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Molecular Interactions in Binary Organic Liquid Mixtures Containing Ethyl Oleate and Ethanol at 2MHz Frequency

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ABSTRACT

Molecular interactions of binary mixtures of Ethanol with a new organic compound Ethyl Oleate are investigated at a constant ultrasonic frequency of 2MHz under the temperature range of 303.15K-318.15K. The effect of mole fraction of Ethyl Oleate on velocity of sound wave and the density and viscosity of binary mixtures at various temperatures were studied. The effects on density (ρ), viscosity (η), adiabatic compressibility (β_{ad}), inter molecular free length (L_f) and internal pressure (Π_i) also was studied.

***Keywords*:** Ethyl Oleate, Ethanol, molecular interactions, adiabatic compressibility

1. INTRODUCTION

Molecular interactions are interactions between electrically neutral molecules or atoms. Other than atomic bonds these are electrical in nature and consist of attractive forces (orientation, induction, and dispersion forces) and repulsive forces. Molecular interaction first taken into consideration by J. D. van der Waals (1873) in explaining the properties of real gases and liquids. These depend on the distance between the molecules and usually are described by the potential energy of interaction. Studies on liquid- liquid mixtures either binary, ternary or more has importance of its own in various fields of con temporal 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 extensive 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 an advantageous tool if these two fields were combined for conducting studies on inter and intra particulate behavior. Ultrasonic investigations of binary mixtures have been taking place since decades by so many scholars under various heads like acoustic, thermodynamic, molecular interactions etc. Lot of literature survey has been conducted as part of author's doctoral program and found some new compounds with an observation that there were no publications till now in the field of ultrasonic studies on binary mixtures with fatty acid ethyl ester (Z)-9-Octadecenoic Acid Ethyl Ester**.** The author has been carrying out the studies on binary organic liquid mixture of

fatty acid ethyl ester (Z)-9-Octadecenoic Acid Ethyl Ester (here after called as Ethyl Oleate) with some selected alcohols (ethanol, butanol, iso propyl alcohol), amines (aniline, o-toluidine, m-toluidine), aromatic and halogenated aromatic hydrocarbons (toluene, o-xylene, o-chlorotoluenes), carbonyl compounds (acetophenane, benzoldehyde, cyclohexanone) and some esters as doctoral research work. In the present paper the author submitting part of the studies as the effect of temperature and concentration on ultrasonic velocity(**v**) of 2MHz wave in the pure and mixtures of two organic liquids Ethyl Oleate and Ethanol at various temperatures 303.15K, 308.15K, 313.15K and 318.15K. The effects on density (**ρ**), viscosity (**η**), Adiabatic compressibility ($\boldsymbol{\beta_{ad}}$), Inter molecular free length ($\mathbf{L_f}$) and Internal pressure ($\boldsymbol{\Pi_i}$) also were studied. Results were tabulated and the relations among the mentioned parameters were represented as Graph.1.

2. MATERIALS

Organic liquids Ethyl Oleate ($C_{20}H_{38}O_2$, 310.51g /mol) and Ethanol (C_2H_6O, 46.08644 gm/mol) of AR grade were procured from Sigma-Aldrich with CAS no.111-62-6 and 64-17-5 respectively are used directly without purification. The densities and viscosities of the liquid compounds were measured with specific gravity bottle/pyknometer and Ostwold viscometer pre calibrated with 3D water of Millipore to nearest mg/ml. The time taken for flow of viscous fluid in Ostwold 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 (S.No.1314421)** 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.

3. EXPERIMENT AND RESULTS

Ethyl Oleate and Ethanol were mixed in different mole fractions and the physical parameters density and viscosity were measured with standard methods by varying the temperature from 303.15 K to 318.15 K. The velocity of 2MHz ultrasonic wave in pure and liquid mixtures was determined with interferometer at each temperature. The results obtained for pure liquids were compared with the available literature and presented in Table.1.

Table 1. Density, viscosity and velocity of pure compounds.

