Ultrasound Velocity related interpretation of molecular interactions in Binary systems

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ABSTRACT :*Here we have studied different amines in a common non-polar solvent carbon tetra chloride. The ultrasound velocity, density and viscosity have been determined practically in the binary systems at two different temparatures. We computed various acoustic, thermodynamic and viscosity paramteres of propyl amine and butyl amine with carbon tetra chloride. The excess values of isentropic compressibility, intermolecular free length, molar and available volume, viscosity and specific acoustic impedence have also been computed in the both binary systems. The molecular interaction have been defined on the basis of excess values of above acoustic and thermodynamic parameters. It is concluded that the rate of interactions decrease on increasing size of amines.*

Key Words : Ultrasound velocity, Molecular interaction, Binary system, thermodynamic parameter.

INTRODUCTION :

Ultrasound velocity and related acoustic and thermodynamic parameters yield valuable information regarding the behaviour of liquid molecules in binary and ternary systems because of intermolecular and interamolecular association effect, the compressibility of the system which observe in the variation of ultrasound velocity Subbarangiah et.al[1] investigated ultrasound behaviour of aqueous solutions by the results of hydrogen bonded (H-bonded) complex formation. Rajendran[2] observed ultrasound velocity, density and viscosity in binary mixtures of N-heptane with N-propanol, isopropanol, N-butanol and isobutanol over the entire range of mole fraction at a constant temperature 298.15K. Prakash et.al[3] and Deshpandey et.al[4] discussed molecular interactions on the basis of excess free voluness. A few binary liquid mixtures[5-6] have also been tried. In this paper we are reporting the results of study of binary systems--

(1) Propyl amine + Carbon tetra chloride
(2) Butyl amine + Carbon tetra chloride

Equations used for Calculations :

For any homogeneous non-dissipative liquid system, υ for a compressional acoustic wave is related to the density (ρ) and the adiabatic compressibility (β_s) of the medium by the equation of Newton & Laplace :

$$\upsilon = \left(\rho \,.\, \beta_s\right)^{-½} \qquad \ldots\ldots(1)$$

V_a can be calculated from the following expression obtained on combining the equations of Jacobson[7] and Schaffs[8] :

$$V_a = V_T \left(1 - \frac{\upsilon}{\upsilon_\infty}\right) \qquad \ldots\ldots(2)$$

where V_T is the volume at T (in K) and υ_∞ = 1600 m/sec.

L_f, the distance covered by a sound wave between the surface of two molecules, is given by the relation

$$L_f = \sqrt[k]{\beta_s} \qquad \ldots\ldots(3)$$

where *k* is a temperature dependent constant.

The excess properties are given by the equation—

$$A^E = A_{\exp} - A_{ideal} \quad \ldots\ldots(4)$$

Where—

$$A_{ideal} = \left(X_1 A_1 + X_2 A_2\right)$$

In the above expression*A* represents the properties such as β_s, L_f, V_m and V_a and X_1 and X_2 are the mole fractions of the components whose properties are A_1 and A_2 respectively.

Results & Discussion :

The values of the ultrasound velocity, density, viscosity determined experimentally and tabulated on the tables. The computed acoustic and thermodynamic functions like isentropic compressibility, intermolecular free length, molar and available volume, specific acoustic impedance and their excess like β_s^E, L_f^E, V_m^E and η_a^E also graphed in figures (1-8) of the binary systems of propyl amine and butyl amine in non-polar carbon tetra chloride. The ultrasound velocity increases on increasing mole fraction or amine in both system. The density decreases on increasing mole fraction of amine also in both systems. It conduct that carbon tetra chloride molecules are more dense in comparisonto amines. The peaks of curves are maximum on mole fraction of 0.6508 in propyl amine while at 0.6030 in butyl amine. This predicts that more interaction between the molecules of amine and carbon tetra chloride. It is due to the hydrogen bonding between Me group of amine and group of CCl4. The

existence of structurally different species in structure is also reflected by physical and thermodynamic like vander-waal for us. The other physical and thermodynamic function as intermolecular free length and molar volume support the above facts between the molecules.

