Excess Acoustical Properties and Molecular Interactions in Ternary Liquid Mixtures of 3(Meta)Methoxy Phenol, 1 Propanol and n-Hexane at 303 K, 308 K & 313 K using Ultrasonic Techniques

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Abstract**:** ***The Ultrasonic velocity(U), density(ρ), and viscosity(η) have been measured experimentally for the ternary liquid mixtures of 3(meta) methoxy phenol(MMP), 1 propanol and n hexane at various temperatures viz., 303 K, 308 K and 313 K at constant frequency of 2 MHz. for different concentrations ranges from 0.001M to 0.01M. The thermodynamic and acoustical parameters such as adiabatic compressibility(β), Rao constant(R), absorption coefficient (α/f^2), internal pressure(π_i), cohesive energy(CE), free volume(V_f), free length(L_f), acoustic impedence(z), available volume(V_a), viscous relaxation time and Lenard Jones potential were calculated from the experimental data. The various excess properties including excess Ultrasonic velocity, excess acoustic impedence, excess free length, excess adiabatic compressibility, excess free volume and excess internal pressure were also computed. The variation of these excess parameters with respect to concentration and temperatures have been discussed in the light of molecular interaction. The molecular interactions were predicted based on the results obtained for ultrasonic velocities of different concentrations of the ternary mixtures at different temperatures.***

Index Terms: molecular interactions, ultrasonic velocity, ternary liquid mixture, internal pressure, acoustic impedence.

I. INTRODUCTION

The physical or chemical nature and the corresponding strength of the molecular interactions between the components of the ternary liquid mixtures have been successfully investigated by the ultrasonic method [1-3]. These interactions provide better understanding of the molecular structures i.e., whether there is a change with respect to system i.e its structural modifications or distorts the structure of the constituents under the influence of ultrasonic sound. The measurement of ultrasonic velocity suggests the accurate determination of some useful acoustical and thermodynamic parameters and their excess properties which are highly sensitive to molecular interactions in liquid mixtures [4,5]. Thermodynamic and transport properties of binary and ternary mixtures with different organic liquids have been studied by many authors [6]. Although a large number of investigations are carried out in liquid mixtures having cyclohexane (or) benzene as one of the components, it is found that no work has been made so for to measure the ultrasonic velocity of the ternary mixtures of 3 (meta) methoxy phenol (MMP), 1 propanol and n hexane. It is used in wide variety of reactions, including electrophilic substitution, nucleophilic substitution, oxidation and reduction. The meta substituted –OCH3 group in MMP permit us to study the effect of methoxy group in C-3 of the benzene ring on the electrophilic attack because of its electron donating nature. Further 1 propanol possessing high octane number is suitable for engine fuel, however due to its high production cost, it is not used in macro level, this prompted the author to undertake this study and n-hexane, since it is very difficult to deprotonate, is used in the separation techniques, preparation of organolithiums etc..n-hexane is highly inert towards an electrophile or nucleophile at ordinary temperature and being non polar, is not expected to be involved in any strong interaction with the other components of the mixture. However, dispersive types of interactions are possible between them.

II. EXPERIMENTAL

The mixtures (MMP+1 propanol+n hexane) of various concentrations were prepared by taking analytical reagent grade and spectroscopic reagent grade chemicals with minimum assay of 99.9% and obtained from E.Merck Ltd (India). All the component liquids were purified by the standard methods. The density, viscosity, and ultrasonic velocity were measured for various concentrations ranging from 0.001M to 0.01 M at different temperatures viz. 303 K, 308 K, and 313 K keeping constant frequency of 2 MHz. Ultrasonic velocity measurements were made using an ultrasonic interferometer (Model F-81, supplied by M/S Mittal Enterprises, New Delhi) with the accuracy of $\pm 0.1 ms^{-1}$. Water at desired temperature is

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circulated through the outer jacket of the double-walled measuring cell containing the experimental liquid. The densities of the mixture were measured using a 10 ml specific gravity bottle by relative measurement method with an accuracy of ±0.01 kg•m−3. An Oswald viscometer (10 ml) with an accuracy of ±0.001 Ns•m−2 was used for the viscosity measurement. The flow time was determined using a digital racer stopwatch with an accuracy of ±0.1s.

