STUDY OF EXCESS PARAMETERS OF BINARY MIXTURES OF DMSO WITH HEXANOL-1-OL USING ULTRASONIC METHOD AT VARIOUS TEMPERATURES

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Abstract:
The viscosity**(η),** density(ρ) and ultrasonic velocity(U) of Dimethylsulphoxide with Hexanol-1-ol have been measured at five temperatures from 298K to 318K. Using above 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 evaluated. These observed excess parameters are helpful to explain the strength and characteristics of the interaction in molecule of liquid binary mixture under investigation.

Keywords—excess internal pressure, excess free length, ultrasonic velocity.

1. INTRODUCTION

Investigations by ultrasonic technique of liquid mixtures are having vital importance to understanding the intermolecular interaction among molecules of component. 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 was vast study regarding molecular interactions had been made in the systems of liquid with the help of different physical methods such as Raman Effect [1], Infrared Radiation (IR) technique [2], [3], NMR technique, Ultraviolet and ultrasonic methods [4]. 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 [5], [6]. 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 [7], [8]. 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 [9], [10], [11], [12].

Study of dimethyl Sulphoxide 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. DMSO is well known due to its Cryo-protective effects on biological systems. Also, the use of dimethyl Sulphoxide is well established, as an anti-inflammatory agent, which is commonly used in arthritic condition. Dimethyl Sulphoxide also utilized as free radical scavenger in various cancer

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treatment. Due to unique property of dimethyl Sulphoxide, gives rise to its broad use as a solvent as described by Thirumaran et al. [13]. In the present research work binary liquid system such as dimethyl Sulphoxide + hexan-1-ol, of entire mole fractions of dimethyl Sulphoxide with five different temperatures like 298K, 303K, 308K 313K and 318K have been taken for the investigation to calculate various excess parameters.

2. TABLES AND FIGURES

Table -1: The Excess values of adiabatic compressibility (β^E), acoustic impedance (Z^E), free length (L_f^E), relaxation time (τ^E), free volume (V_f^E) and available volume (V_a^E) of DMSO + 1-Hexanol at 298^{0}K

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	0.000	0.000	0.000	0.000	0.000	0.000
0.1864	0.546	-0.012	0.037	0.191	0.039	-0.298
0.3401	0.666	-0.057	0.042	0.331	-0.242	-0.400
0.4691	0.610	-0.099	0.037	-0.002	-0.279	-0.423
0.5788	0.475	-0.129	0.027	0.253	-0.675	-0.426
0.6734	0.338	-0.145	0.017	0.099	-0.756	-0.399
0.7557	0.189	-0.146	0.008	0.027	-0.806	-0.379
0.8279	0.096	-0.132	0.002	0.109	-0.808	-0.303
0.8919	0.049	-0.107	0.000	-0.307	-0.471	-0.207
0.9489	-0.025	-0.055	-0.003	-0.542	-0.086	-0.135
1.0000	0.000	0.000	0.000	0.000	0.000	0.000

Table -2: The Excess values of adiabatic compressibility (β^E), acoustic impedance (Z^E), free length (L_f^E), relaxation time (τ^E), free volume (V_f^E) and available volume (V_a^E) of DMSO + 1-Hexanol at 303^{0}K

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	0.000	0.000	0.000	0.000	0.000	0.000
0.1864	0.569	-0.011	0.037	0.430	-0.038	-0.306
0.3401	0.694	-0.056	0.043	0.469	-0.209	-0.416
0.4691	0.592	-0.093	0.037	-0.236	-0.093	-0.472
0.5788	0.473	-0.124	0.027	0.376	-0.624	-0.461
0.6734	0.346	-0.142	0.017	0.128	-0.681	-0.421
0.7557	0.205	-0.144	0.008	0.135	-0.771	-0.388
0.8279	0.091	-0.127	0.002	0.254	-0.785	-0.323
0.8919	0.040	-0.103	-0.001	-0.101	-0.536	-0.225
0.9489	-0.027	-0.053	-0.003	-0.585	-0.099	-0.139
1.0000	0.000	0.000	0.000	0.000	0.000	0.000

