Available online at www.derpharmachemica.com

ISSN 0975-413X
CODEN (USA): PCHHAX

Der Pharma Chemica, 2016, 8(10):88-94
(http://derpharmachemica.com/archive.html)

Acoustic Studies on Binary Liquid Mixtures of *O*-Chlorotoluene and Ethanol at 303.15K to 318.15K

N. Sai Kiranmai* and P. Usha

Department of Physics, Narsimha Reddy Engineering College, Maisammaguda, Kompally, Hyderabad

---

ABSTRACT

Ultrasonic velocity, viscosity and density of O-Chlorotoluene with Ethanol have been determined at various temperatures in the range of 303.15K to 318.15K. The ultrasonic velocity, viscosity and density data are used to estimate adiabatic compressibility, intermolecular free length and free volume along with their excess values. The experimental variations of these parameters, with concentration and temperature, are discussed in terms of the intermolecular interactions between the unlike molecules of the binary mixtures.

Key words: O-Chlorotoluene **,** Ethanol**,** ultrasonic speed, viscosity, density.

INTRODUCTION

The ultrasonic studies are extensively used to estimate the thermodynamic properties and analyze the intermolecular interactions of binary liquid mixtures. The sound velocity is one of those physical properties that help in understanding the nature of liquid state. Using the measured values of sound velocity (u) and density (ρ),viscosity(η) the thermodynamic parameters such as adiabatic compressibility (β_{ad}),excess free volume(V_f)and intermolecular free length (L_f) can be evaluate. 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 [**1-2]**. 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 [**3**].The excess thermodynamic parameters such as excess adiabatic compressibility (β_{ad}), excess intermolecular free length (L_f) and free volume (V_f) are very useful to understand the intermolecular interactions in binary mixtures. When negative excess perameters are observed [**4-6]**, complex formation is suspected more often. The present examination aims at understanding the molecular interactions based on thermo dynamical parameters β_{ad} and L_f and their excess functions & in the binary mixture of at 303.15K to 318.15K.

MATERIALS AND METHODS

All the materials procured of Sigma-Aldrich AR grade and glassware used of Borosilicate make. Organic liquids O-Chlorotoluene , Ethanol was AR grade procured from Sigma-Aldrich are used directly without purification. The densities and viscosities of the liquid compounds were measured with specific gravity bottle and Ostwald viscometer pre calibrated with 3D water[8] 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. An electronic digital stopwatch with an accuracy of ± 0.01s was used for flow time measurement. Borosilicate glassware, Japan make Shimadzu electronic balance of sensitivity

±0.001gm and an electrically operated constant temperature water bath of accuracy ±0.1K has been used to circulate water through the double walled measuring cell made up of steel containing the experimental solution at the desired temperature while conducting the experiments. 2MHz ultrasonic interferometer model no. F-05 [9] with least count of micrometer 0.001mm of Mittal Enterprises was used for calculating velocities of sound waves and all the tests were conducted as per ASTM standard procedures.

Theory and Calculations

In order to observe the inter molecular interactions in liquid mixtures of O-Chlorotoluene with Ethanol, 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 consideration. From the experimental data of binary mixtures, the derived, excess values were calculated at various mole fractions of O-Chlorotoluene for understanding inter and intra molecular interactions at each temperature.

Table.1. Comparison of experimental and literature values of density (ρ), viscosity (η) and velocity (U) of 2MHz ultrasonic wave of 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[15] 1072.86[16] 1072.50[17] 1072.80[18]	1067.20	1068.21[16] 1067.60[17] 1068.21[4]	1063.10	1064.21[16]	1061.6	-
Viscosity(η) Ns/m^2	0.8871	0.8870[15]	**0.8186**	-	0.7551	-	0.6902	-
Velocity(U) m/s	1281.2	1284.00[15] 1280.70[16] 1283.61[18]	1266.9	1262.70[17] 1265.64[18]	1249.8	-	1230.2	-