If the mixtures were ideal, all the excess values should have been zero. The deviations in negative direction suggest the more interaction between the molecules because the excess values of intermolecular free length and molar volume also show the negative variation and deviation forces as observed one the same composition.

The excess deviation of viscosity drawn as a mole fraction of amines at two different temperature in carbon tetra chloride. The more interaction between the spacies of binary mixture decrease.The less flow of capability hence decrease in viscosity of increasing mole fraction of amines in both system. This is due the heavy molecules of carbon tetra chloride. This concluded the positive excess values of viscosity.

At last we suggested the strong molecular interaction between the molecules of amines in carbon tetra chloride due to hydrogen bond and vander wall positive forces between the molecules.

Propyl Amine + Carbon Tetra Chloride

Table No. 3 : The values of Ultrasound velocity, Density, Isentropic compressibility, Molar and Available volume and Viscosity of the binary liquid mixture at 28°C

X	U	ρ	β_s	L_f	V_m	V_a	η
0.0000	1020	1.6240	59.18	0.4831	94.71	34.33	0.9080
0.1377	1036	1.5042	61.93	0.4942	93.59	32.97	0.8380
0.2715	1054	1.3850	64.99	0.5062	92.49	31.56	0.7688
0.4015	1076	1.2547	68.83	0.5210	92.29	30.22	0.7011
0.5279	1087	1.1515	73.49	0.5383	90.16	28.9	0.6346
0.6508	1105	1.0373	78.95	0.5580	88.86	27.49	0.5688
0.7703	1125	0.9239	85.82	0.5817	87.52	26.09	0.5042

0.8867	1141	0.8111	94.70	0.6111	86.10	24.69	0.4415
1.0000	1160	0.6980	106.47	0.6479	84.68	23.28	0.3780

Table No. 4 : The values of Ultrasound velocity, Density, Isentropic compressibility, Molar and Available volume and Viscosity of the binary liquid mixture at 33°C

X	U	ρ	β_s	L_f	V_m	V_a	η
0.0000	990	1.5272	66.80	0.5181	100.72	38.39	0.7840
0.1377	1008	1.4203	69.29	0.5277	99.11	36.67	0.7131
0.2715	1024	1.3149	72.52	0.5399	97.42	35.07	0.6439
0.4015	1040	1.2100	76.40	0.5541	95.69	33.48	0.5765
0.5279	1057	1.1049	81.00	0.5706	93.96	31.89	0.5101
0.6508	1075	1.0010	86.44	0.5894	92.15	30.29	0.4440
0.7703	1094	0.8955	93.30	0.6123	90.30	28.55	0.3793
0.8867	1112	0.7896	101.41	0.6415	88.45	26.97	0.3159
1.0000	1130	0.6840	114.49	0.6783	86.41	25.38	0.2540

