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THERMODYNAMIC AND ACOUSTIC ANALYSIS OF BINARY LIQUID MIXTURE AT VARYING TEMPERATURES

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Abstract :
The ultrasonic velocity (u), mass density (ρ) and sheer viscosity (η) of the binary liquid mixture of toluene and 1,2 di chloro ethane have been determined using ultrasonic interferometer for a constant frequency 2 MHz at different temperatures viz 30^{O}C, 35^{O}C, 40^{O}C. From these experimental data values, various acoustic and thermodynamic parameters namely isentropic compressibility (βs), intermolecular free length (Lf), molar volume (Vm), available volume (Va), Nissan's parameter (d) and their excess values have been calculated. It is used in so many fields of scientific researches in physics, chemistry, biology medicines and industry. All these parameters and their excess values have been interpreted in terms of molecular interactions and their strength influenced by the size, shape and chemical nature of component molecules.

Keywords : Binary liquid mixture, ultrasonic velocity, acoustic parameters, molecular interaction, excess values.

Introduction : The study of acoustic and thermodynamic properties in liquid mixture provides valuable insight in to the physical nature and strength of molecular interaction in the studied medium. Excess parameters play a significant role in a assessing the compactness due to molecular arrangement and the extent of molecular interactions in the liquid mixture through charge transfer, dipole – dipole and dipole induced dipole interactions.[1] The ultrasonic velocity is the best tool to measure the mechanical stability of liquids gives information on the physico chemical behavior and thermodynamic parameters of the complexes in pure liquid and liquid mixtures.[2-5] Its theoretical evaluation comparison with experimental data shows the behavior of molecular interactions and used to develop theoretical model for liquids. It is deeply connected to the binding forces between atoms or molecules and has been fruitfully employed in understanding the nature of molecular interactions not only in pure liquid but also in binary liquid mixtures. Intermolecular interaction in various binary liquid mixtures at different temperatures has been study by several authors.[6-10] The combined study of ultrasonic velocity and density of solution gives more understanding on the behavior of ideal and non ideal nature ,elastic properties and other co-related parameters of the liquid mixtures. A number of mathematical theories on velocity of sound measurements gives positive implications to industry and chemical processes. Acoustic parameters like density, viscosity and ultrasonic velocity have got considerable importance in forming theoretical models as well as their applications in a number of branches of science[11-14]. A considerable progress has been made theoretical understanding of liquid – liquid mixture consisting polar-polar and polar and non polar components is of considerable importance to understand intermolecular interaction between the component molecules and find application in several industrial and technological processes. Many investigations [15-20] have been engaged in the task of collecting more and more data and explaining in terms of the properties of pure liquids for determination of some useful acoustic and thermodynamic parameters in liquid mixtures.

In view of the importance of above mentioned, the present study deals to elucidate the molecular interactions in the mixture of toluene with 1,2 di chloro ethane at different temperatures as 30^{O}**C**, 35^{O}C and 40^{O}C. The excess values of some of the acoustical and thermodynamic properties like molar volume (Vm), isentropic compressibility ((βs), intermolecular free length (Lf), available volume (Va), Nissan's parameter (d) and their excess values have been calculated from the measurement of ultrasonic velocity, density and viscosity of the mixture, these excess functions are used to explain intermolecular interactions in their binary liquid mixture.

METHOD AND METARIALS:

In the present work the chemical toluene and 1,2 di chloro ethane were used of analytical grade [E-Merck]. The purity of chemical were checked by comparing their derivatives with literature value [21-22] . The density of pure liquids and liquid mixtures were determined using pycnometer with an accuracy of ± 0.053 % at 30^{O}, 35^{O} and 40^{O}. An Ostwald's viscometer was used for the viscosity measurement of pure liquid and liquid mixtures. The flow of time of pure liquid and liquid mixtures were measured using an accurate stop watch with a precision of ± 0.15 s. The ultrasonic velocity were obtained by using ultrasonic interferometer model M – 84 at 2MHz frequency. All measurements were made in a thermostatically controlled water bath with temperature accuracy of ± 0.1^{O}C .

The molar volume of binary liquid mixture is given by

$$Vm = [\ X_1M_1 \ \text{--}\ X_2M_2\ ] \ \text{--}\ \rho \qquad \text{---------------------} \ (1)$$

Where Vm is molar volume, M_1 and M_2 are molecular weight of pure compounds and X_1, X_2 are mole fractions of the component 1 and 2. ρ is the density of liquid. The isentropic compressibility (βs) and molecular free length (Lf) are calculated using following methods.

$$\beta s = 1 / u^2\rho \qquad \text{----------------------} \ (2)$$

$$Lf = K / u\, \rho^{1/2} \qquad \text{----------------------} \ (3)$$

Where 'K' is temperature constant, 'u' is the ultrasonic velocity and ρ is the density of Liquid. Nissan's parameter also calculated as

$$d = Ln\, \eta^E / \ X_1X_2 \qquad \text{---------------------} \ (4)$$

where ηE is the excess value of viscosity, X_1 , X_2 are the mole fraction f the liquid 1 and 2.

