International Letters of Chemistry, Physics and Astronomy *Online: 2015-07-03*
ISSN: 2299-3843, Vol. 54, pp 98-103
doi:10.18052/www.scipress.com/ILCPA.54.98
2015 SciPress Ltd, Switzerland

Study of Molecular Interactions in Binary Liquid Mixtures Containing Ethyl (*Z*)-octadec-9-enoate and o-toludine

D. CHINNARAO, M. SRI LATHA, K. RAJA, CH. V. PADMARAO

Department of Engineering Chemistry, AU College of Engineering (A), Visakhapatnam-03

e-mail ID: padmaraochekuri@gmail.com, bvsaradhi70@gmail.com.

Keywords: o-toludine, Ethyloleate, ultrasonic speed, viscosity, density

ABSTRACT. Density, speed of sound and viscosity have been measured for binary liquid mixture containing Ethyloleate+o-toludine over the entire composition range at temperatures 303.15, 308.15, 313.15 and 318.15 K and at atmospheric pressure. By using these values various parameters like adiabatic compressibility (β_{ad}), free volume (V_f), intermolecular free length (L_f), internal pressure (π) and their excess values have been calculated. The intermolecular interactions and structural effects are analyzed on the basis of the measured and derived properties.

1. INTRODUCTION

In the estimation of structural properties of molecules, the study of molecular interaction in liquid mixtures is of significant importance. Thermo-acoustic studies have been widely used to study the molecular interactions in liquid mixtures [1]. Since, acoustic parameters provide a better approaching into molecular environments in liquid mixtures, it seemed important to study molecular interactions which motivated the authors to carry out the present investigations in binary liquid mixtures of o-toludine with Ethyl (*Z*)-octadec-9-enoate also called Ethyloleate using ultrasonic technique. An attempt was made as a part of the doctoral research programme to find the interactions among the selected organic compounds in binary mixtures of Ethyl Oleate with aromatic amines. o-toludine is used as an intermediate in the manufacture of dyes. The esters are commonly used as solvents in the production of lacquers and other products and also as synthetic fruit flavorings in food industry [2]. Literature survey showed that no data on thermodynamic and transport properties of mixtures containing o-toludine with ester were reported. In this paper we report the ultrasonic speed, density and viscosity of Ethyl oleate with o-toludine over the entire range of composition at temperatures 303.15, 308.15, 313.15 and 318.15 K. From these experimental values various acoustical parameters and some of their excess values have been evaluated.

2. MATERIALS AND EXPERIMENTS

All the materials procured of Sigma-Aldrich AR grade and glassware used of Borosilicate make. Organic liquids Ethyl Oleate, o-toludine 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 [3] 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 $\pm$0.001gm and constant temperature water bath of accuracy $\pm$0.1K were used while conducting the experiments. 2MHz ultrasonic interferometer model no. F-05 with least count of micrometer 0.001mm of Mittal Enterprises [4] was used for calculating velocities of sound waves and all the tests were conducted as per ASTM standard [5] procedures.

3. RESULTS AND DISCUSSION

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 303.15, 308.15, 313.15 and 318.15 K are presented in Table 1

TABLE 1. Density (ρ), speed of sound (u) and viscosity (η) of binary mixture of Ethyl Oleate(x_1) + o-toluidine(x_2)