Fig 1 : Propyl Amine + Carbon Tetra Chloride

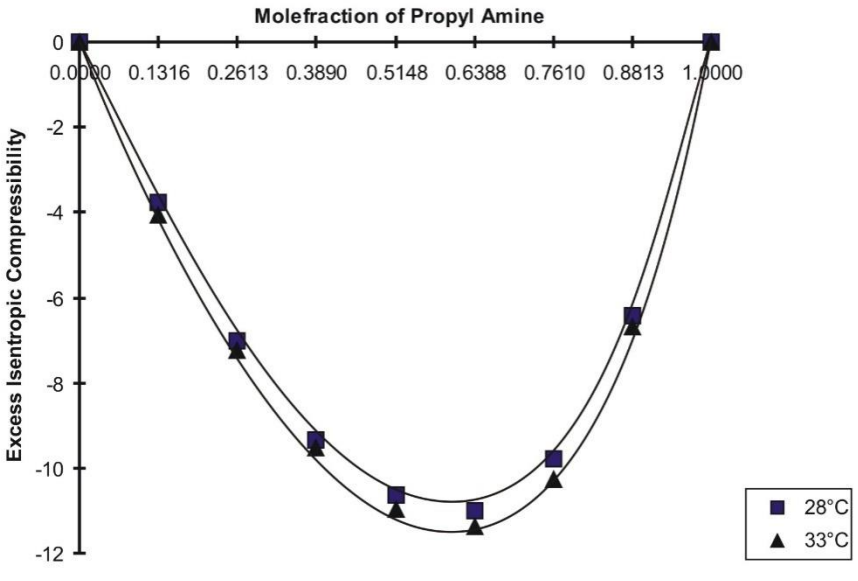


Fig 2 : Propyl Amine + Carbon Tetra Chloride

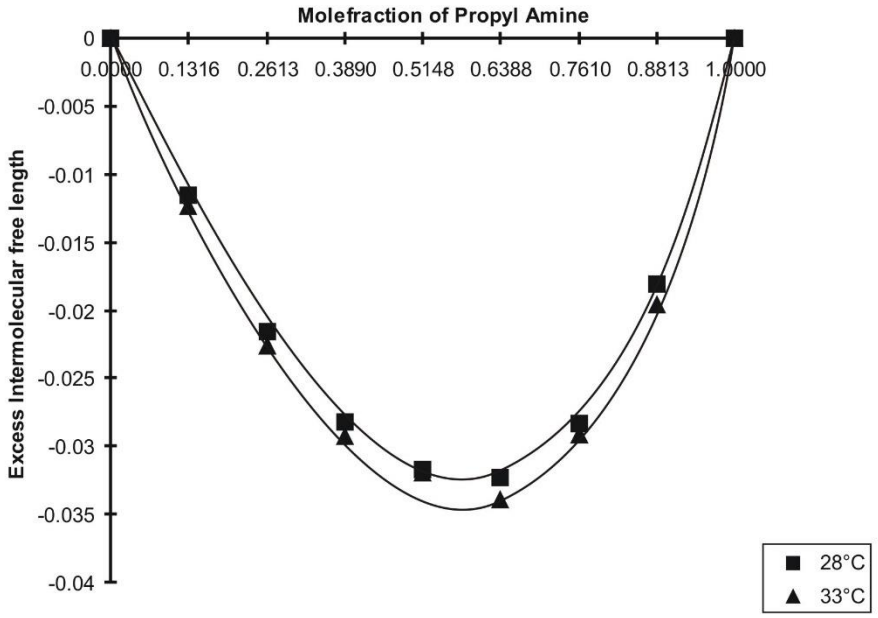


Fig 3 : Propyl Amine + Carbon Tetra Chloride

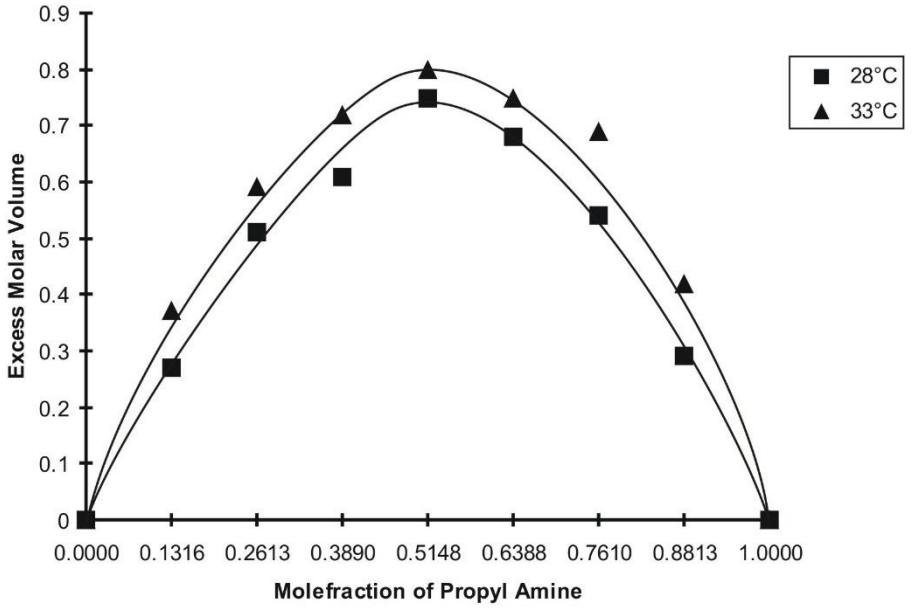
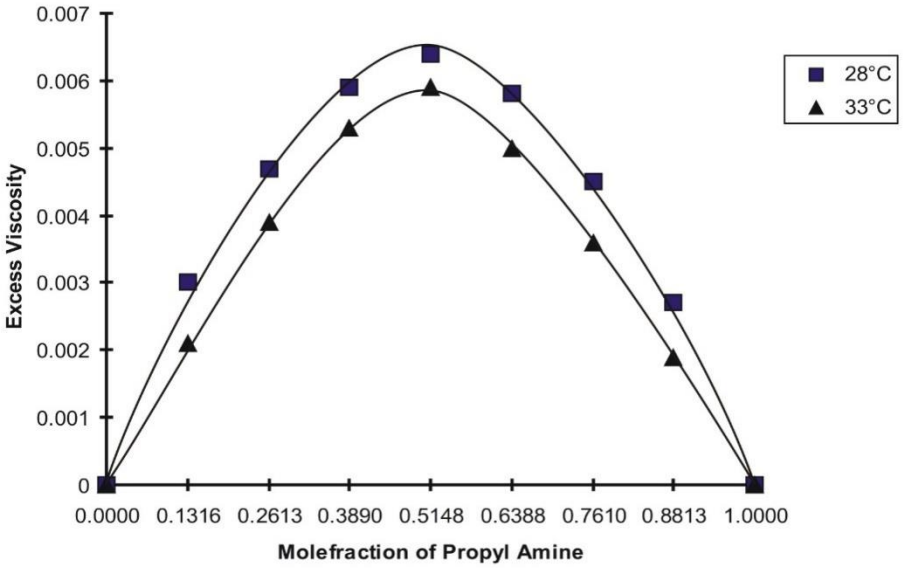


Fig 4 : Propyl Amine + Carbon Tetra Chloride



Butyl Amine + Carbon Tetra Chloride

Table No. 1 : The values of Ultrasound velocity, Density, Isentropic compressibility, Molar and Available volume and Viscosity of the binary liquid mixture at 28°C

X	U	ρ	β_s	L_f	V_m	V_a	η
0.0000	1020	1.6240	59.18	0.4831	94.71	34.33	0.9080
0.1152	1044	1.5143	60.58	0.4887	95.44	33.16	0.8573
0.2330	1070	1.3994	62.41	0.4961	96.48	31.95	0.8044
0.3535	1096	1.2851	64.78	0.5054	97.50	30.71	0.7492
0.4769	1121	1.1711	67.95	0.5176	98.49	29.48	0.6920