Excess values of binary liquid mixtures of varying composition were calculated using relations

$$V^E = Vobs - Vid \qquad \text{---------------------} \ (5)$$

Where VE is the excess value of binary liquid mixture, Vobs the experimental value of binary liquid mixture, Vid refers the to the value for ideal binary mixture.

RESULTS AND DISCUSSION :

The experimentally measured values of density, viscosity and ultrasonic velocity of toluene with 1,2 di chloro ethane at different temperatures as 30^{0}C, 35^{0} C and 40^{0} C were used to calculate isentropic compressibility (βs), intermolecular free length (Lf), available volume and their excess values using the standard relations with accuracy up to second decimal digit. The variation of acoustic parameters with entire concentration range of toluene with 1,2 di chloro ethane shown in table – (1- 4) and figure (I – IV) at different temperature range as 30^{0}C, 35^{0}C and 40^{0}C.

The calculated value of density, ultrasonic velocity, molar volume and their excess values for the system toluene and 1,2 di chloro ethane are reported at table – 1. The table -2 shows isentropic compressibility, intermolecular free length and their excess values for the system toluene and 1,2 di chloro ethane. Table -3 shows available volume and their excess values for the system toluene and 1,2 di chloro ethane. Table – 4 indicates the viscosity and their excess values Ln η^E (logarithm of excess values f viscosity) and nissan's parameter 'd' have been calculated for the system toluene and 1,2 di chloro ethane. All the experimental values are taken in table (1 - 4) at three different temperatures as 30^{0}C, 35^{0} C and 40^{0} C.

The figures I,II,III and IV shows the excess molar volume (Vm^E) , excess isentropic compressibility (βs), excess intermolecular length (Lf) and excess viscosity (η^E) with mole fraction of toluene and 1,2 di chloro ethane at the temperatures 30^0C, 35^0 C and 40^0 C. The mixture of toluene have been prepared by adding 1,2 di chloro ethane in respective system table (1 – 4) and the excess functions of these derived properties which are better measure strength of interactions between the molecules are also calculated and plotted against mole fraction of toluene figure (I –IV).

The mixture f toluene and 1,2 di chloro ethane have been prepared in respective system Table (1-4) and the excess functions of these derived properties which are better measure of strength of interactions are also calculated and plotted against mole fraction of toluene Fig (I – IV). Deviation in the properties computed demonstrated that their exist a molecular interaction between the liquid mixture of unlike molecules, these may be attributed to the change the adhesive and cohesive forces. In the mixture of toluene and 1,2 di chloro ethane at 30^0C, 35^0 C and 40^0 C the ultrasonic velocity and molar volume increases with the increase in the mole fraction of the toluene. However the density, available volume , isentropic compressibility, intermolecular free length and viscosity decrease under similar conditions. Table (1 – 4) and Fig. (I – IV) .

Excess molar volume (Vm^E) excess isentropic compressibility (βs^E), excess intermolecular length (Lf^E) excess available volume (Va^E) are all positive under all condition of composition and temperature, while the excess viscosity and Nissan's parameter 'd' are negative at all the three temperatures ie 30^0C, 35^0 C and 40^0 C.

Mole fractionofToluene (X1)	Ultrasonic Velocity m/sec	Density g/ml	Molar Volume (exp) ml/mole	Molar Volume (add) ml/mole	Excess Molar Volume ml/mole
0.0000	1154	1.2304	80.42	80.42	0.00
0.1000	1157	1.1805	83.25	83.19	+ 0.06

TABLE-1 ULTRASONIC VELOCITIES , DENSITIES, MOLAR VOLUMES AND THEIR EXCESS VALUES FOR THE SYSTEM TOLUENE + 1,2 DI CHLORO ETHANE AT 30 ^{O}C