III. THEORY AND CALCULATIONS

Intermolecular free length (Lf), is calculated using the standard expression

$$L_f = K\beta^{1/2} \qquad (1)$$

Where K is a temperature dependent constant known as Jacobson constant and β is the adiabatic compressibility that can be calculated from the speed of sound (U) and the density of the medium (ρ) as

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

The relation for free volume in terms of ultrasonic velocity and the viscosity (η) of liquid as

$$V_f = (M_{eff}U/k\eta)^{1/2} \quad (3)$$

Expression for the determination of internal pressure πi by the use of free volume as

$$\pi_i = bRT(K\eta/U)^{1/2}(\rho^{2/3}/M^{7/6}_{eff}) \quad (4)$$

Where b stands for cubic packing which is assumed to be 2 for liquids and K is a dimensionless constant independent of temperature and nature of liquids and its value is 4.281x109, T is the absolute temperature and Meff is the effective molecular weight.

The viscous relaxation time was obtained using the relation

$$\tau = (4/3)\,\beta\,\eta \qquad (5)$$

Gibbs free energy is calculated from the relation

$$\Delta G = KT\ln(KT\tau/h) \qquad (6)$$

Where τ is the viscous relaxation time, K the Boltzman constant, T the absolute temperature and h is the Planks constant.

The acoustic impedence is given by,

$$Z = U\rho \qquad (7)$$

Where U and ρ are the velocity and density of liquid respectively.

In order to study the non-ideality of the liquid mixtures, namely excess parameters (AE) of all the acoustic parameter were computed by

$$A^E = A_{exp} - A_{ideal} \qquad (8)$$

Where Aid = ∑nAiXi,

Where Ai is any acoustical parameters and Xi is the mole fraction of the liquid components i.e., the excess parameters of the ultrasonic velocity, acoustic impedance, and intermolecular free length were calculated using the equations

$$U^E = u - (x_1u_1 + x_2u_2 + x_3u_3) \qquad (9)$$

$$Z^E = (\rho u) - (x_1u_1\rho_1 + x_2u_2\rho_2 + x_3u_3\rho_3) \qquad (10)$$

$$L_f^E = \frac{k}{(u^2\rho)^{1/2}} - \left[\frac{x_1k}{(u_1^2\rho_1)^{1/2}} + \frac{x_2k}{(u_2^2\rho_2)^{1/2}} + \frac{x_3k}{(u_3^2\rho_3)^{1/2}}\right] \qquad (11)$$

where u and ρ denote the ultrasonic velocity and density for the mixture, u_1u_2 and u_3 and $\rho_1\rho_2$and ρ_3 denote the ultrasonic velocities and densities for the pure components.

k is Jacobson's constant

The values of U^E , Z^E, and L_f^E for each mixture has been fitted to the Redlich–Kister polynomial equation

$$Y^E = x(1-x)\sum_{i=1}^{10} a_i(1-2x)^{i-1} \qquad (12)$$

The values of the coefficients a_i were calculated by the method of least squares along with the standard deviation $\sigma(Y^E)$. The coefficient i is an adjustable parameter for the best fit of the excess functions.

$$\sigma(Y^E) = \left[\frac{\sum(Y_{expt} - Y_{cal})}{n-p}\right]^{1/2} \qquad (13)$$

where n is the number of experimental points, p is the number of parameters, and Y_{expt} and Y_{cal} are the experimental and calculated excess parameters.

The values of V_f^E is calculated using the following relation

$$V_f^E = x_1M_1\left(\frac{1}{\rho} - \frac{1}{\rho_1}\right) + x_2M_2\left(\frac{1}{\rho} - \frac{1}{\rho_2}\right) + x_3M_3\left(\frac{1}{\rho} - \frac{1}{\rho_3}\right) \qquad (14)$$

Where x_1M_1, x_2M_2, x_3M_3 are equimolar solutions and molecular weights of components (MMP,1 propanol and n hexane respectively) and ρ_1 ρ_2 ρ_3 are densities of pure components (MMP,1 propanol and n hexane respectively) and ρ is the density of the system under investigation.