0.6030	1150	1.0540	71.74	0.5319	99.78	28.06	0.6324
0.7322	1182	0.3973	76.36	0.5487	101.08	26.40	0.5701
0.8645	1216	0.8206	82.41	0.5700	102.44	24.58	0.5053
1.0000	1260	0.7040	89.47	0.5940	103.89	22.07	0.4385

Table No. 2 : The values of Ultrasound velocity, Density, Isentropic compressibility, Molar and Available volume and Viscosity of the binary liquid mixture at 33°C

X	U	ρ	β_s	L_f	V_m	V_a	η
0.0000	990	1.5272	66.8	0.5181	100.72	38.39	0.7840
0.1152	1016	1.4308	67.7	0.5216	101.01	36.86	0.7326
0.2330	1043	1.3303	69.1	0.5270	101.49	35.33	0.6796
0.3535	1070	1.2279	71.13	0.5347	102.04	33.8	0.6245
0.4769	1098	1.1237	73.81	0.5446	102.64	32.2	0.5675
0.6030	1128	1.0178	77.21	0.5570	103.33	30.48	0.5077
0.7322	1161	0.9101	81.51	0.5723	104.10	28.56	0.4452
0.8645	1198	0.8009	86.99	0.5913	104.97	26.37	0.3810
1.0000	1242	0.6900	93.95	0.6145	106.00	23.71	0.3146