Mole fraction of Toluene (X_1)	Ultrasonic Velocity m/sec	Density g/ml	Molar Volume (exp) ml/mole	Molar Volume (add) ml/mole	Excess molar Volume ml/mole
0.0000	1170	1.2392	79.85	79.85	0.00
0.1000	1176	1.1890	82.63	82.63	+ 0.02
0.2015	1182	1.1411	85.51	85.44	+ 0.07
0.3011	1190	1.0968	88.31	88.17	+ 0.14
0.4007	1200	1.0550	91.21	90.97	+ 0.24
0.5000	1210	1.0155	94.09	93.73	+ 0.36
0.5981	1222	0.9786	96.95	96.45	+ 0.50
0.7020	1236	0.9457	99.57	99.33	+ 0.24
0.8002	1251	0.9150	102.18	102.05	+ 0.13
0. 8995	1264	0.8852	104.86	104.81	+ 0.05
1.0000	1278.4	0.8563	107.60	107.60	0.00

0.2015	1162	1.1332	86.11	86.00	+0.11
0.3011	1172	1.0890	88.95	88.76	+0.19
0.4007	1181	1.0482	91.80	91.51	+0.29
0.5000	1192	1.0085	94.74	94.26	+0.48
0.5981	1203	0.9726	97.55	96.98	+0.57
0.702	1214	0.9394	100.24	99.86	+0.38
0.8002	1228	0.9099	102.76	102.57	+0.19
0. 8995	1244	0.8806	105.41	105.32	+0.09
1.0000	1258	0.8523	108.10	108.10	0.00

AT – 35^0C

AT -40^OC

Mole fractionofToluene(X1	Ultrasonic Velocity m/sec	Density g/ml	Molar Volume (exp) ml/mole	Molar Volume (add) ml/mole	Excess Molar Volume ml/mole
0.0000	1134	1.2232	80.90	80.90	0.00
0.1000	1136	1.1738	83.72	83.64	+ 0.08
0.2015	1141	1.1271	86.58	86.42	+ 0.16
0.3011	1150	1.0837	89.38	89.15	+ 0.23
0.4007	1161	1.0422	92.33	91.88	+ 0.45
0.5000	1170.4	1.0039	95.17	94.60	+ 0.57
0.5981	1181.4	0.9690	97.91	97.29	+ 0.62
0.7020	1192	0.9353	100.68	100.14	+ 0.54
0.8002	1204	0.9068	103.11	102.83	+ 0.28
0. 8995	1219	0.8783	105.68	105.55	+ 0.13
1.0000	1236	0.8507	108.31	108.31	0.00

TABLE 2 ISENTROPIC COMPRESSIBILITIES, INTER MOLECULAR FREE LENGTHS AND THEIR EXCESS VALUES FOR THE SYSTEM TOLUENE +1,2- DI CHLORO ETHANE

AT -30^OC

Mole fraction of Toluene X_1	Isentropic compressibility (exp) cm^2/dyne $X10^{12}$	Isentropic compressibility (add)cm^2/dyne $X10^{12}$	Excess isentropic compressibility cm^2/dyne X 10^{12}	Inter molecular Free length (exp) A^0	Inter molecular Free length (add) A^0	Excess inter molecular Free Length A^0
0.0000	58.95	58.95	0.00	0.4844	0.4844	0.0000
0.1000	60.81	60.20	+ 0.61	0.4920	0.4892	+ 0.0028
0.2015	62.72	61.47	+ 1.25	0.4997	0.4941	+ 0.0056
0.3011	64.38	62.72	+ 1.66	0.5062	0.4989	+ 0.0073
0.4007	65.82	63.96	+ 1.85	0.5119	0.5040	+ 0.0079
0.5000	67.25	65.21	+ 2.04	0.5174	0.5089	+ 0.0085
0.5981	68.43	66.44	+ 1.98	0.5219	0.5136	+ 0.0083
0.7020	69.21	67.74	+ 1.47	0.5249	0.5187	+ 0.0062
0.8002	69.83	68.97	+ 0.85	0.5272	0.5235	+ 0.0037
0.8995	70.70	70.20	+ 0.50	0.5305	0.5283	+ 0.0022
1.0000	71.47	71.47	0.00	0.5334	0.5334	0.0000

AT – 35^OC

Mole fraction of Toluene X1	Isentropic compressibility exp)cm^2/dyne $X10^{12}$	Isentropic compressibility (add)cm^2/dyne $X10^{12}$	Excess isentropic compressibility cm^2/dyne X 10^{12}	Inter molecular Free length (exp) A^0	Inter molecular Free length (add) A^0	Excess inter molecular Free length A^0
0.0000	61.02	61.02	0.00	0 .4972	0.4972	0.0000
0.1000	63.28	62,33	+0.94	0.5063	0.5022	+0.0041
0.2015	65.35	63.66	+1.68	0.5145	0.5074	+0.0071
+0.3011	66.85	64.97	+1.87	0.5204	0.5124	+0.0080
0.4007	68.40	66.28	+2.12	0.5264	0.5174	+0.0090
0.5000	69.78	67.58	+2.20	0.5316	0.5226	+0.0090
0.5981	71.04	68.86	+2.18	0.5364	0.5275	+0.0089
0.7020	72.22	70.23	+1.99	0.5409	0.5327	+0.0082
0.8002	72.88	71.51	+1.37	0.5433	0.5378	+0.0055
0.8995	73.38	72.82	+0.56	0.5452	0.5428	+0.0024
1.0000	74.13	74.13	0.00	0.5480	0.5480	0.0000