The values of β^E is calculated using the following relation

$$\beta^E = \beta_s - (x_1\beta_1 + x_2\beta_2 + x_3\beta_3) \qquad (15)$$

Where x_1, x_2, x_3, are equimolar solutions, β^E *is the* excess adiabatic compressibility, $\beta_1, \beta_2, \beta_3$ are the adiabatic compressibility of pure components (MMP,1 propanol and n hexane respectively)β_s is the adiabatic compressibility of the mixture.

Similarly excess internal pressures will also be calculated using the following relation.

$$\pi_i^E = bRT(K_\eta/U)^{1/2}\left(\frac{\rho^{2/3}}{M_{eff}^{7/6}}\right) - \left\{\begin{array}{c} bRT\left(\frac{K_\eta}{U_1}\right)^{1/2}\left(\frac{\rho_1^{2/3}}{M_{1\,eff}^{7/6}}\right) \\ +bRT\left(\frac{K_\eta}{U_2}\right)^{1/2}\left(\frac{\rho_2^{2/3}}{M_{2\,eff}^{7/6}}\right) \\ +bRT(K_\eta/U_3)^{1/2}\left(\frac{\rho_3^{2/3}}{M_{3\,eff}^{7/6}}\right) \end{array}\right\} \qquad (16)$$

Where U ρ M are velocity, density and molecular weight of the system respectively.

and $U_1\rho_1$ M_1, $U_2\rho_2$ M_2, $U_3\rho_3$ M_3 are velocity, density and molecular weight of the pure components respectively.

Where Aid = ∑nAiXi, Ai is any acoustical parameters andXi the concentration of the liquid components of I.

IV. RESULTS AND DISCUSSIONS

The experimentally measured values of density, viscosity and ultrasonic velocity for the mixtures at 303 K, 308 K and 313 K are presented in Table-I.

Table-II represents the values of excess properties of acoustic impedence, adiabatic compressibility and free length. Excess values of properties like intermolecular free volume, internal pressure and ultrasonic velocity for the mixtures are depicted in Table-III.

From the Table-I, it was observed that the ultrasonic velocity of the ternary liquid mixtures increases with increasing concentration of the mixture at all the working temperatures which suggests that weak interactions due to dipole-dipole nature of particles while an uneven trend is observed for the viscosity and density with increasing the concentration at all the working temperatures. Also at each particular concentration, the ultrasonic velocity and viscosity decrease while the temperature increases which is due to thermal agitation.

In order to understand more about the nature of interaction between the components of liquid mixtures, it is necessary to discuss the same in terms of excess parameters rather than actual values. They can yield an idea about the nonlinearity of the system as association

or other type of interactions [7]. The calculated values

of normal properties like adiabatic compressibility(β), Rao constant(R), absorption coefficient (α/f2), internal pressure(πi), cohesive energy(CE), free volume(Vf), free length(Lf), acoustic impedence(z), available volume(Va), viscous relaxation time and Lenard Jones potential whose values were tabulated from tables IV to VII respectively for which no detailed discussions were provided in this study.

It can be seen from Table-II, that the excess compressibility is negative over the entire range of concentration for the systems at all the working temperatures. Sridevi et al. [8] suggested that the negative excess compressibility has been due to closely packed molecules which causes strong interaction between the molecules (the corresponding plot is given in Fig 2). Similar conclusions were also arrived by Islam and Quadri [9]. Further the values(magnitude) of βE increases regularly when the temperature increases at each concentration of the mixtures. This property strongly supports the linear behavior of the system. The values of excess inter molecular free length (LEf) are negative. But the magnitude increase with respect to temperature at all the concentrations and hence strong interaction are expected among the molecules (the corresponding plot is given in Fig 3). Once again the same negative trend is followed for the excess acoustic impedence (ZE) which also supports the strong interactions which is mainly due to steric effect of the substituent in the meta position of the benzene ring of the MMP and the formation of hydrogen bonding in between the constituents of the system (the corresponding plot is given in Fig 1). It is also noticed that across the temperature the values(magnitude) of ZE decreases at each and every concentration of the mixture which is due to thermal agitation of molecules present in the mixture.