Mole fraction (X_1)	Velocity m/sec (U)	Density Kg/m^3 (ρ)	Viscosity Nsm^{-2} (η)	Ad. Comp. (β_{ad})	Free length 10^{-10} m (L_f)	Free Volume (V_f)	Internal pressure (π)
T= 303.15 K							
0.0000	1580.1	995.4	2.8612	4.0238	4.1623	0.514	599.12
0.0565	1544.8	979.7	3.2691	4.2774	4.2915	0.4739	569.06
0.1302	1509.4	957.8	3.677	4.5824	4.4419	0.4587	523.47
0.2304	1474.1	934.6	4.0849	4.9240	4.6044	0.4678	465.46
0.3745	1438.8	912.0	4.4928	5.2968	4.7756	0.5078	396.70
0.5995	1403.5	894.1	4.9007	5.6783	4.9446	0.5999	319.23
1.0000	1368.1	863.5	5.3086	6.1871	5.1613	0.8082	230.56
T=308.15 K							
0.0000	1570.8	988.1	2.6119	4.1016	4.2429	0.5841	580.73
0.0565	1532.5	976.3	2.9626	4.3615	4.3752	0.543	551.44
0.1302	1494.1	956.1	3.3133	4.6850	4.5346	0.5285	506.83
0.2304	1455.8	933.4	3.6640	5.0550	4.7103	0.5409	450.21
0.3745	1417.5	911.7	4.0147	5.4590	4.8949	0.5885	383.67
0.5995	1379.2	893.1	4.3654	5.8868	5.0830	0.6956	308.53
1.0000	1340.8	859.3	4.7161	6.4731	5.3302	0.9365	222.41
T=313.15 K							
0.0000	1541.6	981.2	2.3019	4.2884	4.3799	0.6864	556.64
0.0565	1505.4	974.8	2.6209	4.527	4.5	0.6356	531.11
0.1302	1469.1	954.9	2.9399	4.8522	4.6589	0.6169	488.61
0.2304	1432.9	931.8	3.2589	5.2273	4.8356	0.6302	434.11
0.3745	1396.6	909.1	3.5779	5.6395	5.0226	0.6848	369.81
0.5995	1360.4	892.2	3.8969	6.0567	5.2051	0.8086	297.87
1.0000	1324.1	855.6	4.2159	6.6663	5.4608	1.0873	214.43
T=318.15 K							
0.0000	1525.4	975.9	2.1191	4.4038	4.4803	0.7649	543.51
0.0565	1488.7	973.1	2.3963	4.637	4.5974	0.7151	518.16
0.1302	1452	953.1	2.6735	4.9767	4.7629	0.6992	475.44
0.2304	1415.3	930.1	2.9507	5.3677	4.9465	0.7184	421.6
0.3745	1378.6	908.2	3.2279	5.7938	5.1390	0.7841	358.81
0.5995	1341.9	890.3	3.5051	6.2381	5.3324	0.9291	288.48
1.0000	1305.1	852.1	3.7823	6.8896	5.6040	1.2522	207.27

TABLE 2. Excess intermolecular free length (**L_f^E**), deviation in adiabatic compressibility (**$\Delta\beta_{ad}$**), Excess free volume (**V_f^E**), Excess internal Pressure (**Π^E**).

Deviation in ad comp β^E_{ad}	Excess int.mol. Freelenght L_f^E	Excess free volume V_f^E	Excess internal Pressure Π^E
T= 303.15 K			
0.0000	0.0000	0.0000	0.0000
0.1314	0.0727	-0.0566	-9.2348
0.277	0.1495	-0.0936	-27.659
0.4018	0.2119	-0.114	-48.748
0.4629	0.2391	-0.1163	-64.386
0.3576	0.1833	-0.0905	-58.939
0.0000	0.0000	0.0000	0.0000
T=308.15 K			
0.0000	0.0000	0.0000	0.0000
0.1255	0.0708	-0.061	-8.9934
0.274	0.1499	-0.1016	-27.142
0.406	0.2164	-0.1245	-47.804
0.4679	0.2441	-0.1278	-62.658
0.362	0.1877	-0.0999	-57.178
0.0000	0.0000	0.0000	0.0000
T=313.15 K			
0.0000	0.0000	0.0000	0.0000
0.1036	0.0588	-0.0736	-6.0974
0.2528	0.1376	-0.1219	-23.273
0.3888	0.2057	-0.1489	-43.369
0.4577	0.2367	-0.1523	-58.254
0.3398	0.1759	-0.1186	-53.186
0.0000	0.0000	0.0000	0.0000
T=318.15 K			
0.0000	0.0000	0.0000	0.0000
0.0919	0.0532	-0.0775	-6.2439
0.2474	0.1354	-0.1294	-24.045
0.3884	0.2059	-0.1593	-44.056
0.4553	0.2362	-0.164	-58.266
0.3402	0.1767	-0.1287	-52.934
0.0000	0.0000	0.0000	0.0000

