308.15K								
0	1	1113.6	771.79	1.5649	10.448	6.7719	0.8595	0.3158
0.1151	0.8849	1139.1	821.03	1.4404	9.3863	6.4185	0.9353	0.4434
0.2455	0.7545	1164.7	870.26	1.3159	8.4711	6.0975	1.0136	0.6294
0.3942	0.6058	1190.2	919.5	1.1914	7.677	5.8047	1.0944	0.9061
0.5655	0.4345	1215.8	968.73	1.0669	6.9838	5.5364	1.1778	1.3291
0.7649	0.2351	1241.3	1018	0.9424	6.3753	5.2898	1.2636	1.9976
1	0	1266.9	1067.2	0.8179	5.8384	5.0621	1.352	3.0997
313.15K								
0	1	1089	769.12	1.3254	10.964	7.0033	0.8375	0.3917
0.1151	0.8849	1115.8	818.11	1.2304	9.8185	6.6272	0.9128	0.5444
0.2455	0.7545	1142.6	867.09	1.1354	8.8343	6.2863	0.9907	0.7629
0.3942	0.6058	1169.4	916.07	1.0404	7.9831	5.9758	1.0712	1.0812
0.5655	0.4345	1196.2	965.05	0.9454	7.2421	5.6917	1.1544	1.5549
0.7649	0.2351	1223	1014	0.8504	6.5935	5.4309	1.2401	2.2788
1	0	1249.8	1063	0.7554	6.0228	5.1905	1.3285	3.4219
318.15K								
0	1	1076.4	763.49	1.1349	11.304	7.1781	0.8218	0.486
0.1151	0.8849	1102.1	813.18	1.0619	10.124	6.7932	0.8962	0.667
0.2455	0.7545	1127.8	862.86	0.9889	9.1113	6.4445	0.9731	0.922
0.3942	0.6058	1153.5	912.55	0.9159	8.2357	6.127	1.05266	1.285
0.5655	0.4345	1179.2	962.23	0.8429	7.4738	5.8367	1.1346	1.811

0.7649	0.2351	1204.9	1011.9	0.7699	6.8069	5.5702	1.2192	2.589
1	0	1230.6	1061.6	0.6969	6.2202	5.3248	1.30640	3.773

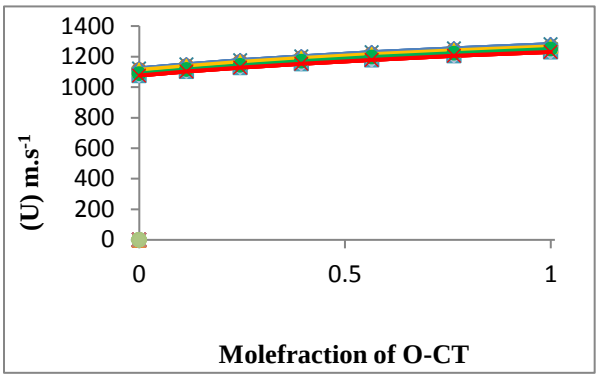
Table4. Excess adiabatic compressibility($\Delta\beta_{ad}$), excess inter molecular free length(L_f^E),excess acoustic impedance (Z^E),excess free volume(V_f^E) and excess viscosity($\Delta\eta$)for binary mixture of o-Chlrotolueneand 2-propanolat temperature range from303.15K to 318.15K.

(X_1)	$\Delta\beta_{ad}$	L_f^E	Z^E	V_f^E	$\Delta\eta$
303.15K					
0	0	0	0	0	0
0.1151	-0.5126	-0.1514	0.01907	-0.1788	-0.0451
0.2455	-0.8167	-0.2466	0.03319	-0.3443	-0.077
0.3942	-0.9223	-0.2841	0.04078	-0.4747	-0.0927
0.5655	-0.8297	-0.2605	0.03977	-0.5289	-0.0886
0.7649	-0.5294	-0.1692	0.02742	-0.4261	-0.0599
1	0	0	0	0	0
308.15K					
0	0	0	0	0	0
0.1151	-0.527	-0.155	0.0186	-0.195	-0.0378
0.2455	-0.838	-0.252	0.0324	-0.374	-0.0644
0.3942	-0.944	-0.29	0.0398	-0.513	-0.0775
0.5655	-0.848	-0.265	0.0387	-0.567	-0.074
0.7649	-0.54	-0.172	0.0266	-0.452	-0.0499
1	0	0	0	0	0