Fig 5 : Butyl Amine + Carbon Tetra Chloride

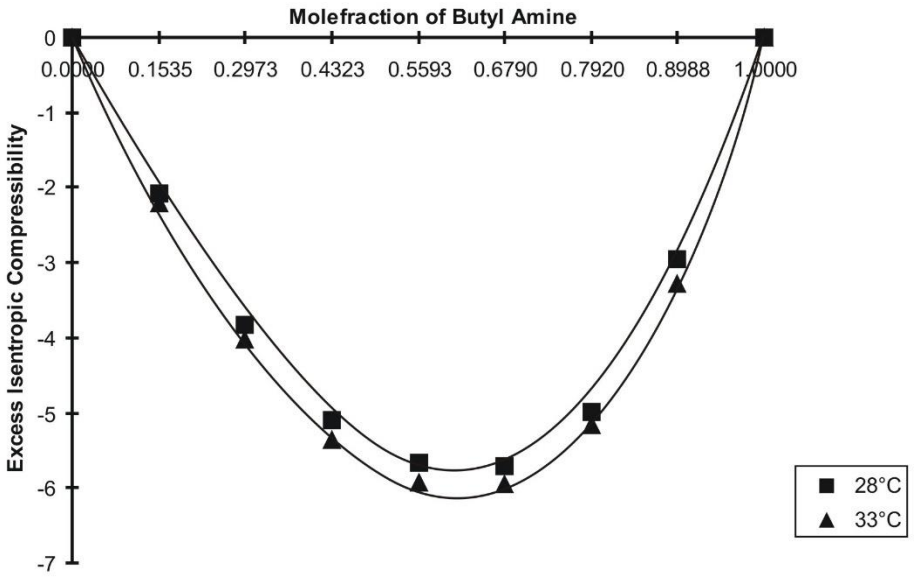


Fig 6 : Butyl Amine + Carbon Tetra Chloride

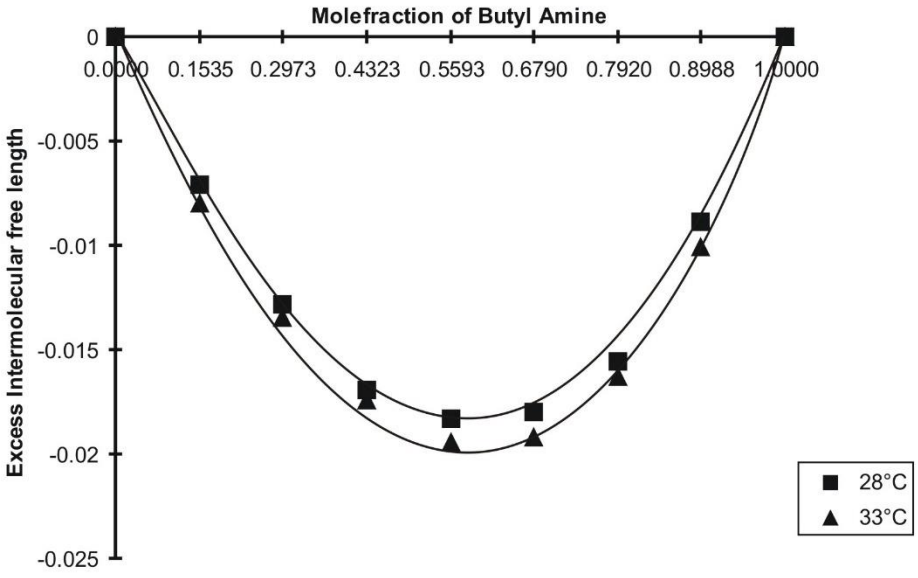


Fig 7 : Butyl Amine + Carbon Tetra Chloride