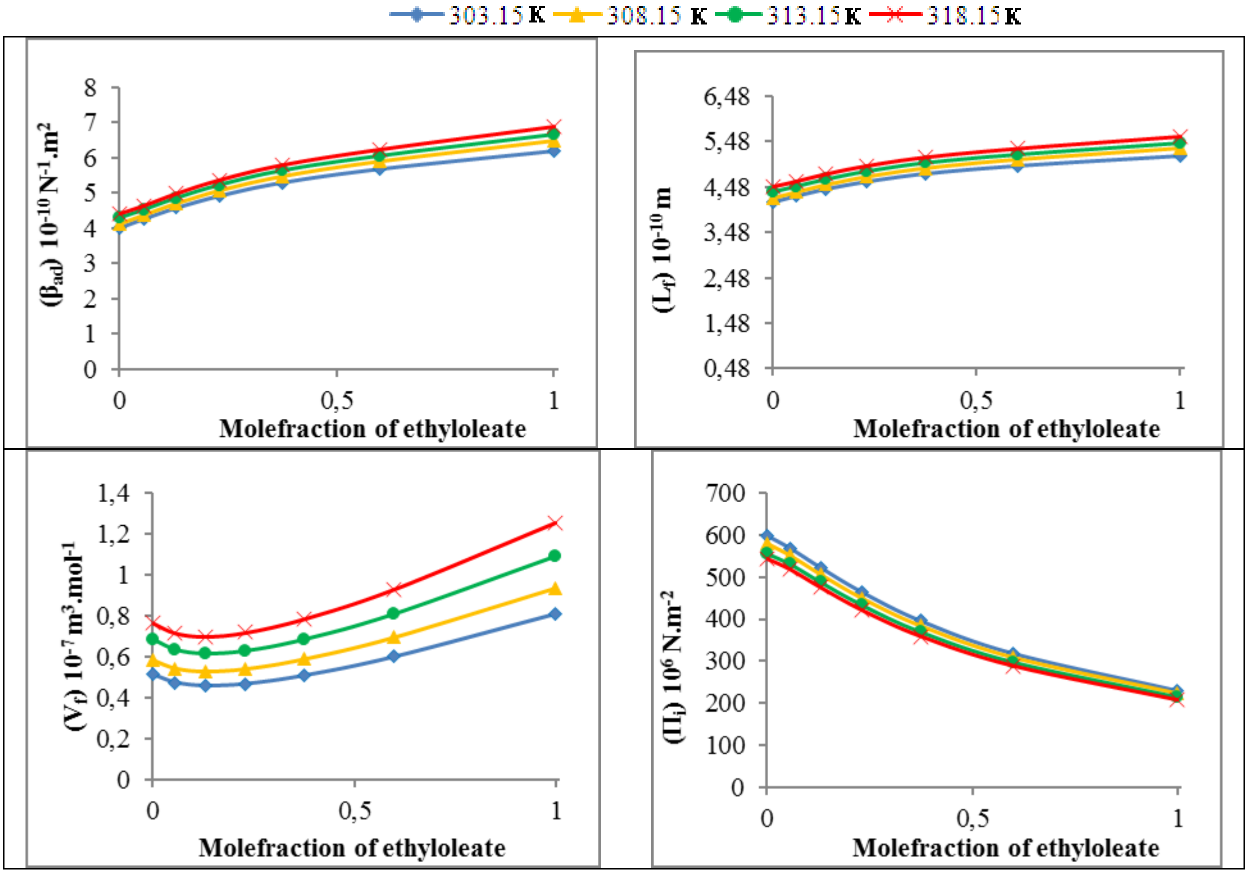

FIGURE-I: The plots of Ethyl oleate mole fraction verses adiabatic compressibility **(β_{ad})**, inter molecular free length **(L_f)**, free volume **(V_f)** and internal pressure **(п).**

From the Figure-I we concluded that the adiabatic compressibility, inter molecular free length and free volume increases with increasing the mole fraction of Ethyl oleate in parallel to temperature. But the internal pressure decreases with increasing the mole fraction of Ethyl oleate.