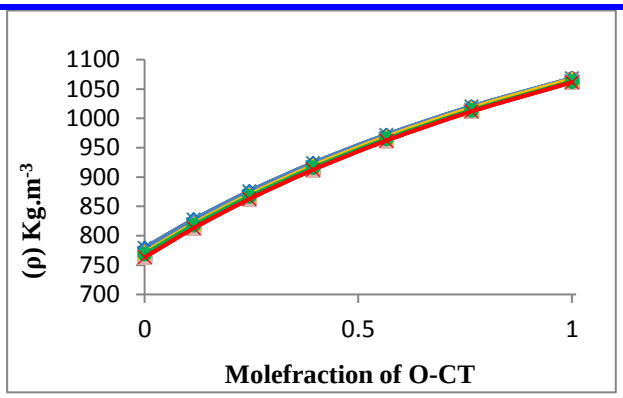
313.15K					
0	0	0	0	0	0
0.1151	-0.573	-0.166	0.0183	-0.1988	-0.0289
0.2455	-0.909	-0.269	0.0319	-0.3774	-0.0492
0.3942	-1.023	-0.309	0.0392	-0.5111	-0.0592
0.5655	-0.918	-0.283	0.0382	-0.5566	-0.0565
0.7649	-0.584	-0.183	0.0263	-0.4353	-0.0382
1	0	0	0	0	0
318.15K					
0	0	0	0	0	0
0.1151	-0.587	-0.169	0.0179	-0.202	-0.0219
0.2455	-0.931	-0.274	0.0311	-0.3798	-0.0373
0.3942	-1.047	-0.314	0.0381	-0.5084	-0.0448
0.5655	-0.937	-0.287	0.0371	-0.5459	-0.0428
0.7649	-0.595	-0.185	0.0255	-0.4193	-0.0288
1	0	0	0	0	0

Graphs

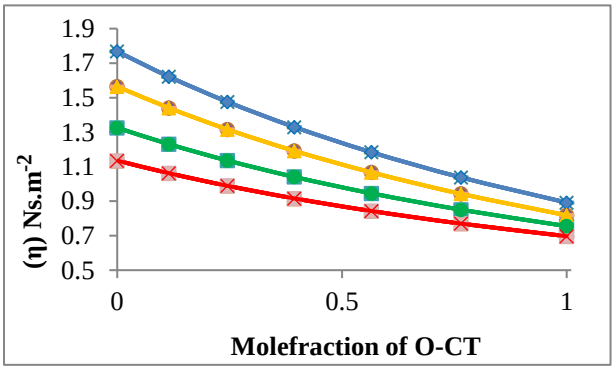
303.15 K 308.15 K 313.15 K 318.15 K



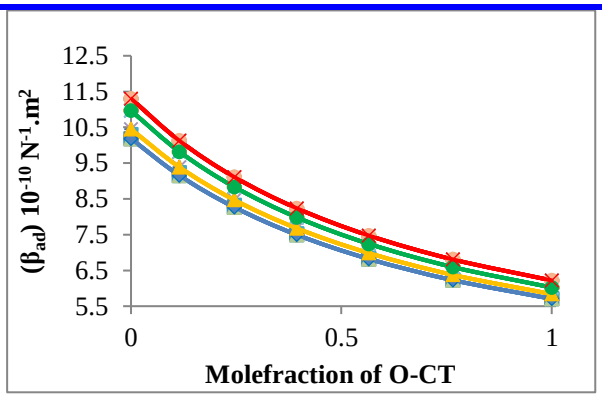
Graph -1: Ultrasonic Velocity Vs Mole fraction of o-Chlorotoluene (X_1)