Table -3: The Excess values of adiabatic compressibility (β^E), acoustic impedance (Z^E), free length (L_f^E), relaxation time (τ^E), free volume (V_f^E) and available volume (V_a^E) of DMSO + 1-Hexanol at 308^{0}K

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	0.000	0.000	0.000	0.000	0.000	-0.829
0.1864	0.536	-0.007	0.036	0.452	0.040	-0.700
0.3401	0.691	-0.053	0.044	0.700	-0.194	-0.627
0.4691	0.615	-0.093	0.037	-0.414	-0.021	-0.625
0.5788	0.474	-0.122	0.027	0.727	-0.628	-0.548

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0.6734	0.343	-0.140	0.017	0.083	-0.590	-0.538
0.7557	0.215	-0.144	0.008	0.228	-0.718	-0.509
0.8279	0.088	-0.127	0.001	0.385	-0.740	-0.483
0.8919	0.016	-0.099	-0.003	-0.329	-0.437	-0.480
0.9489	-0.045	-0.051	-0.005	-0.715	-0.109	-0.469
1.0000	0.000	0.000	0.000	0.000	0.000	-0.435

Table -4: The Excess values of adiabatic compressibility (β^E), acoustic impedance (Z^E), free length (L_f^E), relaxation time (τ^E), free volume (V_f^E) and available volume (V_a^E) of DMSO + 1-Hexanol at 313^0K

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	0.000	0.000	0.000	0.000	0.000	0.000
0.1864	0.579	-0.010	0.039	0.635	0.047	-0.368
0.3401	0.721	-0.055	0.045	0.564	-0.067	-0.488
0.4691	0.643	-0.094	0.039	-0.744	0.048	-0.531
0.5788	0.516	-0.124	0.029	0.930	-0.548	-0.518
0.6734	0.350	-0.139	0.018	0.111	-0.530	-0.496
0.7557	0.218	-0.143	0.009	0.925	-0.760	-0.442
0.8279	0.106	-0.129	0.002	0.418	-0.656	-0.365
0.8919	0.019	-0.099	-0.002	-0.530	-0.381	-0.277
0.9489	-0.029	-0.054	-0.004	-1.040	0.030	-0.165
1.0000	0.000	0.000	0.000	0.000	0.000	0.000

Table -4: The Excess values of adiabatic compressibility (β^E), acoustic impedance (Z^E), free length (L_f^E), relaxation time (τ^E), free volume (V_f^E) and available volume (V_a^E) of DMSO + 1-Hexanol at 318^0K

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	0.000	0.000	0.000	0.000	0.000	0.000
0.1864	0.576	-0.009	0.039	0.924	0.077	-0.409
0.3401	0.731	-0.054	0.046	1.165	-0.070	-0.533
0.4691	0.655	-0.093	0.039	-0.380	-0.044	-0.575
0.5788	0.511	-0.122	0.029	1.498	-0.466	-0.570
0.6734	0.363	-0.139	0.018	0.410	-0.472	-0.530
0.7557	0.205	-0.139	0.008	1.490	-0.658	-0.483
0.8279	0.089	-0.124	0.001	0.855	-0.582	-0.399
0.8919	0.011	-0.097	-0.003	-0.443	-0.365	-0.300
0.9489	-0.037	-0.053	-0.004	-1.461	-0.076	-0.177
1.0000	0.000	0.000	0.000	0.000	0.000	0.000