From the Table III, the negative deviation of excess free volume is an indication of the existence of strong interaction between the components [10] (the corresponding plot is given in Fig 4). The negative excess internal pressure (πiE) over the entire range of concentration of the system also supports the presence of interaction. The internal pressure is one of the significant parameters in the study of thermodynamic properties of liquid mixtures. The internal pressure is the measure of the resultant force of attraction and force of repulsion between the interacting components in the liquid mixtures. The internal pressure is the only tool which depends upon the all types of interactions such as dipole-dipole, dipole - induced dipole interactions and the formation of charge transfer complexes. The values of internal pressure decreases with increases in temperature as well as with increase in concentration which attributed the increase in interaction between the associated molecules. This is because of presence of hydrogen bonding in the system [11] (the corresponding plot is given in Fig 6). The excess ultrasonic velocity shows negative values which reveals a strong interactions are possessed by the system and these values (magnitude) decrease while the temperatures increases irrespective of all the concentrations that may be attributed to the thermal agitations. And at particular temperature the excess ultrasonic velocities increase with increase in concentration which also support the existence of strong interactions among the molecules (the corresponding plot is given in Fig 5).Similar conclusions were also arrived byG.Arulet.al[12].

TABLE I. EXPERIMENTALVALUESOFVELOCITY,VISCOSITYANDDENSITYFORMETA METHOXY PHENOL+1 PROPANOL+n HEXANE

Sl. No.	**Conc. (M) X 10^{-3}**	**Velocity (U) ms^{-1} at**			**Viscosity (η)Nsm^{-2}X10^{-4}at**			**Density (ρ) Kgm^{-3} at**		
		303 K	***308 K***	***313 K***	***303 K***	***308 K***	***313 K***	***303 K***	***308 K***	***313 K***
1	1	1052.15	1024.41	1008.40	5.430	4.637	3.637	780.3	782.4	783.4
2	2	1052.89	1025.12	1008.65	5.467	4.715	3.817	787.7	787.7	788.5
3	3	1054.26	1026.19	1008.91	5.427	4.704	3.803	782.6	782.6	785.7
4	4	1056.58	1027.28	1009.15	5.649	4.773	3.795	787.2	787.2	785.7
5	5	1057.35	1028.36	1009.20	5.924	4.807	3.815	789.4	779.6	788.4

Sl. No.	**Conc. (M) X 10^{-3}**	**Velocity (U) ms^{-1} at**			**Viscosity (η)Nsm^{-2}X10^{-4}at**			**Density (ρ) Kgm^{-3} at**		
		303 K	***308 K***	***313 K***	***303 K***	***308 K***	***313 K***	***303 K***	***308 K***	***313 K***
6	6	1059.14	1029.35	1010.22	5.668	4.871	3.792	784.3	784.3	784.4
7	7	1062.86	1032.81	1012.63	5.658	4.882	3.791	786.1	786.1	784.1
8	8	1064.11	1035.32	1013.44	5.639	4.893	3.799	794.1	781.9	786.2
9	9	1065.46	1036.75	1014.84	5.586	4.947	3.809	789.4	788.4	788.5
10	10	1066.95	1038.52	1015.15	5.583	4.966	3.803	787.2	787.2	785.2

TABLE II.
COMPUTEDVALUES OF EXCESSACOUSTIC IMPETENCE, ADIABATICCOMPRESSIBILITY AND FREELENGTH FORMETA METHOXY PHENOL+1 PROPANOL+n HEXANE

Sl. No.	**Conc. (M) X10^{-3}**	**Excess Acoustic Impedence(Z^E) Kg/(m^{2}s)**			**Excess Adiabatic Compressibility(β^E) x10^{-6}N^{-1}m^2**			**Excess Free length ($L^E{}_f$) (m^3)x10^{-10}**		
		Temperature (K)			***Temperature (K)***			***Temperature (K)***		
		303	***308***	***313***	***303***	***308***	***313***	***303***	***308***	***313***
1	1	433364.2	466661.5	572292.1	-0.211	-0.248	-0.291	-6.35	-6.52	-6.68
2	2	-186666.9	-119986.2	3054.6	-0.451	-0.531	-0.622	-6.06	-6.25	-6.42
3	3	-86890.1	-75272.3	-53270.1	-0.706	-0.831	-0.973	-5.78	-5.99	-6.16
4	4	-138999	-123837	-103269	-0.984	-1.161	-1.362	-5.53	-5.75	-5.93
5	5	-190581	-181224	-146438	-1.290	-1.522	-1.771	-5.30	-5.53	-5.72
6	6	-245137	-222893	-193202	-1.620	-1.910	-2.241	-5.09	-5.33	-5.52
7	7	-287097	-261243	-230924	-1.990	-2.350	-2.740	-4.89	-5.15	-5.33
8	8	-321831	-303615	-264918	-2.400	-2.831	-3.310	-4.71	-4.97	-5.16
9	9	-366660	-334306	-296454	-2.860	-3.370	-3.941	-4.53	-4.81	-5.00
10	10	-405865	-368575	-331771	-3.380	-3.980	-4.652	-4.37	-4.66	-4.85

TABLE III.