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

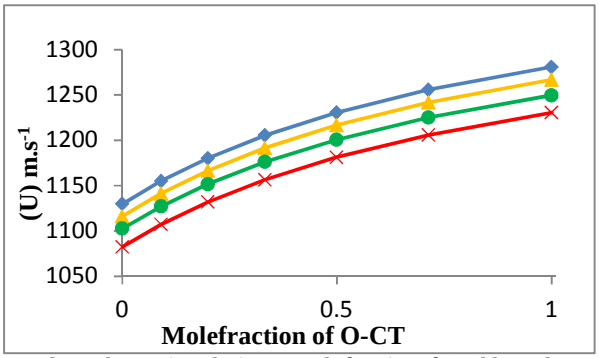
Parameter	303.15K		308.15K		313.15K		318.15K	
	Expt.	Lite.	Expt.	Lite.	Expt.	Lite.	Expt.	Lite.
Density(ρ) kg/m^3	782.9	781.00[10] 780.00[11] 784.40[14]	778.3	776.82[13] 779.80[14]	775.1	772.9[010] 775.00[11] 774.50[14]	770.9	768.08[13]
Viscosity(η) Ns/m^2	0.9817	1.0040[10] 1.0400[11] 0.9944[12] 0.9675[14]	**0.9174**	0.9014[12] 0.9382[14]	0.8333	0.8350[10] 0.8306[12] 0.8938[14]	0.7753	0.7642[12]
Velocity(U) m/s	1129.8	1132.2[12] 1144.0[14]	1116.2	1117.6[12] 1109.6[13] 1123.0[14]	1102.6	1101.6[12] 1109.0[14]	1082.4	1084.7[12] 1075.5[13]

Table3. Ultrasonic velocity *(U)*, Density *(ρ)*, Viscosity *(η)*, adiabatic compressibility *(β_{ad})*, inter molecular free length *(L_f)*, Acoustic Impedence (Z) and free volume (V_f) for binary mixture of O-Chlorotoluene and Ethanol at different temperatures