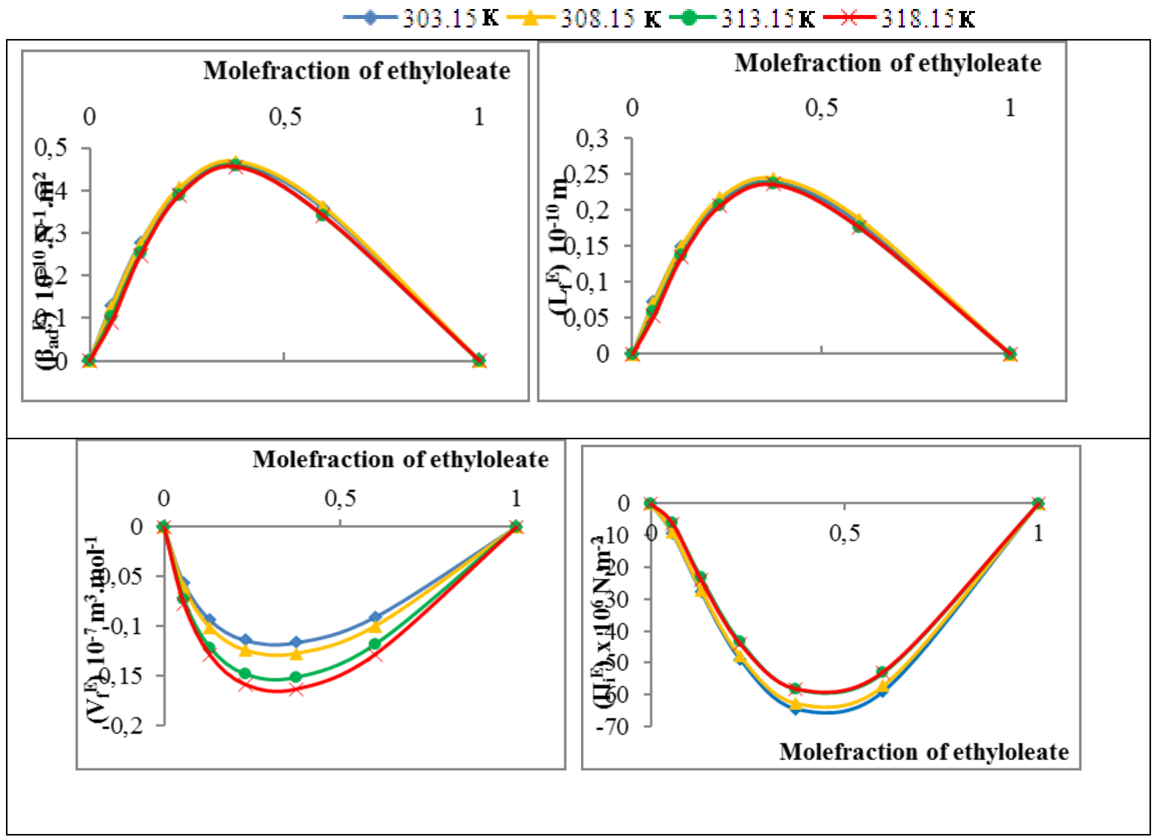

FIGURE-II: The plots of Ethyl oleate mole fraction verses Excess intermolecular free length (L_f^E), deviation in adiabatic compressibility ($\Delta\beta_{ad}$), Excess free volume (V_f^E), Excess internal Pressure (Π^E).

The deviation in adiabatic compressibility ($\Delta\beta_{ad}$) versus mole fraction (x_1) is plotted and presented in Figure-II over the entire composition range and at T = (303.15, 308.15, 313.15 and 318.15) K. The $\Delta\beta_{ad}$ values are found to be positive over the entire range of composition. The liquids of different molecular sizes usually mix with decrease in volume results variation in $\Delta\beta_{ad}$ values as. The strength of the interaction between the component molecules increase, when excess values tend to become increasingly negative [6]. This also may be quantitatively interpreted in terms of closer approach of unlike molecules leading to reductions in compressibility and volume [7]. The excess free volume (V_f^E), excess inter molecular free length(L_f^E) and excess internal pressure(π^E) versus mole fraction (x_1) is plotted and is presented in Figure-II over the entire range of composition at different temperatures. In the present investigation, the excess free volume (V_f^E) exhibit negative values over the entire range of composition at all temperatures studied clearly indicate the presence of strong interactions [8] between o-toludine and ethyl oleate. Further, the excess internal pressure (π^E) which is usually explained in terms of molecular interaction, whose negative excess values suggest that strong molecular interaction between the different molecules [9].

4. CONCLUSIONS

From the data of ultrasonic speed, density and viscosity, various acoustical parameters and their excess values for the binary liquid mixture of o-toludine with Ethyloleate were measured at (303.15, 308.15, 313.15 and 318.15) K, it is obvious that there exist strong molecular interactions between Ethyloleate and o-toludine. The negative excess values of free volume and internal pressure concluded that there exists a strong interaction among the molecules.

References

[1] P.J. Singh and K.S. Shrama. 1996, *Pramana*. 46, 259.

[2] J.M. Resa, C. Gonzalez, J.M. Goenaga, M. Iglesias. 2004, *J. Solution Chem*, 33, 169.

[3] Joseph Kestin, Mordechai Sokolov, Willium A. Wakeham, 1978, *J. Phys. Chem. Ref. Data*, 7(3), 941.

[4] Instruction manuals for ultrasonic interferometer model F-05, Constant temperature water bath Mittal Enterprises.

[5] American Society for Testing and Materials (ASTM) Standard D6751. ASTM: West Conshohocken, PA, 2009.

[6] R.J. Fort and M.W.R. Moore, 1965, *Trans Faraday Soc*. 61, 2102.

[7] A. Jayakumar, S. Karunanithi and V. Kannappan, 1996, *Ind. J. Pure Appl. Phys*. 34, 761.

[8] S.N. Gour, J.S. Tomar and R.P. Varma, 1986, *Ind. J. Pure Appl. Phys*. 24, 602.

[9] R. Singh, J.P. Mishra and M.C. Shukla, 1983, *J.Mol. Liq*. 26, 29.