AT 40^OC

Mole fraction of Toluene X1	Isentropic compressibility exp)cm^2/dyne X10^{12}	Isentropic compressibility (add)cm^2/dyne X10^{12}	Excess isentropic compressibility cm^2/dyne X 10^{12}	Inter molecular Free length (exp) A^0	Inter molecular Free length (add) A^0	Excess inter molecular Free length A^0
0.0000	63.57	63.57	0.00	0.5118	0.5118	0.0000
0.1000	66.01	64.90	+1.11	0.5216	0.5169	+0.0047
0.2015	68.15	66.26	+1.89	0.5299	0.5214	+0.0085
0.3011	69.77	67.60	+2.17	0.5362	0.5271	+0.0091
0.4007	71.18	68.93	+2.25	0.5416	0.5323	+0.0093
0.5000	72.71	70.25	+2.46	0.5457	0.5374	+0.0100
0.5981	73.92	71.57	+2.35	0.5519	0.5423	+0.0096
0.7020	75.24	72.96	+2.28	0.5568	0.5477	+0.0091
0.8002	76.07	74.27	+1.80	0.5599	0.5527	+0.0072
0.8995	76.62	75.60	+1.02	0.5619	0.5579	+0.0040
1.0000	76.94	76.94	0.00	0.5631	0.5631	0.0000

TABLE - 3

AVAILABLE VOLUMES AND THEIR EXCESS VALUES FOR THE SYSTEM TOLUENE + 1,2- DI CHLORO ETHANE

AT – 30^{O}C

Mole fraction of Toluene X_1	Available volume (exp) ml /mole	Available volume (add) ml / mole	Excess available volume ml /mole
0.0000	21.45	21.45	0.00
0.1000	21.89	21.46	+ 0.43
0.2015	22.33	21.47	+ 0.86
0.3011	22.62	21.49	+ 1.13
0.4007	22.80	21.51	+ 1.29
0.5000	22.93	21.53	+ 1.40
0.5981	22.90	21.55	+ 1.35
0.7020	22.65	21.56	+ 1.09
0.8002	22.28	21.58	+ 0.70
0.8995	22.02	21.59	+ 0.43
1.0000	21.62	21.62	0.00

AT 35^{O}C

Mole fraction of Toluene X_1	Available volume (exp) ml /mole	Available volume (add) ml / mole	Excess available volume ml /mole
0.0000	22.41	22.41	0.00
0.1000	23.04	22.47	+ 0.57
0.2015	23.57	22.54	+ 1.03
0.3011	23.79	22.61	+ 1.18
0.4007	24.04	22.68	+ 1.36
0.5000	24.15	22.75	+ 1.40
0.5981	24.20	22.81	+ 1.39
0.7020	24.18	22.88	+ 1.30
0.8002	23.89	22.95	+ 0.94
0.8995	23.45	23.02	+ 0.43
1.0000	23.10	23.10	0.00

AT -40^{O}C

Mole fraction of Toluene X_1	Available volume (exp) ml /mole	Available volume (add) ml / mole	Excess available volume ml /mole
0.0000	23.56	23.65	0.00
0.1000	24.27	23.74	+ 0.53
0.2015	24.83	23.85	+0.98
0.3011	25.13	23.93	+1.20

0.4007	25.33	24.04	+1.29
0.5000	25.55	24.14	+1.41
0.5981	25.61	24.23	+1.38
0.7020	25.67	24.33	+1.34
0.8002	25.51	24.43	+1.18
0.8995	25.16	24.53	+0.63
1.0000	24.64	24.64	0.00