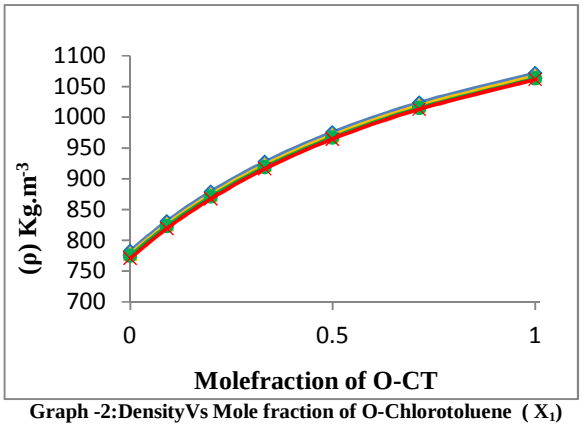
Mole fraction (X_1)	Mole fraction (X_2)	Velocity m/sec (U)	Density Kg/m^3 (ρ)	Viscosity Nsm^{-2} (η)	Ad. Comp. 10^{-10} $N^{-1}.m^2$ (β_{ad})	Int. Mol. Free length 10^{-10} m (L_f)	Acoustic Impedence (Z)	Free Volume (V_f)
T=303.15K								
0.0000	1.0000	1129.8	782.9	0.9817	10.006	6.5639	0.8845	0.4357
0.0906	0.9094	1155	831.03	0.9667	9.0197	6.2318	0.9599	0.5746
0.1994	0.8006	1180.2	879.16	0.9517	8.1658	5.9295	1.0376	0.7633
0.3325	0.6675	1205.4	927.29	0.9367	7.4216	5.6529	1.1178	1.0245
0.499	0.501	1230.6	975.42	0.9217	6.7694	5.3988	1.2004	1.3951
0.7135	0.2865	1255.8	1023.6	0.9067	6.1948	5.1646	1.2854	1.9382
1.0000	0.0000	1281	1071.7	0.8917	5.6861	4.948	1.3729	2.7688
T=308.15K								
0.0000	1.0000	1116.2	778.3	0.9174	10.312	6.7277	0.8687	0.4736
0.0906	0.9094	1141.31	826.45	0.9008	9.2891	6.3851	0.9432	0.6277
0.1994	0.8006	1166.42	874.6	0.8842	8.4038	6.0732	1.0201	0.8379
0.3325	0.6675	1191.53	922.75	0.8676	7.6331	5.7881	1.0994	1.1301
0.499	0.501	1216.64	970.9	0.851	6.9582	5.526	1.1812	1.5467
0.7135	0.2865	1241.75	1019.05	0.8344	6.3640	5.2859	1.2654	2.1596
1.0000	0.0000	1266.86	1067.2	0.8178	5.8384	5.0621	1.3519	3.1003
T=313.15K								
0.0000	1.0000	1102.6	775.1	0.8333	10.612	6.8899	0.8546	0.8546
0.0906	0.9094	1127.1	823.1	0.8203	9.5631	6.5405	0.9277	0.9277
0.1994	0.8006	1151.6	871.1	0.8073	8.6553	6.2223	1.0032	1.0032
0.3325	0.6675	1176.1	919.1	0.7943	7.8647	5.9313	1.081	1.081
0.499	0.501	1200.7	967.1	0.7813	7.1721	5.6641	1.1612	1.1612
0.7135	0.2865	1225.2	1015.1	0.7683	6.5621	5.4179	1.2438	1.2438
1.0000	0.0000	1249.7	1063.1	0.7553	6.0222	5.1903	1.3286	1.3286
T=318.15K								
0.0000	1.0000	1082	770.9	0.7753	11.072	7.1041	0.8344	0.5822
0.0906	0.9094	1107	819.4	0.7603	9.9576	6.7372	0.9071	0.774
0.1994	0.8006	1132	867.8	0.7463	8.9958	6.4035	0.9822	1.0341
0.3325	0.6675	1157	916.3	0.7323	8.1601	6.0988	1.0596	1.3958
0.499	0.501	1181	964.7	0.7183	7.4295	5.8194	1.1395	1.9109
0.7135	0.2865	1206	1013	0.7043	6.7874	5.5622	1.2218	2.6678
1.0000	0.0000	1231	1062	0.6903	6.2202	5.3248	1.3064	3.8274

Table4.Excess adiabatic compressibility($\Delta\beta_{ad}$), excess inter molecular free length(L_f^E),excess Acoustic Impedence (Z^E) and excess free volume (V_f^E) for binary mixture of O-Chlorotoluene and Ethanol at different temperatures

