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ULTRASONIC ANALYSIS OF EXCESS PARAMETERS OF BINARY MIXTURES OF DMSO WITH 1-OCTANOL USING ULTRASONIC METHOD AT VARIOUS TEMPERATURES

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Abstract- The ultrasonic velocity (U), viscosity (η) and density (ρ) of dimethylsulphoxide with Hexanol-1-ol have been measured at five temperatures from 298.15K to 318.15K. Using derived data, the excess values of adiabatic compressibility (β^E), acoustic impedance (Z^E), free length (L_f^E), free volume (V_f^E), and available molar volume (V_a^E), internal pressure (π_i^E) are also calculated. These observed excess parameters are helpful to explain the strength and characteristics of the interaction in molecule of liquid binary mixture under investigation.

Keywords- ultrasonic velocity, viscosity, density, excess adiabatic compressibility, excess acoustic impedance, excess free length, excess free volume, excess available molar volume, and excess internal pressure.

1. INTRODUCTION

Investigations by ultrasonic technique of liquid mixtures are having vital importance to understanding the intermolecular interaction among molecules of liquid mixture. It is found to be applicable in numerous industrialized and scientific reactions. The works on chemical compounds which are used for medicinal purpose require making the awareness regarding the society with whole characteristics including ultrasonic behaviors. There were huge study regarding molecular interactions had been made in the systems of liquid with the help of different physical methods such as Raman Effect [8], Infrared Radiation (IR) technique [6], [10], NMR technique, Ultraviolet and ultrasonic methods [7]. In current path, an ultrasonic technique has been played an important role to provide the informative aspects with respect to molecular behavior of liquids due to its aptitude of characterizing physio-chemical behaviors of the medium.

Ultrasonic velocity method is one of the active interests, to study the nature of molecular interactions in pure liquids and their mixtures. Physical properties like ultrasonic speed, viscosity and density and their variations with composition as well as with different temperatures of the liquid mixture are useful in chemical industries. The study regarding the changes in above parameters of liquids and liquid mixtures has been found that, there exist outstanding quantitative as well as qualitative technique to carry out the information regarding structure of molecule and also the forces among molecules. Thermo-acoustic and thermo-dynamic property of binary liquid mixtures are of great importance in getting deep information of the molecular interactions.

The liquid mixtures under ultrasonic investigation, consisting of polar and non-polar components and this have great significance for understanding the molecular interaction among the molecules. This investigation has found to be large number of applications in many technical and industrial processes [1], [5]. Variations in ultrasonic speed and other related parameters of liquid binary mixtures have been studied by the researchers. They were made focus on change structure related with liquid mixture of strongly as well as weakly interacting compounds [2], [3]. The study of molecular interactions in binary mixtures in which, alcohol is one of the components of particular interest, because strong self-association is presented in alcohol. Also, they are having 3-D network of hydrogen bonding and they can easily correlate with any other group with equivalent extent of polar attractions [4], [9], [11], [12].

Study of dimethylsulphoxide has become important because of its utilization in wide range of applications in medicine. It easily penetrates the biological membrane as well as facilitating chemical transport in the biological tissue. Also, the use of dimethylsulphoxide is well established, as an anti-inflammatory agent, which is commonly used in arthritic condition. Dimethylsulphoxide also utilized as free radical scavenger in various cancer treatment. Due to unique property of dimethylsulphoxide, gives rise to its broad use as a solvent as described by Thirumaran *et al.* [13]. Octanol is a straight chain fatty alcohol with eight carbon atoms. Therefore in order to have a clear understanding of the intermolecular interactions between the component molecules, a thorough study on the binary liquid mixtures (DMSO + 1-Octanol) using ultrasonic velocity, density and viscosity data has been performed at temperatures 303.15K, 308.15K, 313.15K and 318.15K.

In the present study several acoustic parameters and their excess values of a binary system of dimethylsulphoxide with 1-Octanol have been reported using the experimental values of density, viscosity and ultrasonic velocity of the binary liquid mixture.