COMPUTED VALUES OF EXCESS FREE VOLUME, ULTRASONIC VELOCITY AND INTERNAL PRESSURE FORMETA METHOXY PHENOL+1PROPANOL+n HEXANE.

S. No.	**Conc. (M) X10^{-3}**	**Excess Free Volume(V_f^E) x10^{-8} (m$^{3/}$mol)**			**Excess Ultrasonic Velocity(U^E) (m/s)**			**Excess Internal Pressure (Nm^{-2})x10^{+8}**		
		Temperature (K)			***Temperature (K)***			***Temperature (K)***		
		303	***308***	***313***	***303***	***308***	***313***	***303***	***308***	***313***
1	1	4.97	11.8	27.3	-60.508	-62.467	-51.947	-0.70	-0.79	-0.90
2	2	3.04	7.69	17.2	-93.163	-91.424	-77.226	-1.45	-1.50	-1.47
3	3	2.93	7.42	17.0	-122.418	-117.561	-100.378	-2.17	-2.15	-2.02
4	4	1.79	7.02	17.3	-148.285	-141.511	-121.685	-2.73	-2.70	-2.51
5	5	3.00	6.78	1.70	-173.543	-163.554	-141.533	-3.21	-3.24	-2.94
6	6	1.46	5.94	17.1	-195.861	-183.981	-158.942	-3.85	-3.71	-3.39
7	7	2.30	6.63	17.9	-214.534	-200.414	-173.651	-4.37	-4.16	-3.77
8	8	2.67	6.91	18.1	-234.139	-216.431	-188.784	-4.82	-4.62	-4.12
9	9	2.35	5.80	17.3	-252.259	-232.298	-202.268	-5.30	-4.98	-4.45
10	10	2.95	5.72	17.4	-268.988	-246.712	-215.885	-5.72	-5.35	-4.79

TABLE IV.

CALCULATED VALUES OF ACOUSTIC IMPETENCE, ADIABATIC COMPRESSIBILITY AND FREE VOLUME FOR META METHOXY PHENOL+1 PROPANOL+ n HEXANE.

S.No.	**Conc. (M) X 10^{-3}**	**Acoustic impedence(Z) Kg/(m^{2}s) x10^{+5}**			**Adiabatic Compressibility(β) x10^{-9}N^{-1}m^2**			**Free Volume(V$_f$) x10^{-7} (m^3/mol)**		
		Temperature (K)			***Temperature (K)***			***Temperature (K)***		
		303	***308***	***313***	***303***	***308***	***313***	***303***	***308***	***313***
1	1	8.21	8.01	7.90	1.16	1.22	1.26	3.133	3.82	5.36
2	2	8.29	8.07	7.95	1.15	1.21	1.25	2.332	2.80	3.75
3	3	8.25	8.03	7.93	1.15	1.21	1.25	2.363	2.81	3.77
4	4	8.32	8.09	7.93	1.14	1.20	1.25	2.232	2.75	3.78
5	5	8.35	8.02	7.96	1.13	1.21	1.25	2.081	2.73	3.75
6	6	8.31	8.07	7.92	1.14	1.20	1.25	2.229	2.68	3.79
7	7	8.36	8.12	7.94	1.13	1.19	1.24	2.247	2.68	3.81
8	8	8.45	8.10	7.97	1.11	1.19	1.24	2.262	2.68	3.80
9	9	8.41	8.17	8.00	1.12	1.18	1.23	2.299	2.65	3.79
10	10	8.40	8.18	7.97	1.12	1.18	1.24	2.305	2.64	3.80

TABLE V.