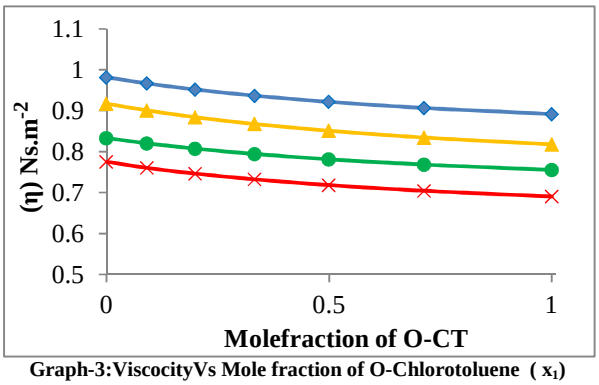
(X_1)	$\Delta\beta_{ad}$	L_f^E	Z^E	V_f^E
T=303.15K				
0.0000	0.0000	0.0000	0.0000	0.0000
0.0906	-0.5951	-0.1857	0.0311	-0.0724
0.1994	-0.9794	-0.3122	0.0557	-0.1376
0.3325	-1.1485	-0.3738	0.0709	-0.1869
0.499	-1.0811	-0.3587	0.0722	-0.2049
0.7135	-0.7291	-0.2464	0.0525	-0.1621
1.0000	0.0000	0.0000	0.0000	0.0000
T=308.15K				
0.0000	0.0000	0.0000	0.0000	0.0000
0.0906	-0.6175	-0.1914	0.0307	-0.0843
0.1994	-1.0154	-0.3219	0.0549	-0.1602
0.3325	-1.1902	-0.3852	0.0699	-0.2178
0.499	-1.1197	-0.3695	0.0711	-0.2388
0.7135	-0.7546	-0.2537	0.0517	-0.1891
1.0000	0.0000	0.0000	0.0000	0.0000
T=313.15K				
0.0000	0.0000	0.0000	0.0000	0.0000
0.0906	-0.6325	-0.1952	0.0301	0.0301
0.1994	-1.0403	-0.3282	0.0539	0.0539
0.3325	-1.2194	-0.3928	0.0686	0.0686
0.499	-1.1473	-0.3768	0.0698	0.0698
0.7135	-0.7733	-0.2586	0.0507	0.0507
1.0000	0.0000	0.0000	0.0000	0.0000
T=318.15K				
0.0000	0.0000	0.0000	0.0000	0.0000
0.0906	-0.6724	-0.2049	0.0297	-0.1038
0.1994	-1.1042	-0.3441	0.0532	-0.1982
0.3325	-1.2924	-0.4114	0.0677	-0.2696
0.499	-1.2140	-0.3941	0.0688	-0.2956
0.7135	-0.8169	-0.2701	0.0521	-0.2338
1.0000	0.0000	0.0000	0.0000	0.0000



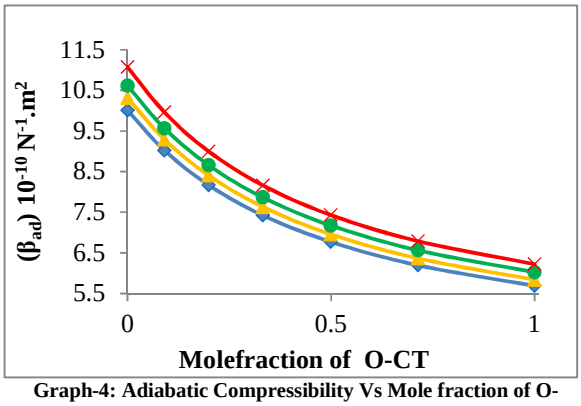
Graph-1: Ultrasonic Velocity Vs Mole fraction of O-Chlorotoluene (X_1)



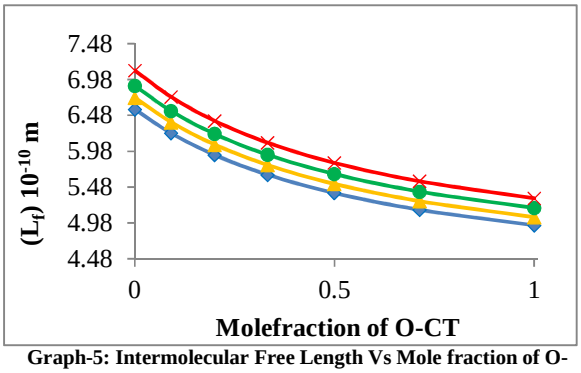
Graph -2:DensityVs Mole fraction of O-Chlorotoluene (X_1)



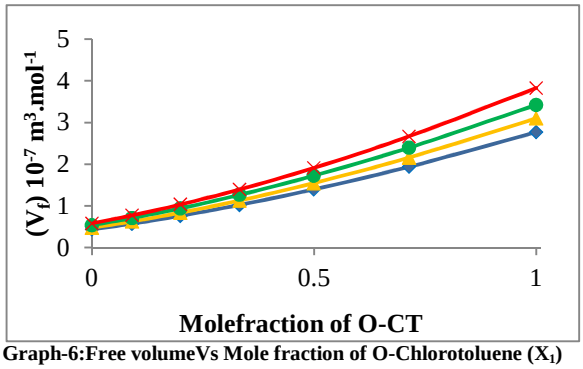
Graph-3:ViscocityVs Mole fraction of O-Chlorotoluene (x_1)