In order to understand the nature of molecular interactions between the components of the liquid mixtures, it is of interest to discuss the same in terms of excess parameter rather than actual values. Non-ideal liquid mixtures show considerable deviation from linearity in their physical behavior with respect to concentration and these have been interpreted as arising from the presence of strong or weak interactions. The effect of deviation depends upon the nature of the constituents and composition of the mixtures. The variation in excess values of adiabatic compressibility, acoustic impedance, free length, free volume, internal pressure and available volume are tabulated in tables: 1- 4.

2. TABLES AND GRAPHS

Table -1: The Excess values of adiabatic compressibility (β^E), acoustic impedance (Z^E), free length (L_f^E), free volume (V_f^E) and available volume (V_a^E) of DMSO + 1-Octanol 303.15K

Mole fraction of DMSO	β^E $\times10^{-10}$ ms^2 kg^{-1}	Z^E $\times10^6$ kg m^{-2}s^{-1}	L_f^E $\times10^{-9}$m	V_f^E $\times10^{-6}$ (ml)	π_i^E ($\times10^3$ Nm^{-2})	V_a^E $\times10^{-6}$ (ml)
0.0000	-0.0005	-0.0001	-0.0003	0.0000	0.000	0.000
0.1434	0.6834	0.0018	0.0453	-0.1300	-0.581	-0.029
0.2736	0.8544	-0.0502	0.0527	-0.2491	-0.862	-0.030
0.3923	0.7592	-0.0886	0.0445	-0.9526	-0.602	-0.031
0.5011	0.6213	-0.1212	0.0336	-1.0098	-0.781	-0.022
0.6010	0.5212	-0.1495	0.0250	-0.4610	-1.146	-0.010
0.6932	0.3722	-0.1507	0.0154	-0.7494	-0.969	-0.006
0.7785	0.2446	-0.1369	0.0080	-0.8633	-0.777	-0.001
0.8577	0.1525	-0.1105	0.0035	-0.2799	-0.737	0.008
0.9313	0.0742	-0.0680	0.0009	0.3458	-0.578	0.004
1.0000	-0.0001	-0.0004	-0.0005	0.0000	0.000	0.000

Table -2: The Excess values of adiabatic compressibility (β^E), acoustic impedance (Z^E), free length (L_f^E), free volume (V_f^E) and available volume (V_a^E) of DMSO + 1-Octanol 308.15K

Mole fraction of DMSO	β^E $\times10^{-10}$ ms^2 kg^{-1}	Z^E $\times10^6$ kg m^{-2}s^{-1}	L_f^E $\times10^{-9}$m	V_f^E $\times10^{-6}$ (ml)	π_i^E ($\times10^3$ Nm^{-2})	V_a^E $\times10^{-6}$ (ml)
0.0000	0.0000	-0.0002	0.0004	0.0000	0.000	0.000
0.1434	0.7135	0.0025	0.0476	-0.2522	-0.349	-0.034
0.2736	0.8931	-0.0482	0.0554	-0.3669	-0.671	-0.039
0.3923	0.7858	-0.0841	0.0466	-1.2218	-0.393	-0.047

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0.5011	0.6584	-0.1177	0.0360	-1.3054	-0.586	-0.036
0.6010	0.5429	-0.1442	0.0266	-0.5689	-1.015	-0.021
0.6932	0.3781	-0.1439	0.0162	-0.8621	-0.867	-0.010
0.7785	0.2596	-0.1321	0.0092	-0.9248	-0.748	-0.005
0.8577	0.1691	-0.1075	0.0047	-0.3205	-0.702	0.007
0.9313	0.0932	-0.0668	0.0022	0.2697	-0.501	0.004
1.0000	-0.0002	-0.0003	-0.0004	0.0000	0.000	0.000

Table -3: The Excess values of adiabatic compressibility (β^E), acoustic impedance (Z^E), free length (L_f^E), free volume (V_f^E) and available volume (V_a^E) of DMSO + 1-Octanol at 313.15K