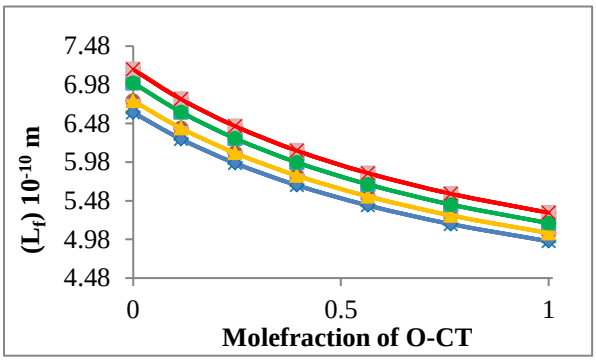
Graph -2:DensityVs Mole fraction of o-Chlorotoluene (X_1)



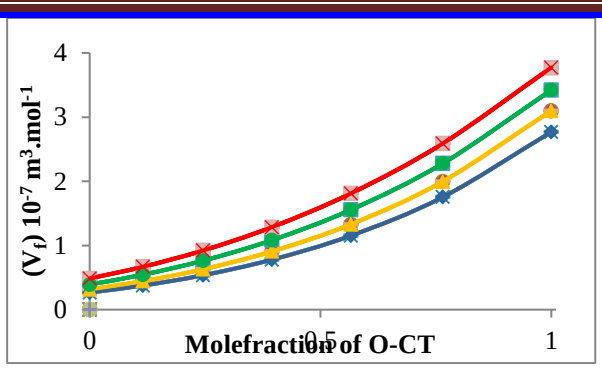
Graph-3:ViscocityVs Mole fraction of o-Chlorotoluene (x_1)



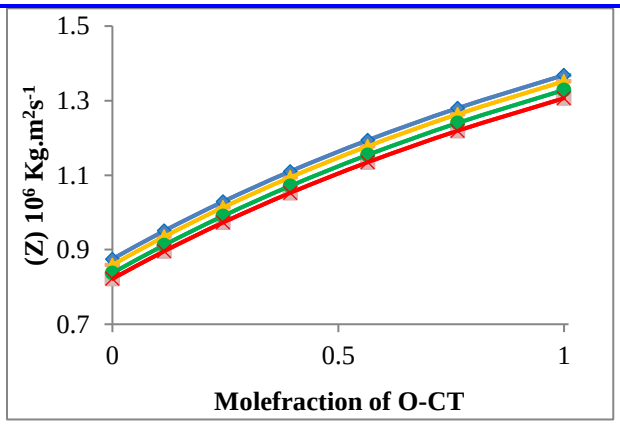
Graph-4: Adiabatic Compressibility Vs o-Chlorotoluene (x_1)



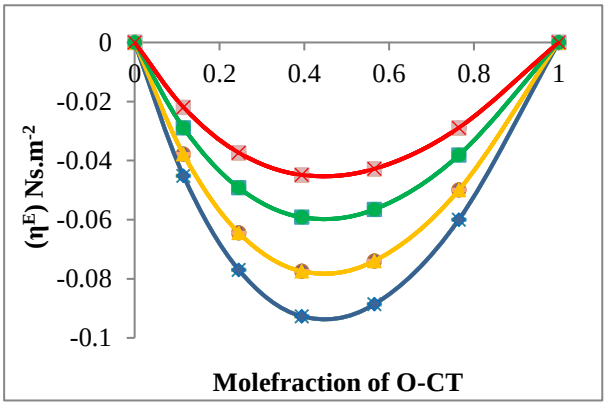
Graph -5: Intermolecular Free Length Vs Mole fraction of o-Chlorotoluene (X_1)