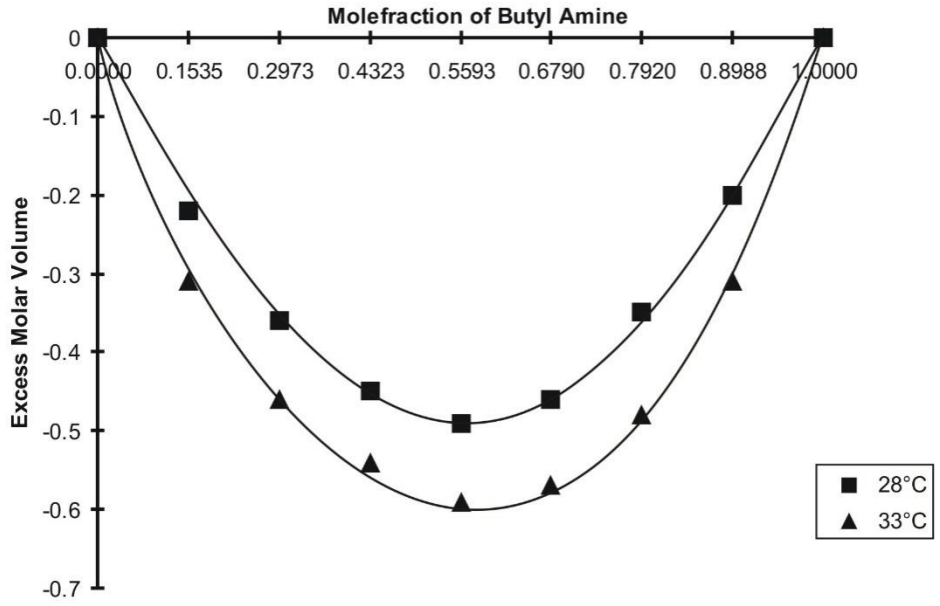
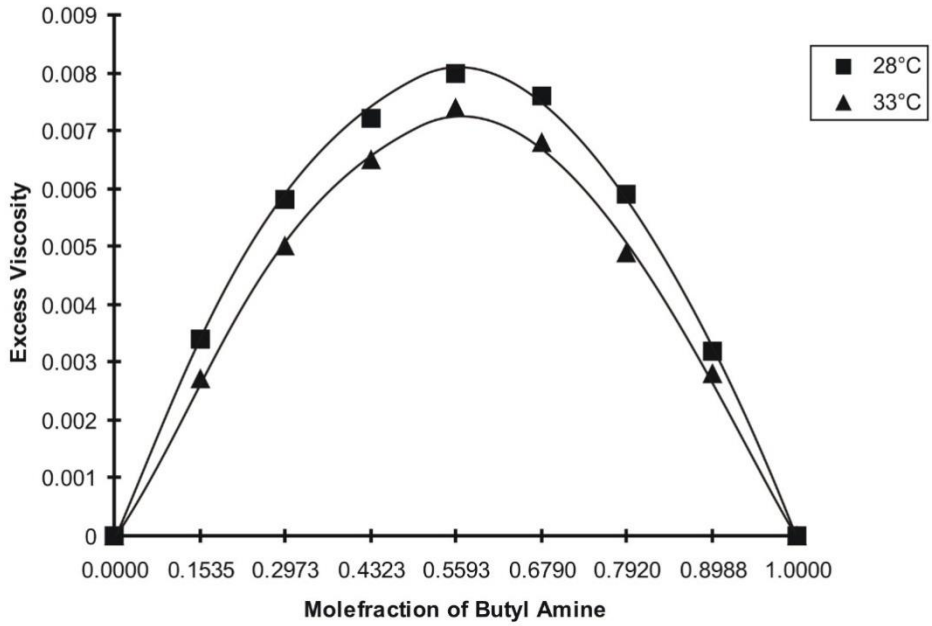


Fig 8 : Butyl Amine + Carbon Tetra Chloride



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