Mole fraction of DMSO	β^E $\times10^{-10}$ ms^2 kg^{-1}	Z^E $\times10^6$ kg m^{-2}s^{-1}	L_f^E $\times10^{-9}$m	V_f^E $\times10^{-6}$ (ml)	π_i^E ($\times10^3$ Nm^{-2})	V_a^E $\times10^{-6}$ (ml)
0.0000	-0.0002	-0.0004	-0.0003	0.0000	0.000	0.000
0.1434	0.7436	0.0030	0.0489	-0.3738	-0.201	-0.044
0.2736	0.9117	-0.0449	0.0564	-0.5784	-0.439	-0.056
0.3923	0.8102	-0.0825	0.0478	-1.5950	-0.219	-0.067
0.5011	0.6670	-0.1138	0.0365	-1.6149	-0.422	-0.056
0.6010	0.5682	-0.1424	0.0278	-0.5995	-0.930	-0.033
0.6932	0.4016	-0.1424	0.0174	-0.9225	-0.809	-0.020
0.7785	0.2569	-0.1282	0.0092	-1.0224	-0.700	-0.009
0.8577	0.1641	-0.1042	0.0047	-0.3507	-0.651	0.007
0.9313	0.0755	-0.0628	0.0016	0.1348	-0.444	0.004
1.0000	-0.0005	-0.0002	-0.0003	0.0000	0.000	0.000

Table -4: The Excess values of adiabatic compressibility (β^E), acoustic impedance (Z^E), free length (L_f^E), free volume (V_f^E) and available volume (V_a^E) of DMSO + 1-Octanol 318.15K

Mole fraction of DMSO	β^E $\times10^{-10}$ ms^2 kg^{-1}	Z^E $\times10^6$ kg m^{-2}s^{-1}	L_f^E $\times10^{-9}$m	V_f^E $\times10^{-6}$ (ml)	π_i^E ($\times10^3$ Nm^{-2})	V_a^E $\times10^{-6}$ (ml)
0.0000	0.0001	0.0004	0.0005	0.0000	0.000	0.000
0.1434	0.7503	0.0058	0.0503	-0.5530	-0.101	-0.056
0.2736	0.9064	-0.0400	0.0571	-0.7473	-0.283	-0.073
0.3923	0.7830	-0.0748	0.0474	-1.8398	-0.066	-0.087
0.5011	0.6472	-0.1070	0.0362	-1.9311	-0.298	-0.073
0.6010	0.5506	-0.1359	0.0273	-0.6964	-0.843	-0.045
0.6932	0.4061	-0.1387	0.0177	-1.0111	-0.733	-0.033
0.7785	0.2695	-0.1265	0.0097	-1.0703	-0.622	-0.020
0.8577	0.1764	-0.1032	0.0050	-0.3879	-0.586	0.006
0.9313	0.0798	-0.0618	0.0015	0.1882	-0.421	0.004
1.0000	-0.0007	-0.0001	-0.0001	-0.0002	0.000	0.000

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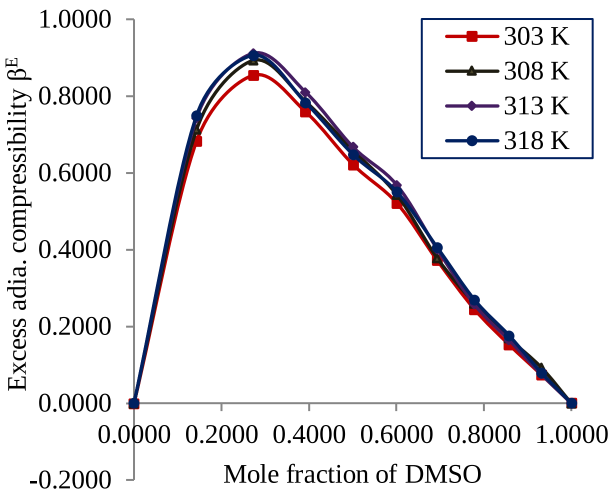