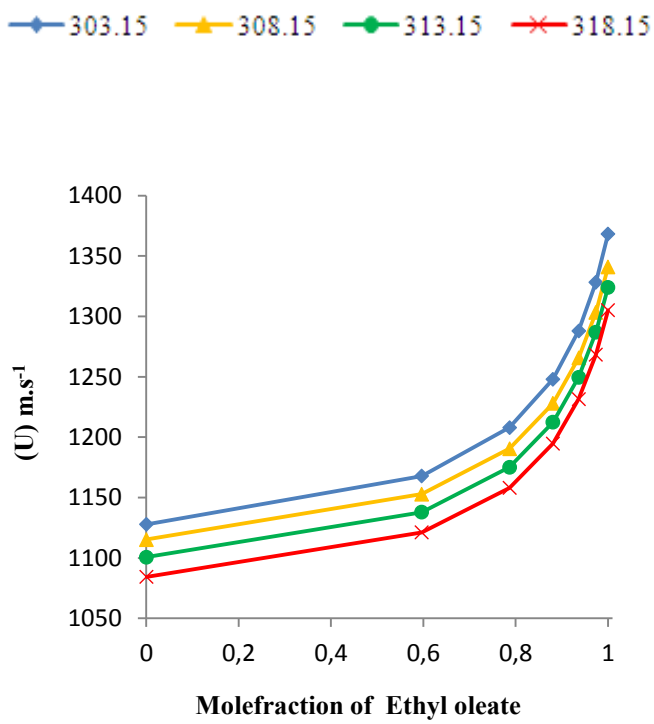
Compound	Temp. K	Density (ρ) kg/m^3		Viscosity(η) Ns/m^2		Velocity (U) m/s	
		Expe.	Lite.	Expe.	Lite.	Expe.	Lite.
Ethyl Oleate	303.15	863.50	863.20[3]	5.3101	5.3094[3]	1368.16	-
	308.15	859.34	859.50[3]	4.7164	4.7156[3]	1340.78	-
	313.15	855.62	855.80[3]	4.2163	4.2137[3]	1324.00	-
	318.15	852.04	852.20[3]	3.7820	3.7876[3]	1305.09	-
Ethanol	303.15	787.90	781.00[2]	0.9917	0.9944[8]	1127.80	1132.2[8]
	308.15	785.30	-	0.8974	0.9015[8]	1115.20	1117.6[8]
	313.15	784.00	772.90[2]	0.8133	0.8306[8]	1100.60	1101.6[8]
	318.15	780.90	768.00[7]	0.7553	0.7642[8]	1084.40	1084.7[8]

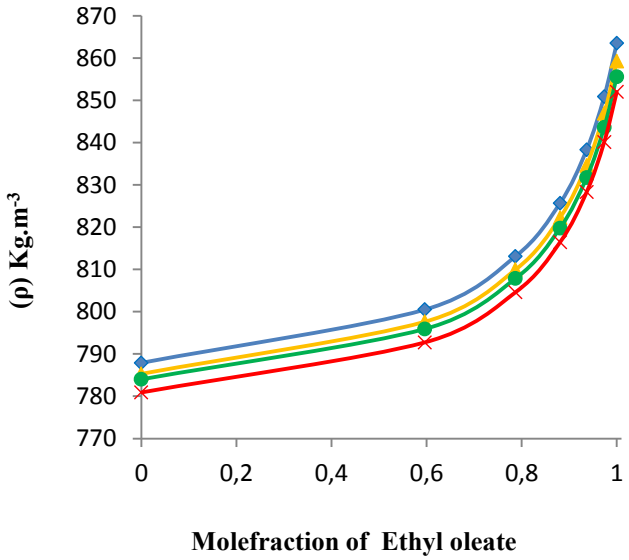
The density, viscosity and velocity for mixtures of various mole fractions of Ethyl Oleate are presented in Table 2. along with the some thermodynamic parameters Adiabatic compressibility, Inter molecular free length and Internal pressure. The density, viscosity and velocity for pure solutions are decreasing with the increase of temperatures.