CALCULATED VALUES OF FREE LENGTH, ULTRASONIC VELOCITY AND INTERNAL PRESSURE FOR METAMETHOXYPHENOL+1PROPANOL+n HEXANE.

S.No.	**Conc. (M) X10^{-3}**	**Free Length (L$_f$) (m^3)x10^{-11}**			**Internal Pressure (Nm^{-2})x10^{+8}**		
		Temperature (K)			***Temperature (K)***		
		303	***308***	***313***	***303***	***308***	***313***
1	1	6.75	6.93	7.03	2.89	2.71	2.42
2	2	6.66	6.84	6.95	3.65	3.43	3.12
3	3	6.67	6.85	6.96	3.62	3.41	3.10
4	4	6.64	6.83	6.95	3.70	3.45	3.10
5	5	6.62	6.85	6.94	3.80	3.44	3.12
6	6	6.63	6.82	6.95	3.70	3.47	3.09
7	7	6.60	6.79	6.94	3.69	3.48	3.09
8	8	6.56	6.80	6.92	3.71	3.46	3.10
9	9	6.57	6.76	6.90	3.67	3.50	3.11
10	10	6.57	6.75	6.92	3.66	3.50	3.09

TABLE VI

CALCULATED VALUES OF LENARD JONES POTENTIAL, DELTA G AND COHESIVE ENERGY FOR META METHOXY PHENOL +1 PROPANOL+n HEXANE.

S.No.	**Conc. (M) X10^{-3}**	**Lenard Jones Potential**			**Delta G**			**Cohesive Energy**		
		Temperature (K)			***Temperature (K)***			***Temperature (K)***		
		303	***308***	***313***	***303***	***308***	***313***	***303***	***308***	***313***
1	1	4.522	3.679	3.227	4.602	4.313	3.718	37.451	35.133	31.391
2	2	4.549	3.698	3.233	4.592	4.330	3.833	39.055	36.744	33.352
3	3	4.591	3.729	3.242	4.582	4.335	3.831	38.687	36.496	33.182
4	4	4.666	3.761	3.250	4.664	4.354	3.824	39.648	36.950	33.201
5	5	4.690	3.793	3.247	4.781	4.360	3.829	40.607	36.797	33.331
6	6	4.751	3.823	3.276	4.671	4.409	3.820	39.537	37.172	33.106
7	7	4.872	3.926	3.345	4.640	4.390	3.808	39.604	37.308	33.145
8	8	4.912	4.002	3.367	4.596	4.355	3.802	39.628	37.030	33.107
9	9	4.957	4.044	3.407	4.580	4.394	3.793	39.228	37.380	33.161
10	10	5.008	4.096	3.413	4.576	4.403	3.798	39.209	37.496	33.126

TABLE VII.

CALCULATED VALUES OF AVAILABLE VOLUME, VISCOUS RELAXATION TIME AND ABSORPTION COEFFICIENT FOR META METHOXY PHENOL +1 PROPANOL+n HEXANE.

S. No.	**Conc. (M) X 10^{-3}**	**Available Volume X10^{-5}**			**Viscous Relaxation Time X10^{-13}**			**Absorption Coefficient X10^{-14}**		
		Temperature (K)			***Temperature (K)***			***Temperature (K)***		
		303	***308***	***313***	***303***	***308***	***313***	***303***	***308***	***313***
1	1	4.472	4.698	4.810	8.381	7.550	6.087	1.57	1.45	1.19
2	2	3.653	3.839	3.945	8.352	7.595	6.344	1.56	1.46	1.24
3	3	3.668	3.857	3.957	8.323	7.610	6.340	1.56	1.46	1.24
4	4	3.631	3.827	3.955	8.572	7.661	6.324	1.60	1.47	1.24
5	5	3.616	3.809	3.942	8.944	7.678	6.335	1.67	1.47	1.24
6	6	3.627	3.827	3.955	8.593	7.815	6.316	1.60	1.50	1.23
7	7	3.594	3.795	3.940	8.498	7.763	6.287	1.58	1.48	1.22
8	8	3.550	3.740	3.924	8.363	7.665	6.273	1.55	1.46	1.22
9	9	3.562	3.753	3.903	8.317	7.774	6.254	1.54	1.48	1.22
10	10	3.562	3.752	3.918	8.302	7.799	6.266	1.53	1.48	1.22