TABLE -4

VISCOSITIES AND THEIR EXCESS VALUES, $Ln\eta^E$ AND NISSAN'S PARAMETER (d) FOR THE SYSTEM TOLUENE + 1,2-DI CHLORO ETHANE

AT 30^{O}C

Mole fraction of Toluene X_1	Viscosity (exp) Cp	Viscosity (add) Cp	Excess Viscosity Cp	$Ln\eta^E$	'd'
0.0000	0.797	0.797	0.000	0.000	0.000
0.1000	0.774	0.776	– 0.002	+ 0.001	+ 0.011
0.2015	0.751	0.755	– 0.004	+ 0.001	+ 0.006
0.3011	0.726	0.735	– 0.009	– 0.003	– 0.014
0.4007	0.702	0.714	– 0.012	– 0.007	– 0.029
0.5000	0.680	0.693	– 0.013	– 0.008	– 0.032
0.5981	0.659	0.673	– 0.013	– 0.010	– 0.041
0.7020	0.640	0.651	– 0.011	– 0.008	– 0.038
0.8002	0.623	0.631	– 0.008	– 0.005	– 0.031
0.8995	0.606	0.610	– 0.004	– 0.003	– 0.033
1.0000	0.589	0.589	0.000	0.000	0.000

AT -35^{O}C

Mole fraction of Toluene X_1	Viscosity (exp) Cp	Viscosity (add) Cp	Excess Viscosity Cp	$Ln\eta^E$	'd'
0.0000	0.742	0.742	0.000	0.000	0.000
0.1000	0.721	0.723	- 0.002	- 0000	0.000
0.2015	0.701	0.706	- 0.005	- 0.002	- 0.008
0.3011	0.676	0.684	- 0.008	- 0.004	- 0.019
0.4007	0.654	0.665	- 0.011	- 0.007	- 0.029
0.5000	0.634	0.646	- 0.012	- 0.009	- 0.036
0.5981	0.614	0.627	- 0.013	- 0.010	- 0.041
0.7020	0.596	0.607	- 0.011	- 0.010	- 0.047
0.8002	0.581	0.588	- 0.007	- 0.007	- 0.043
0.8995	0.565	0.569	- 0.004	- 0.004	- 0.044
1.0000	0.550	0.550	0.000	0.000	0.000

AT – 40^{O}C

Mole fraction of Toluene X_1	Viscosity (exp) Cp	Viscosity (add) Cp	Excess Viscosity Cp	$Ln\eta^E$	'd'
0.0000	0.696	0.696	0.000	0.000	0.000
0.1000	0.674	0.676	- 0.002	- 0.001	- 0.011
0.2015	0.651	0.755	-0.004	-0.002	- 0.015
0.3011	0.635	0.642	-0.007	- 0.004	- 0.019
0.4007	0.614	0.624	-0.010	- 0.007	- 0.029
0.5000	0.595	0.607	-0.012	- 0.010	- 0.040
0.5981	0.577	0.590	-0.013	- 0.012	- 0.049
0.7020	0.561	0.571	-0.010	- 0.010	- 0.047
0.8002	0.546	0.553	-0.007	- 0.005	- 0.031
0.8995	0.532	0.536	-0.004	- 0.004	- 0.044
1.0000	0.518	0.518	0.000	0.000	0.000