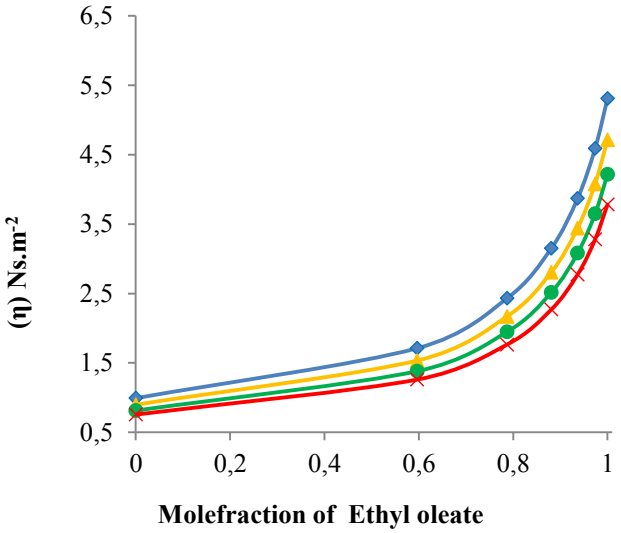
From the graphs drawn it is observed that adiabatic compressibility and inter molecular free length are decreasing with the increase of mole fraction of Ethyl Oleate at a constant temperature where as density, viscosity, velocity and internal pressure are increasing.

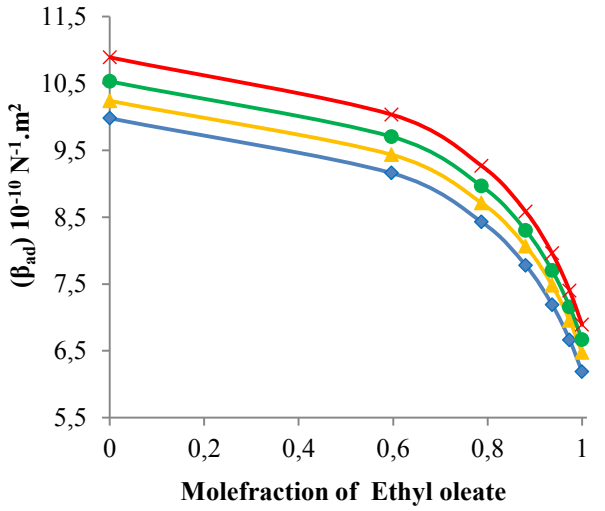
Tables 2. Binary mixture of Ethyl Oleate + Ethanol.

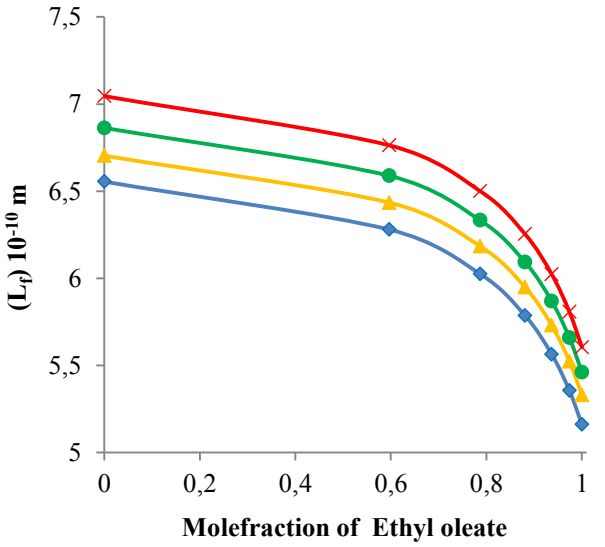
Mole fraction X_1	**Velocity m/sec U**	**Density Kg/m^3 ρ**	**Viscosity Nsm^{-2} η**	**Adiabatic Compressibility 10^{-10} $N^{-1}.m^2$ β_{ad}**	**Intermolecular free length 10^{-10} m L_f**	**Internal Pressure 10^6 $N.m^{-2}$ Π_i**
303.15 K						
0.0000	1127.8	787.9	0.9917	9.9784	6.5546	103.2532
0.5964	1167.86	800.5	1.7112	9.1591	6.2798	308.0956
0.7870	1207.92	813.1	2.4307	8.4290	6.0243	581.9620
0.8808	1247.98	825.7	3.1502	7.7761	5.7862	910.2278
0.9366	1288.04	838.3	3.8697	7.1902	5.5640	1283.1988
0.9736	1328.1	850.9	4.5892	6.6628	5.3560	1693.7541
1.0000	1368.16	863.5	5.3087	6.1867	5.1611	2136.3686
308.15K						
0.0000	1115.2	785.3	0.8974	10.2390	6.7036	100.1830
0.5964	1152.8	797.63	1.5338	9.4338	6.4347	297.4857
0.7870	1190.4	809.96	2.1702	8.7126	6.1838	561.1592
0.8808	1228	822.29	2.8066	8.0645	5.9493	877.3912
0.9366	1265.6	834.62	3.443	7.4802	5.7298	1236.9985
0.9736	1303.2	846.95	4.0794	6.9521	5.5238	1633.2170
1.0000	1340.8	859.28	4.7158	6.4734	5.3303	2060.7837
313.15 K						
0.0000	1100.6	784	0.8133	10.5299	6.8631	97.4537
0.5964	1137.85	795.93	1.3804	9.7040	6.5885	287.8926
0.7870	1175.1	807.86	1.9475	8.9642	6.3323	542.0498
0.8808	1212.35	819.79	2.5146	8.2992	6.0929	846.7372
0.9366	1249.6	831.72	3.0817	7.6998	5.8688	1193.1741
0.9736	1286.85	843.65	3.6488	7.1578	5.6584	1574.8874
1.0000	1324	855.58	4.2159	6.6675	5.46125	1986.9125
318.15 K						
0.0000	1084.4	780.9	0.7553	10.8899	7.0454	95.8705
0.5964	1121.18	792.75	1.2598	10.0349	6.7632	280.7083
0.7870	1157.96	804.6	1.7643	9.2689	6.5000	526.5448
0.8808	1194.74	816.45	2.2688	8.5807	6.2540	820.8146
0.9366	1231.52	828.3	2.7733	7.9602	6.0236	1155.1250
0.9736	1268.3	840.15	3.2778	7.3994	5.8076	1523.2791
1.0000	1305.08	852	3.7823	6.8910	5.6045	1920.4477