Figure1: Graph of excess adiabatic compressibility against mole fraction of DMSO

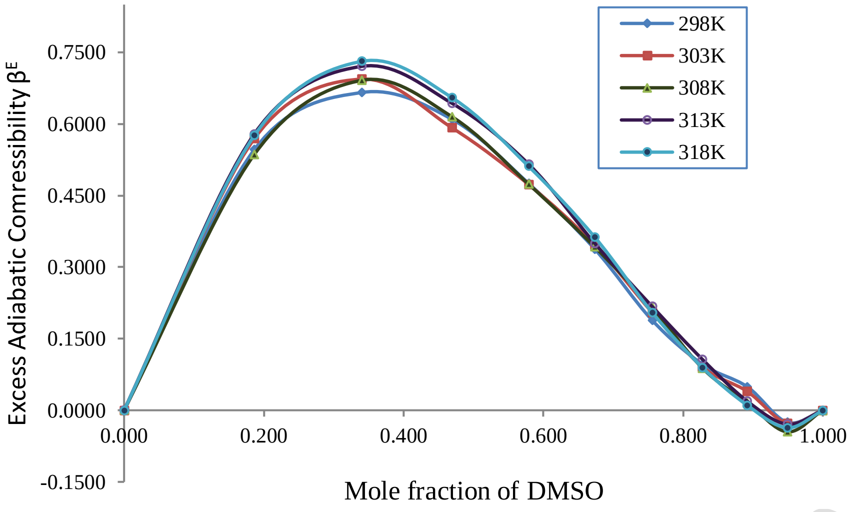


Figure2: Graph of excess acoustic impedance against mole fraction of DMSO

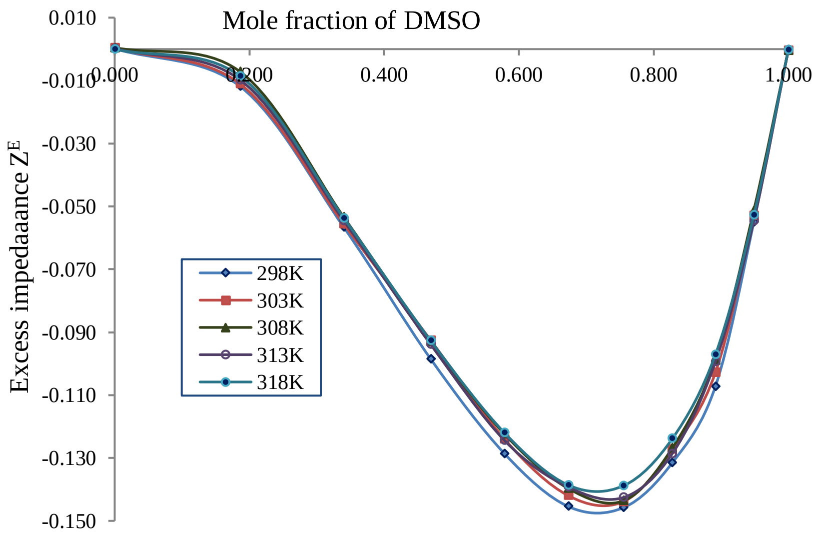


Figure3: Graph of excess free length against mole fraction of DMSO.

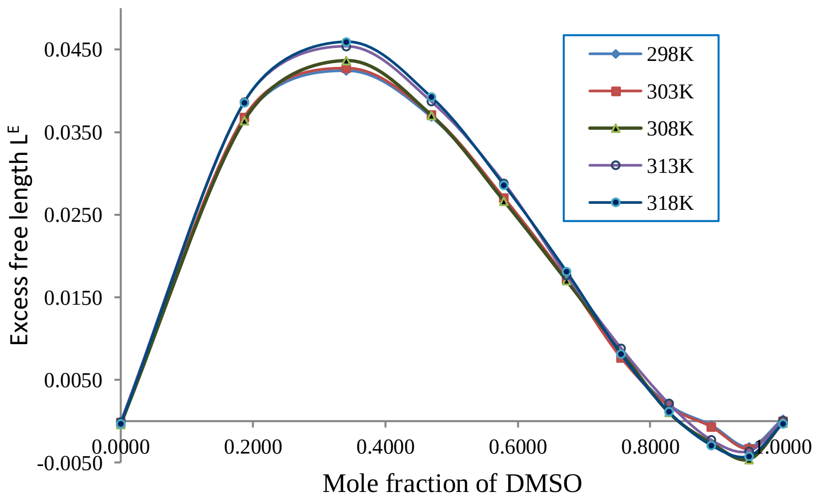


Figure4: Graph of excess free volume against mole fraction of DMSO.