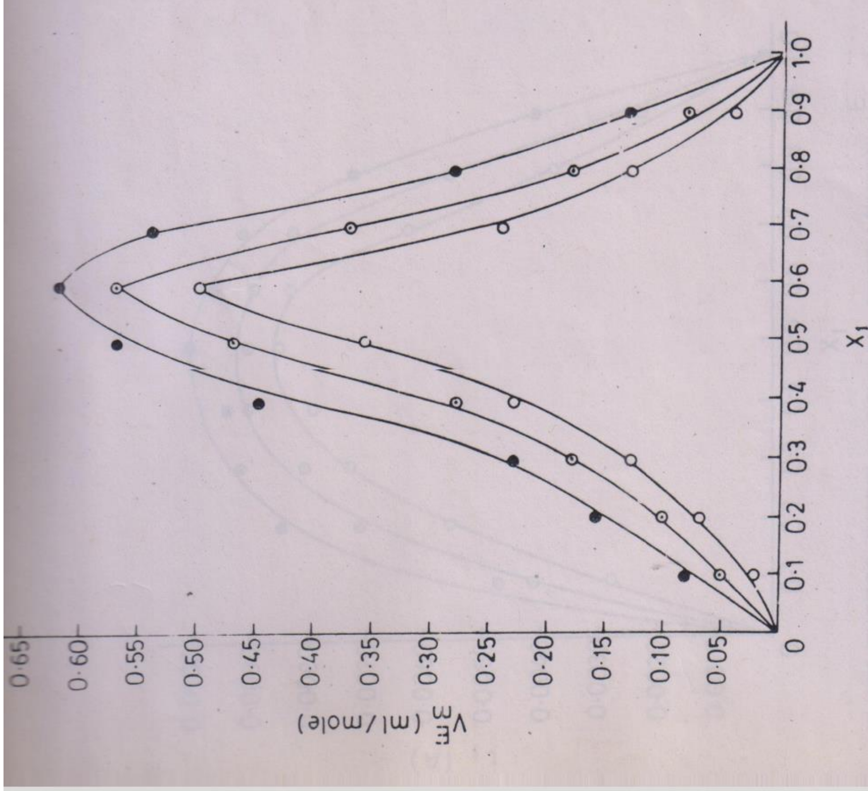

Fig.I EXCESS MOLAR VOLUME V_m^E Vs MOLE FRACTION X_1 OF TOLUENE FOR TOLUENE + 1,2 DICHLOROETHANE AT -o- 30°C, -⊙- 35°C & -●- 40°C

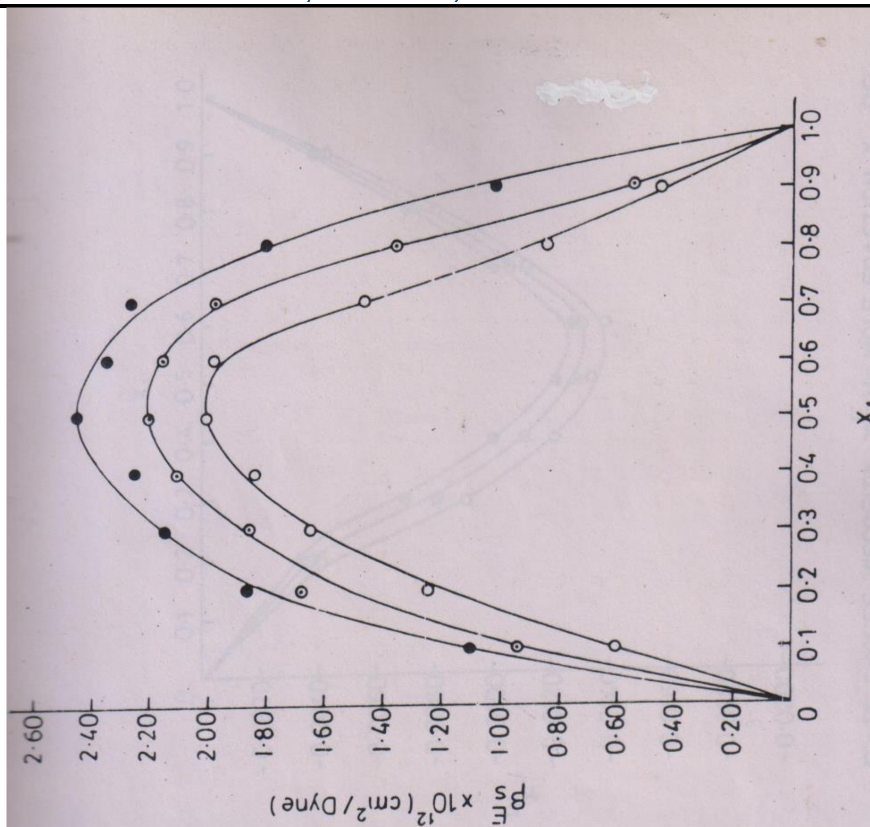

Fig.II EXCESS ISENTROPIC COMPRESSIBILITY β_s^E Vs MOLE FRACTION X_1 OF TOLUENE FOR TOLUENE + 1,2 DICHLOROETHANE AT -o- 30°C, -⊙- 35°C & -●- 40°C