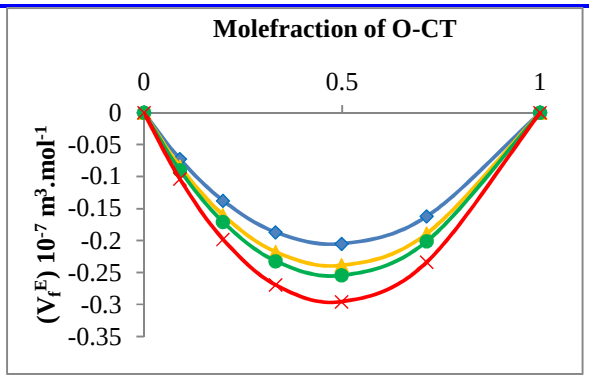
Graph-4: Adiabatic Compressibility Vs Mole fraction of O-Chlorotoluene (X_1)



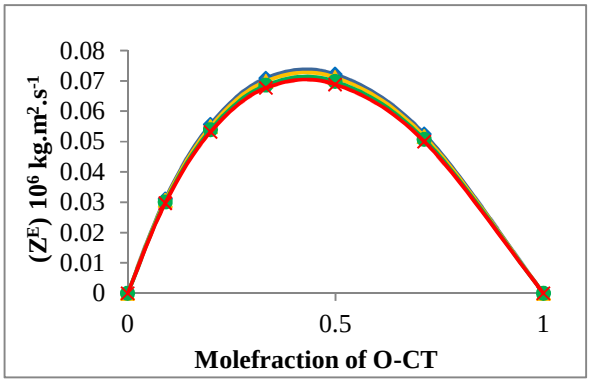
Graph-5: Intermolecular Free Length Vs Mole fraction of O-Chlorotoluene (X_1)



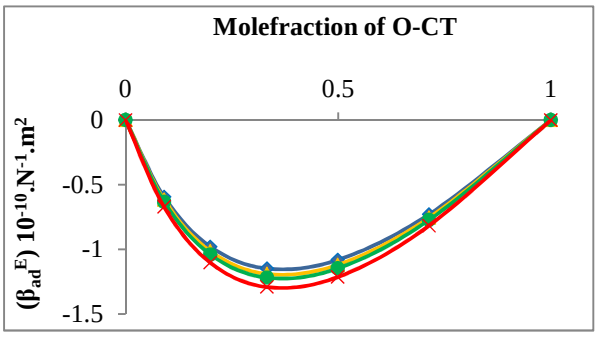
Graph-6:Free volumeVs Mole fraction of O-Chlorotoluene (X_1)



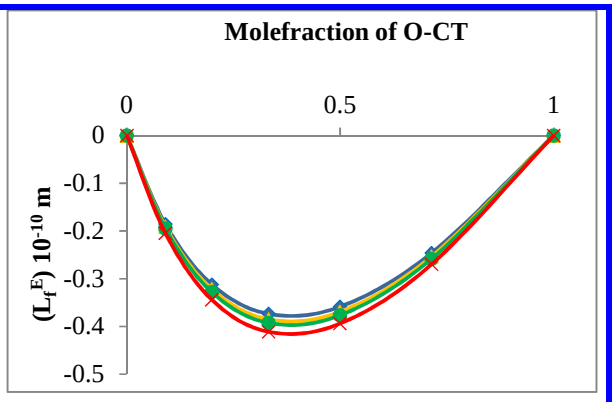
Graph-7:Excess Free Volume Vs Mole fraction of O-Chlorotoluene (X_1)



Graph-8:Excess acoustic impedence 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)