Fig. 1 Plot between conc.(M)x10^{-3} VsExcess Acoustic Impedence(Kg/m^2s)at different temperatures

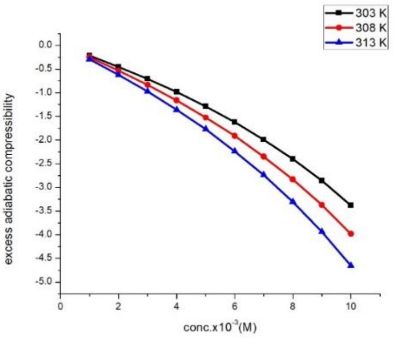


Fig.2 Plot between conc.(M)x10^{-3} VsExcess adiabatic compressibilityx10^{-6}($N^{-1}m^2$)at different temperatures

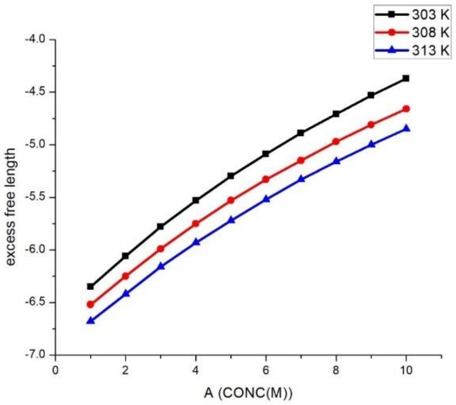
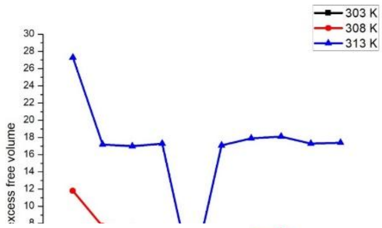
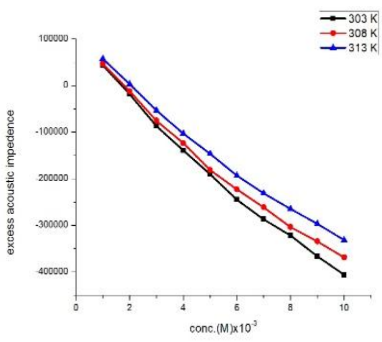


Fig. 3 Plot between conc.(M)x10^{-3} VsExcess free length (m^3)x10^{-10} at different temperatures



$)^{-3}$ VsExcess free volumex10^{-8} ($m^{3/}$mol)at



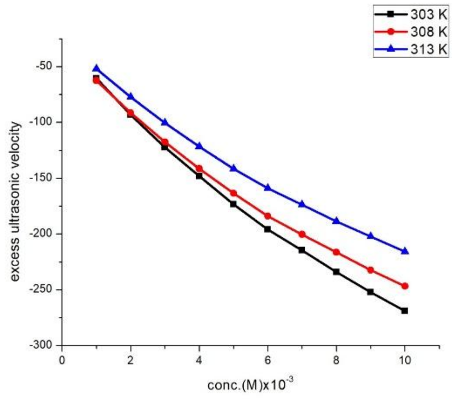


Fig. 5 Plot between conc.(M)x10^{-3} VsExcess ultrasonic velocity(m/s) at different temperatures

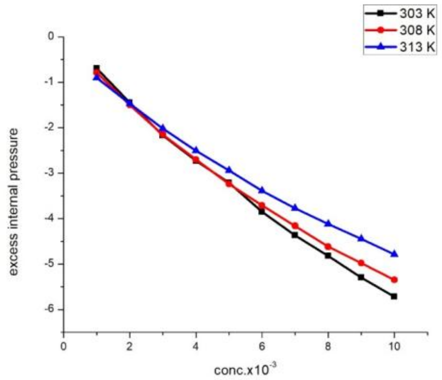


Fig. 6 Plot between conc.(M)x10^{-3} VsExcess internal pressure (Nm^{-2})x10^{+8}at different temperatures

V. CONCLUSION

It is concluded that a strong forces of interactions are expeced due to dipole-dipole,dipole-induced dipole and presence of hydrgen bonding among the components present in the system. Thermal agitation plays a vital role in deciding the nature of the interactions which is due to the random collision of the constituent molecules that attributed to the decrease in ultrasonic velocities.

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