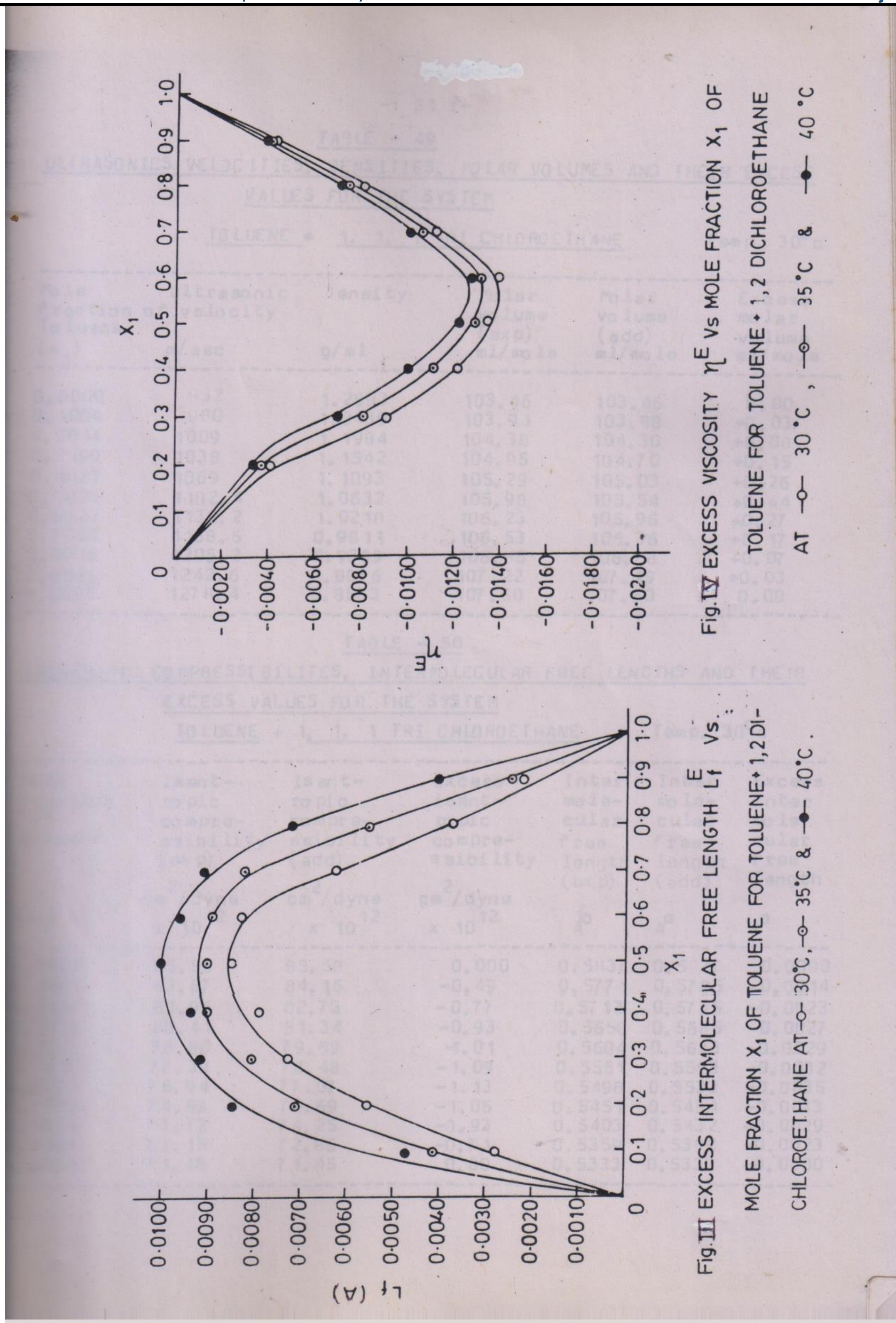

Fig. IV EXCESS VISCOSITY η^E Vs MOLE FRACTION X_1 OF TOLUENE FOR TOLUENE + 1,2 DICHLOROETHANE AT —o— 30°C , —o— 35°C & —●— 40°C

Fig. III EXCESS INTERMOLECULAR FREE LENGTH Lf^E Vs. MOLE FRACTION X_1 OF TOLUENE FOR TOLUENE + 1,2 DI-CHLOROETHANE AT —o— 30°C, —o— 35°C & —●— 40°C .

CONCLUSION

Hence it can be concluded for these studies of ultrasonic velocity , density and viscosity measurement, the excess values of molar volume (Vm^E) , excess available volume (Va^E) excess isentropic compressibility (βs^E), excess intermolecular free length (Lf^E) have been found to be positive, the result shows the presence of weak molecular interaction between the unlike molecule of the binary liquid mixture toluene and 1,2 di chloro ethane at different temperatures 30^0C, 35^0 C and 40^0 C. The negative values of excess viscosity and Nissan's parameter shows different molecular size attributed to the presence of dispersive forces between the mixing components between the toluene and 1,2 di chloro ethane at different temperatures 30^0C, 35^0 C and 40^0 C.

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REFERENCES :

(1) Shakila , A. Srinivasa Krishna, et al. (2020) *Physics Chemistry of Liquids*, Molecular Interaction studies in binary mixtures of tetrahydrofuran with arene substituted alcohols: acoustic and volumetric study, 58(2),267-279.