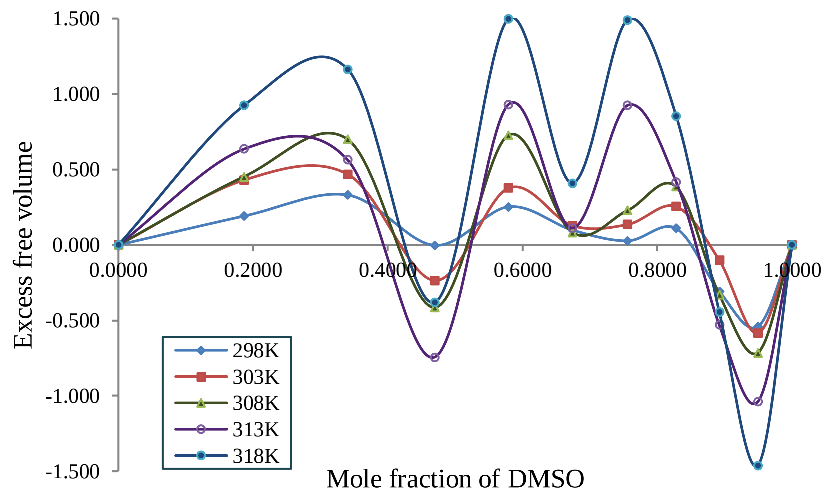


Figure5: Graph of excess internal pressure against mole fraction of DMSO.

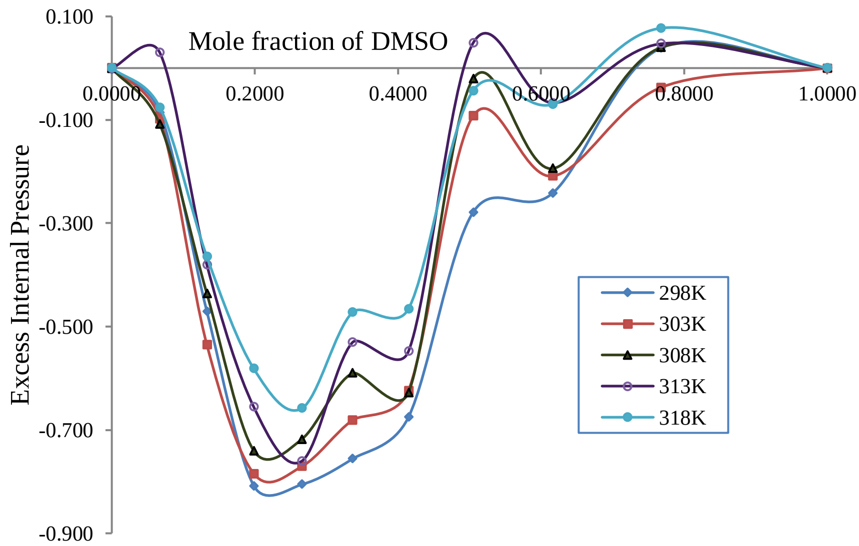
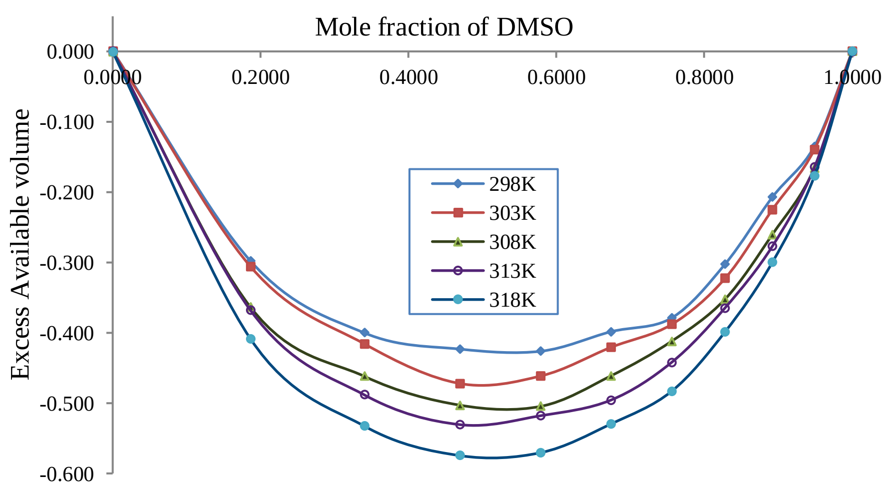