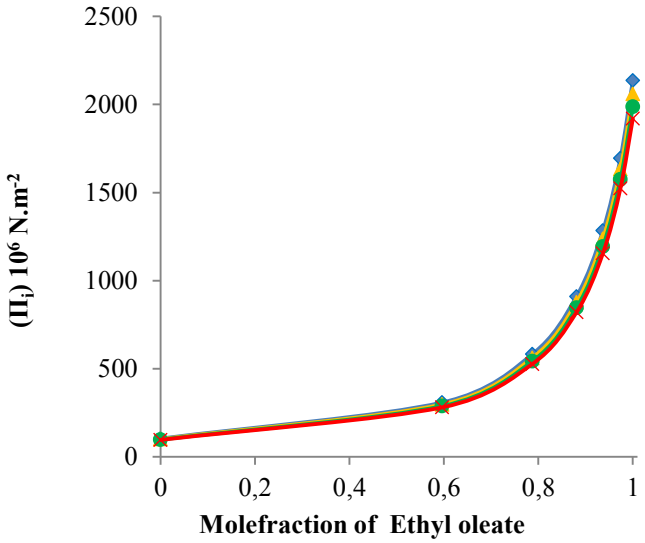

303.15
308.15
313.15
318.15
1400
1350
1300
1250
1200
1150
1100
1050
(U) m.s-1
0
0,2
0,4
0,6
0,8
1
Molefraction of Ethyl oleate


870
860
850
840
830
820
810
800
790
780
770
(ρ) Kg.m-3
0
0,2
0,4
0,6
0,8
1
Molefraction of Ethyl oleate


6,5
5,5
4,5
3,5
2,5
1,5
0,5
(η) Ns.m-2
0
0,2
0,4
0,6
0,8
1
Molefraction of Ethyl oleate


11,5
10,5
9,5
8,5
7,5
6,5
5,5
(βad) 10-10 N-1.m2
0
0,2
0,4
0,6
0,8
1
Molefraction of Ethyl oleate


7,5
7
6,5
6
5,5
5
(Lf) 10-10 m
0
0,2
0,4
0,6
0,8
1
Molefraction of Ethyl oleate



Graphs 1. Mole fraction of Ethyl Oleate VS velocity, density, viscosity, Adiabatic compressibility, Inter molecular free length and Internal pressure.

4. CONCLUSIONS

The velocity, density and viscosity of the pure liquids Ethyl Oleate and Ethanol are matching with pervious literature at various temperatures. The formation of .dipole-dipole interactions or hydrogen bonding is expected in binary mixture. Excess parameters will help in estimating the molecular interactions.

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