Fig.-1: Plot of Excess Adiabatic compressibility versus Mole fraction of DMSO

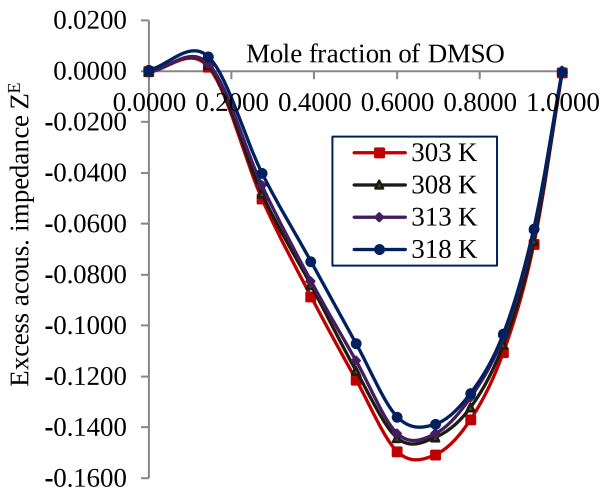

Fig.-2: Plot of Excess Acoustic impedance versus Mole fraction of DMSO

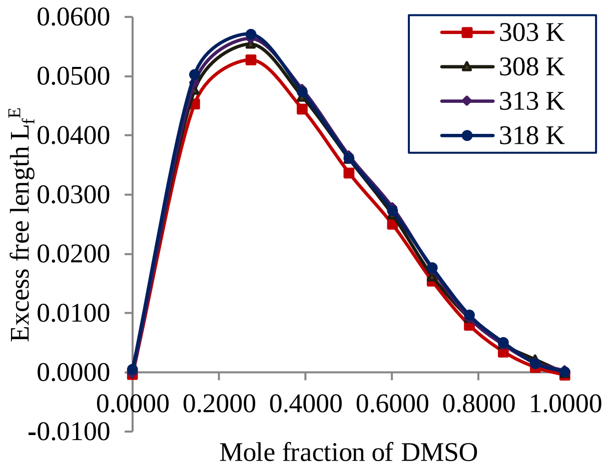

Fig.-3: Plot of Excess Free length versus Mole fraction of DMSO

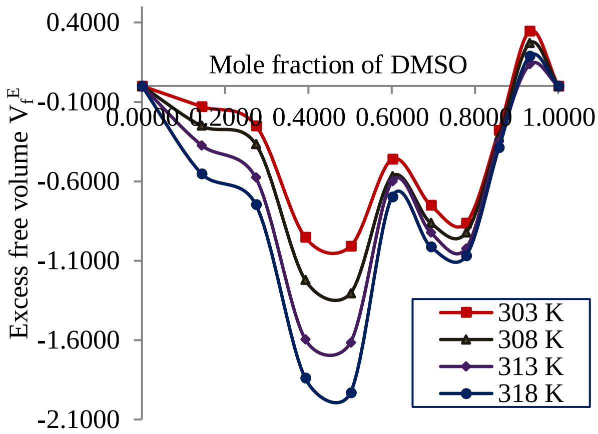

Fig.-4: Plot of Excess Free volume versus Mole fraction of DMSO

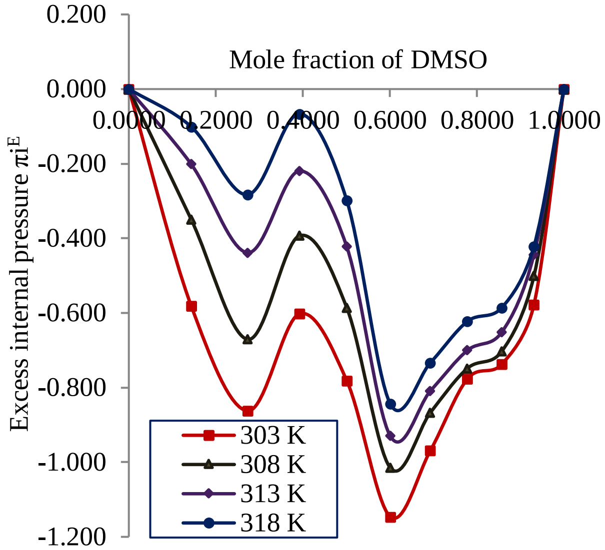

Fig.-5: Plot of Excess Internal pressure versus Mole fraction of DMSO

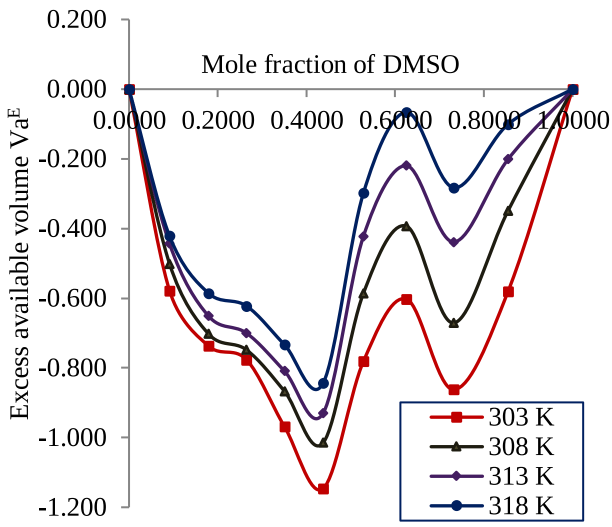

Fig.-6: Plot of Excess Available volume versus Mole fraction of DMSO

3. RESULTS AND DISCUSSION-

From table: 1- 4 and Fig.1, it has been observed that adiabatic compressibility (β^E) has positive values that correspond to the existence of dispersive forces. The positive values of excess adiabatic compressibility are taken to indicate structure breaking tendency due to hetero-molecular interaction between the component molecules of the mixtures [14]. The shape and size of the molecules in the mixture are loosely packed which is due to the positive excess adiabatic compressibility. The positive deviation in excess adiabatic compressibility in binary liquid system has been attributed to dispersive forces that show weak interaction between the unlike molecules. Excess adiabatic compressibility is larger at around 0.2736 mole fraction of DMSO in 1-octanol indicating the attractive and repulsive forces between the components of the binary mixture.

Excess values of acoustic impedance (Z^E) are throughout negative as shown in table: 1- 4 and Fig.1, in all composition of DMSO and at all temperatures that result the possibility of the presence of weak attractive forces between the components of molecules of binary liquid mixtures. It has minimum value at 0.6010 mole fraction of DMSO in 1-octanol implies the independent internal motion among them. The values of excess free length (L_f^E) are positive as shown in table: 1-4 and Fig.3. These positive values of excess free length indicate the existence of molecular interaction in the mixture and should be attributed to the dispersive forces. Excess free length is greater at 0.3923 mole fraction of DMSO indicating the behaving of attractive and repulsive forces between the components in the mixture.