Figure6: Graph of excess available volume against mole fraction of DMSO.



3. RESULT AND DISCUSSION—

The small values of excess adiabatic compressibility as revealed in Table-1-5 and

Fig.1 perhaps qualified the survival of minimum deviation as well as dipolar interaction among the dissimilar molecules. This specifies that, combined structure is less compressible as compared to the standard solution. It also recommends that, the positive excess compressibility is due to the loosely packed molecules. This results into the weak interaction among unlike molecules. The value of excess adiabatic compressibility is observed maximum at 0.3401 mole fraction of DMSO with 1-hexanol. This indicates the behavior of attractive and repulsive forces among the components of binary mixture.

From Table-1-5 and Fig.2, it is examine that, the values of excess acoustic impedance are throughout negative. Excess acoustic impedance with negative values is in favor of the weak attractive forces among the molecules of binary liquid mixture. Excess acoustic impedance is found to be low near 0.750 mole fraction of dimethyl Sulphoxide with 1-hexanol at all the temperatures. This implies that, there is independent internal motion among them.

Table-1-5 and Fig.3 shows the positive values of excess intermolecular free length, which may be the cause for positive values of excess adiabatic compressibility. There is increase in the values of excess free length with increase in mole fraction of dimethyl Sulphoxide with 1-hexanol. The positive values of excess free length (upto70%) indicate the absence of specific intermolecular reactions in the system. The values of excess free length become negative after 70%, which show that, the molecular interaction is present at higher composition of dimethyl Sulphoxide in the mixture. As there is increase in temperature, the excess free length is also increases. The excess free length is found to be higher at around 0.3401 mole fraction of dimethyl Sulphoxide with 1-hexanol, which indicates that, the behavior of attractive and repulsive forces are strong among the molecules of the binary mixture.

Table-1-5 and Fig.4 shows positive values of excess free volume which indicates the survival of weak interaction among the molecules of the liquid mixture. Excess free volume is observed to be greater near 0.340 mole fraction of dimethyl Sulphoxide with 1-hexanol. This indicates the behavior of attractive and repulsive forces among the molecules of the binary mixture. The values of excess internal pressure are observed negative over entire compositions of dimethyl Sulphoxide with 1-hexanol as shown in Table-1-5 and Fig.5. This suggests that, the weak interaction force is working in the binary system. The excess internal pressure is larger near 0.7505 mole fraction of dimethyl Sulphoxide with 1-hexanol at all temperature. This implies that, independent internal motion is present among the molecules. The value of excess available volume is negative as shown in Table-1-5 and Fig.6 with entire composition of dimethyl Sulphoxide in 1-hexanol. The excess available volume shows minimum at around 0.470 mole fraction of dimethyl Sulphoxide with 1-hexanol suggest the weak interaction among the unlike molecules. It is found that, from the study, as interaction takes place among the molecules between two species, the value of excess available volume turn into negative and this is due to the nearer move toward of dissimilar molecules.

4. CONCLUSION

Hence, it is understandable that, feeble reaction between dipoles as well as dipole-induced-dipole forces dominates, that turns into presence of very less interactions in current study. Dispersive forces are also present among the molecules in binary solutions. Acoustic impedance has excess -ve 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 extra adiabatic compressibilities (β^E) and free length among molecules (L_f^E) values are +ve 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, extra acoustic impedance values (Z^E) show -ve nature above whole combination in total five systems. These negative values of acoustic 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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