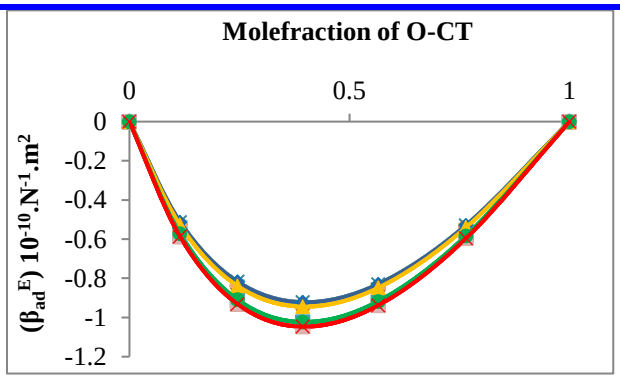
Graph -6: Free volumeVs Mole fraction of o-Chlorotoluene X_1)



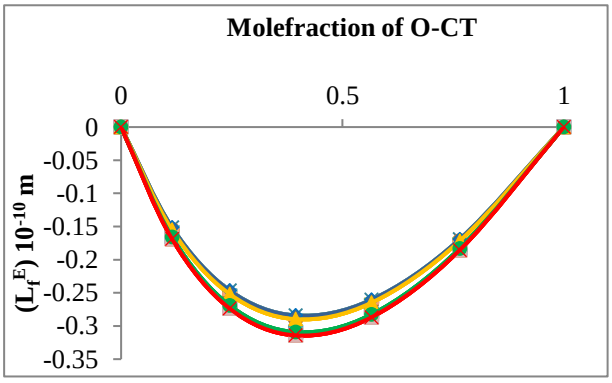
Graph -7: Accoustic impedence Vs Mole fraction of o-Chlorotoluene (X_1)



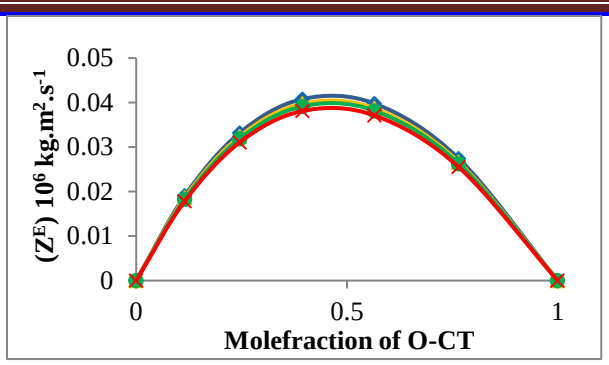
Graph -8:Deviation in Viscosity Vs Mole fraction of o-Chlorotoluene (X_1)



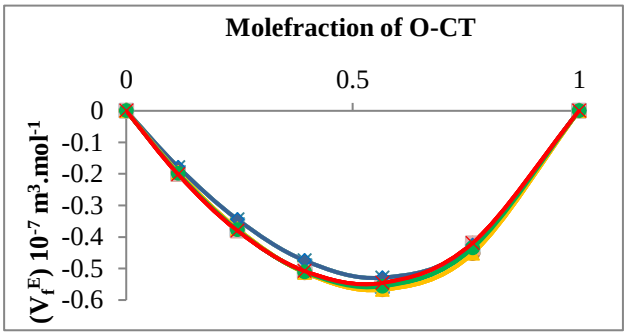
Graph -9: Excess adia. Compressibility VsMolefraction of o-Chlorotoluene (X_1)



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



Graph-11:Excess Accoustic impedence Vs Mole fraction of o-Chlorotoluene (X_1)



Graph -12:Excess molar volumeVs Mole fraction of o-Chlorotoluene (X_1)

Conclusions

The ultrasonic velocity, density, viscosity and other related experimental, derived and their excess parameters were calculated. The miscible organic binary liquid mixture of o-Chlorotouleneand 2-propanol shows the negative excess adiabatic compressibility,excess free volume and excessintermolcular free length and positive excess acoustic impedencerepresents the strong interactions between the unlike molecules of the binary mixture.

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