The values of excess free volume (V_f^E) are found to be negative as shown in table: 1-4 and Fig.4 which indicates the existence of strong interaction in the liquid mixtures. The negative values of excess internal pressure (π_i^E) with composition of DMSO are shown in Fig.5. This negative value of excess internal pressure shows that the strength of molecular interactions decreases gradually as the concentration of DMSO increases in the mixtures. The negative values of excess internal pressure indicate that there is only dispersion and dipolar forces are operating with complete absence of specific interaction. The values of excess available volume (V_a^E) as shown in table: 1-4 and Fig.6 are throughout negative. It is observed from the study of Fort and Moore [14], when interaction occurs between the molecules of the two species, the excess available volume becomes negative. This is due to the closer approach of unlike molecules. The variation in negative values of excess free volume, internal pressure and available volume are due to the structural changes in the binary mixtures.

4. CONCLUSION-

From this research work, it is come to conclusion that, week interaction between dipoles as well as dipole-induced-dipole forces dominates, which turns into presence of very less interactions in current study. Dispersive forces are also present among the molecules in binary solutions. Acoustic

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impedance has excess negative values, so it suggests weak interaction among molecule. Extra value of adiabatic compressibility's and intermolecular free length are found to be positive again showing weak interaction.

In the present investigation it was found that, in binary system the values of excess adiabatic compressibility's (β^E) and free length among molecules (L_f^E) are positive over the entire composition which suggests weak interaction between unlike molecules and it is because of presence of dispersive forces. Further the interactions among dissimilar molecules mainly break hydrogen bonding structure which is the main cause of positive excess compressibility. It is seen that, the values of excess acoustic impedance (Z^E) show negative nature above whole combination in total five systems. These negative values of excess acoustic impedance (effective resistance) recommend weak interactions between constituent molecules. Excess internal pressure (π_i^E) has negative values over entire five binary mixtures. Hence, it obviously confirms the presence of molecular association among dissimilar molecules. The evaluated excess parameters clearly point out and support the presence of weak interaction among liquid solutions for investigation. From the present study, the minimum interactions can be confirmed from complete range of compositions between binary systems. It is found that as temperature increases, rate of interaction decreases which shows weak interaction in the present system.

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