303.15 K 308.15 K 313.15 K 318.15 K

RESULTS AND DISCUSSION

The experimental values of density, viscosity and ultrasonic velocity for the pure compounds at 303.15, 308.15, 313.15 and 318.15K are presented in Table 1 and 2. The values of adiabatic compressibility, free length, acoustic impedence and free volume for the mixture at four different temperatures are given in Table 3. The respective excess values of these parameters have been evaluated and presented in Table 4. The graphs 1-6 represented the variations in adiabatic compressibility (β), free length (L_f) and free volume (V_f) with increasing mole fraction of O-Chlorotoluene and the graphs 7-10 represents the their excess values with increasing mole fraction of O-Chlorotoluene

CONCLUSION

The ultrasonic velocity, density, viscosity and other related experimental, derived and their excess parameters were calculated. The miscible organic binary liquid mixture of O-Chlorotoluene and Ethanol shows the negative excess adiabatic compressibility,free volume and Intemolecular free length represents the strong interactions between the unlike molecules of the binary mixture.

Acknowledgments
The authors are very much thankful to Narsimha Reddy Engineering College for providing infrastructure facilities.

REFERENCES

[1] Ali. A., and Nain. A.K. *Indian J. Pure Appl. Phys.*, **(1997),** 35,729.
[2] Jayakumar. S., Karunanidhi, N, and Kannappan. V. *Indian J. Pure & Appl. Phys.*, **(1996),** 34, 761.
[3] Rajendran. V. *Indian J. Pure Appl. Phys.* **(1996),** 34, 52.
[4] Fort. R.J. and Moore. W.R. *Trans. Faraday. Soc (GB),* **(1975),** 61, 2102.
[5] Sheshadri.K. and Reddy. K.C., *Acustica (Germany,)* **(1973),** 29, 59.
[6] Kaulgud. M.V. and Patil. K.J. *Indian J. Pure Appl. Phys.* **(1975),** 13, 322.
[7] Azhagiri S., Jayakumar S. Padmanaban, R. Gunasekaran and S. Srinivasan S. *J. Sol. Chem.* **(2009),** 38, 441-448.
[8] Joseph Kestin, Mordechai Sokolov and Willium A. Wakeham, *J. Phys. Chem. Ref. Data,* **(1978)**,7(3), 941.
[9] Instruction manuals for ultrasonic interferometer model F-05, Constant temperature water bath Mittal Enterprises.
[10] G. Sivaramprasad, M. VenkateshwaraRao, D.H.L.Prasad. *J. Chem. Eng. Data*, **1990**, 35, 122.
[11] T. E. VittalPrasad, K. Chandrika , M. Haritha, N. B. Geetha, D. H. L. Prasad. *Physics and Chemistry of Liquids*: An International Journal.**1999**, 37, 429.
[12] Anil Kumar Nain. *Journal of Molecular Liquids*.**2008**, 140,108.
[13] Puneet Kumar Pandey, Vrijesh Kumar Pandey, Anjali Awasthi, Anil Kumar Nain, AasheesAwasthi. *ThermochimicaActa*, **2014**, 586, 58.

[14] S. Elangovan, S. Mullainathan.Russian *Journal of Physical Chemistry* A, **2014**, 88(4), 601.
[15] Vardhana Syamala,Ponneri Venkateswarlu,Kasibhatta Siva Kumar. *J. Chem. Eng. Data*, **2006**, 51 (3), 928.
[16] L.Venkatramana, R.L. Gardas, K. Sivakumar, K. Dayananda Reddy.*Fluid Phase Equilibria*, **2014**, 367, 7.
[17] V.K.Sharma, R. Dua. *J. Chem. Thermodynamics*, **2014**, 71, 182.
[18] Sreenivasulu Karlapudi, R.L. Gardas, P. Venkateswarlu and K. Sivakumar.*J. Chem. Thermodynamics*, **2013**, 67, 203. (10).