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RESEARCH ARTICLE

Ultrasonic Studies and Densities Measurements in Binary Liquid Mixture of Toluene with 1,2-Dichloroethane at 303.15 K

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Abstract: Ultrasonic studies and densities in binary liquid mixture of toluene with 1, 2- dichloroethane have been measured. Acoustic parameters like isentropic compressibility, intermolecular free length, available volume, molar volume, Nissan's parameter and their excess function have been calculated for this binary liquid mixture at 303.15 K. The corresponding excess functions are a better measure of the extent of interactions present between the component molecules of the system. It is used in so many fields of scientific researches in physics, chemistry, biology, medicines and industry. These properties also provide important information about molecular packing, molecular motion and the chemical nature of the component molecules.

Keywords: Binary mixture, Toluene, 1,2-Dichloroethane, Density, Viscosity, Ultrasonic interferometer

Introduction

In the recent years, a considerable progress has been made in theoretical understanding of liquid-liquid binary mixture. The ultrasonic studies find extensive applications as sound speed intrinsically related with many parameters which characterized the physico chemical behavior of the liquids and liquid systems. Intermolecular interaction in various binary liquid mixtures at different temperatures have been studied by several authors[1-4]. Besides the theoretical importance, the knowledge of physicochemical properties of binary mixtures is indispensable for many chemical process industries, examples are the petroleum, petrochemical *etc*., are commonly used in industries where physicochemical processes are involved to handle the mixture of hydrocarbons, alcohols, aldehydes, ketones *etc*. Importantly for accurate designing equipment, it is necessary to know the interaction between the components of mixtures. A considerable progress has been made theoretical understanding of liquid-liquid mixture[5-8]. The thermodynamic studies of binary solutions have attracted much attention of scientists and experimental data on a number of systems are available for review and publications[9-22].

In the frame work of a research work, which aims to study the ultrasonic study, density, viscosity measurements and the properties derived. These are excellent tools to detect solute-solute and solute-solvent interactions. It is used in so many fields of scientific researches in physics, chemistry, biology, medicines and industry. The present paper deals with the measurement of density, viscosity, speed of sound, molar volume, available volume, isentropic compressibility, intermolecular free length, Nissan's parameter and their excess values of binary liquid mixture toluene and 1,2-dichloroethane at 303.15 K. This technique using ultrasonic instrument is in the tremendous use in measuring the rate of flow of blood through the human body and getting images of vital organs of the body like kidney, liver, blood vessel, foetus *etc*.

Experimental

Both toluene and 1,2-dichloroethane were obtained from E-Merck. They were purified by the recommended method. The weighing was done on an electronic balance with precision ±0.1 mg. The density of pure liquid and mixtures were measured using precalibrated bicapillary pyknometer with an accuracy 0.053%. The viscosities of binary liquid mixture were measured by Ostwald viscometer designed properly to minimize the loss of liquid components through vaporization. Ultrasonic velocity was measured by multi frequency ultrasonic interferometer model (M-84) at 2 M Hz frequency and data were accurate up to ±0.04%. All measurement was made in a thermostatically controlled water bath with temperature accuracy of ±0.1 ^{o}C. The purity of components was ascertained by comparing the boiling points and density of pure components with those reported in literature[23,24].

The volume of mixing of binary mixture is given by

$$Vm = V - X_1V_1 - X_2V_2 \quad (1)$$

Where V is molar volume, V_1 and V_2 are molar volume of pure components and X_1 and X_2 are mole fractions of the components 1 and 2. Excess volume (V^E) of binary liquid mixture of varying composition was calculated using relations

$$V^E = V^{obs} - V^{id} \quad (2)$$

Where V^{obs} is the experimental value of volume of binary liquid mixture

$$V^{obs} = M_1X_1 + M_2X_2 /\rho \quad (3)$$

'ρ' is the measured density of binary liquid mixture of given composition. V^{id} refers to the value for ideal binary mixture.