(2) Bindhani S.K. Roy G.K . et al. (2020) . Russian Journal of Physical Chemistry A. prediction of thermo physical properties of binary liquid mixtures of propiophenone and ethyl acetate at 303.15,308.15 and 313.15K. Vol.94 (1827-1835)

(3) Arunachalam Mathana Gopal Paulraj Padmavathi et al. (2024) journal of ACS Omega. 9 Pseudo-Gruneisen Parameters for Binary Liquid Mixtures at Different Temperatur; 9(17):

(4) Kaur Parminder, Juglan* K. C, et al. (2023) ,Journal of Chemical and Engineering Data , Volumetric and Ultrasonic Studies of PEG200, PEG400, and Ethanol–Chlorhexidine Solutions at Various Temperatures . 68, 5, 1123–1132

(5) Gangwar Vikas.s. Singh Ashish,K. et al. (2017) International Journal of Applied Chemistry Refractive properties of liquid mixture at different temperatures. vol.13(3) 543-553.

(6)Mullainathanand S. Nithiyananthan, E.(2010) J. Chem.Ultrasonic study of molecular study of molecular interactions in binary mixture at 303K‟. Vol.7(2), 353-356,

(7)ZareenaBegaum et al, (2020)Journal of molecular liquids Ultrasonic studies of binary liquid mixtures of anisaldehyde with alkoxyethanols at different Temperatures. vol. 99, 178 - 188,

(8)Rajgopal, K. and Chenthilnath,S.(2010)“Thermochimica Acta
Molecular interaction studies and theortical estimation of ultrasonic speedsof toluene with nitriles at different temperatures”. , 498 (1-2),

(9) Thanuja, B. Charles, Kangam, et al.Kangam et al. (2011). Journal of ultrasonic sonochemistry
Studies on intermolecular interactions on binary mixture of methyl orangewater system, excess molar functions of ultrasonic parameters atdifferent temperatures.
“” Journal of ultrasonic sonochemistry, 18, ,1274-1278

(10) Swetha Sandhya M., Biswas, Piyashi et al. (2019), *Journal of Molecular Liquids* Molecular Interaction studies based on transport, thermodynamic and excess properties of aniline and alkanol mixtures at varying temperatures, 278, pp 219-225 .

(11) Nain AK, et al.. (2008) Journal of Fluid Phase. Molecular interactions in binary mixtures of formamide with 1 butanol, 2 butanol,1,3butaneol at different temperatures , 265 (1-2): pp 46-56,

(12) Gurung Bhoj Bhadur. Roy Mahendra Nath (2006). Journal of Solution Chemistry, Study of densities, viscosities and ultrasonic speeds of binary mixtures containing 1,2 diethoxy ethane with alkane 1-ol at 298.15 K. Vol. 35, (1587-1606).

(13) Zareena Begaum et al. (2013). Journal of Molecular Liquids, Thermodynamic, ultrasonic studies or binary liquid mixtures of anisaldehyde with akoxy ethanols at different temperatures. volume 178, pp. (99 -112).

(14) Thanuja B, Charles Kanagam, et al. (2011). Journal of Ultrasonics Sonochemistry, Studies on intermolecular interactions on binary mixtures of methyl orange – water system. Excess molar functions of ultrasonic parameters at different temperatures. vol.18: (1274–1278).

(15) Baragi .Jagdish G. , Maganur Seema , et al. (2013)Journal of Molecular Liquid Excess of molar volumes and efractive indices of binary liquid mixtures of acetyl acetone with n-nonane, n-decane at 25ºC,30ºC,35ºC. vol. 178, (175-177).

(16) Raj kumar and Singh Y.P.(2017) International journal of research in applied, natural and social sciences Intermolecular interaction in binary liquid mixture by ultrasonic measurements ” vol.5(6), (31-38),

(17) Ratnam M.V. , Reema T.Sayed et al. (2012) Journal of Molecular Liquids. Molecular interaction study of binary mixtures of methyl benzoate, viscometric and ultrasonic study vol.166 ,(9-16).

(18) Dubey Gyan Prakash , Kishan Kumar. (2011) Journal of Thermochimica. Acta mixtures thermodynamic properties of binary liquid of diethylene tri amine with alcohols a t different temperatures Vol. 524 (7), (1-2) .

(19) Kumar S, Jeevandham P.(2012) Journal of Molecular Liquids Densities, viscoties and excess properties of aniline and o - anisidine with 2 – alkoxy at 303.15^{o}K. Vol. 174, pp(34–41).

(20) Nain. Anil Kumar (2013) Journal of Chemical Thermodynamics Ultrasonic study of molecular interactions in binary mixtures of methyl, acryl ate with 1- alkanols at different temperatures.. Vol. 59 ,(49-64).

(21) Dean JA. Lange's Hand book of chemistry, McGraw Hill, New York; 1987.

(22) David RL. CRC Hand book of chemistry and physics ,CRC Press Florida; 2000