$$V^{id} = X_1V_1+X_2V_2 =X_1M_1 / \rho_1 + X_2M_2 / \rho_2 \quad (4)$$

Where M_1 and M_2 are molar masses and ρ_1 and ρ_2 are densities of component liquid in pure state X_1 and X_2 are mole fractions of first and second component. Thermodynamic properties like isentropic compressibility (βs) and inter molecular free length (Lf) are calculated using following relations

$$\beta s = 1/u^2\rho \quad (5)$$

$$Lf = K / u\ \rho^{1/2} \quad (6)$$

Where 'K' is temperature constant, 'u' is speed of sound and ρ is the density of liquid. Available volume may be calculated as

$$Va = \rho\ [Vm - u/u_\infty] \quad (7)$$

Where Vm is molar volume, 'u'is speed of sound of the liquid, 'u_∞' is the speed of sound at infinity, which is equal to1600 m/s.

$$\text{Nissan's parameter (d)} = L n\eta^{E} / X_1X_2 \quad (8)$$

'η^{E}' is the excess value of viscosity, X_1 and X_2 are the mole fractions of the liquid 1and 2.

Results and Discussion

The various experimental results of acoustic parameters are shown in table[1-4] . Deviation in the properties demonstrated that their exist a molecular interaction between unlike molecule of the liquid mixture. These may be attributed to the change in the adhesive and cohesive forces, the experimental values of ultrasonic speeds, densities, molar volumes and their excess values for the system of toluene and 1,2- dichloroethane at 303.15 K (Table 1). Table 2 shows isentropic compressibility intermolecular free length and their excess value for the system at 303.15 K. Table 3 presents available volume and their excess values for the system at 303.15 K. Table 4 shows the viscosity and their excess values , Ln η^{E} (Logarthem of excess value of viscosity) and Nissan's parameter (d) for the system at 303.15 K.

Table 1. Ultrasonic velocities, densities, molar volumes and their excess values for the system toluene + 1,2- dichloroethane at 303.15 K

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

Table 2. Isentropic compressibilities, inter molecular free lengths and their excess values for the system toluene +1,2- dichloroethane at 303.15 K

Mole fraction of toluene X_1	Isentropic compressibility (exp) cm^2/dyne x10^{12}	Isentropic compressibility (add)cm^2/dyne x 10^{12}	Excess isentropic compressibility cm^2/dyne X10^{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

Table 3. Available volumes and their excess values for the system toluene + 1,2- dichloro-ethane at 303.15 K

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

Table 4. Viscosities and their excess values, $\ln\eta^e$ and nissan's parameter (d) for the system toluene + 1,2-dichloroethane at 303.15 K

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

In the system of toluene + 1,2-dichlorloethane mixture, the ultrasonic velocity and molar volumes increase with the increase in mole fractions of toluene (Table 1). However, the density, available volume, isentropic compressibility, intermolecular free length and viscosity decrease under similar condition (Table 2-4). Excess molar volume, excess isentropic compressibility, exces available volume and excess intermolecular free length are all positive under all condition of composition and temperature which shows weak interactions between the molecule of toluene and 1,2-dichloroethane, thus the positive values predict weak interaction involving dispersion forces. Excess value of viscosity and Nissan;s parameter 'd' were found to be negative which also shows the weak interactions between the molecule of toluene and 1,2- dichloroethane at 303.15 K.

Conclusion

The positive value of excess molar volume, excess available volume, excess isentropic compressibility and intermolecular free length shows the presence of weak molecular interactions between the unlike molecules of the binary liquid mixture (Toluene + 1,2-dichloroethane) at the temperature 303.15 K. Where the negative value of logarithm value

of excess viscosity and Nissan's parameter (d) also shows the weak interactions between the unlike molecules of the binary liquid mixture (Toluene + 1, 2-dichloroethane) at the temperature 303.15 K.

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