Ultrasonic Investigation of Binary Solutions of Petrolium And Its Products

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ABSTRACT

Experiment values of densities and ultrasonic speed of petroleum product Gasoline (Petrol) and 2T Oil were taken in different volume concentrations from 5%, 10%-----, and 95% at different temperatures from 298.15K to 318.15K having difference of 5K. From the experimental data, Apparent Molar Compressibility (ϕ_K), Relative Association (R_A), Solvation Number (S_n), Free Energy of Activation (ΔE), Excess Adiabatic Compressibility (β_{ad}^E), Excess Volume (V^E), Excess Free Length (L_f^E) have been computed. These parameters are used to focus light on the nature of component molecules of binary liquids and the excess functions are found to be sensitive to the nature and extent of the intermolecular interactions taking place in these binary mixtures.

Keywords: Ultrasonic velocity, Acoustical Parameters, Binary system, Molecular interactions.

I. INTRODUCTION

Knowledge of acoustic properties reveals the presence of molecular interactions between the component molecules in the multi-component liquid systems interaction plays an important role in the development of molecular sciences. [1-6] Gasoline or petrol is a petroleum-derived liquid mixture consisting mostly of hydrocarbons and enhanced with benzene or iso-octane to increase octane ratings, used as fuel in internal combustion engines. For decades, Chevron Oronite has been a leader in the development of premium additive systems specifically designed to meet the unique lubrication demands of air-cooled, two-stroke cycle engines. In air-cooled applications, two-stroke cycle engines require an oil to provide reliable lubrication during high engine temperatures and under the most severe operating conditions. In continuation of our earlier work we have evaluated the acoustic Parameters, namely the Apparent Molar Compressibility (ϕ_K), Relative Association (R_A), Solvation Number (S_n), Free Energy of Activation (ΔE), Excess Adiabatic Compressibility (β_{ad}^E), Excess Volume (V^E), Excess Free Length (L_f^E) for the binary mixtures Gasoline+ 2-T Oil. The results are discussed in terms of molecular interactions.[7-15]

II. METHODS AND MATERIAL

The ultrasonic velocities were measured at temperature at different temperatures and atmospheric pressure by using a single crystal variable

path ultrasonic interferometer (F-81) operating at a frequency of 2 MHz. The temperature of the solution was maintained constant within ±0.010 C by circulation of water from thermostatically regulated water bath through the water- jacketed cell. The velocity measurements were precise to ±0.5 m s-1. Densities of the experimental liquids can also be measured by the hydrostatic plunger method, calibrated with deionised double distilled water with 0.9960×103 kg m-3 as its density at temperature 303.15 K. The precision of density measurement was within ±0.0003 kg m-3. Different thermo-acoustical parameters such as apparent Molar Compressibility (ϕ_K), Relative Association (R_A), Solvation Number (S_n), Free Energy of Activation (ΔE), Excess Adiabatic Compressibility ($\beta_{ad}{}^E$), Excess Volume (V^E) and Excess Free Length (L_f^E) have been evaluated from the experimentally measured values of density, ρ and ultrasonic velocity, U [16-21]

$$V = \frac{M}{\rho}$$

$$\beta_{ad} = \frac{1}{u^2\rho}$$

$$L_f = K \times \beta^{1/2}$$

$$\Phi_K = \left(\rho_0\beta_{ad} - \rho\beta_{ad}^0\right) \times \frac{1000}{\rho_0 C} + \frac{\beta_{ad}^0 M_2}{\rho_0}$$

$$R_A = (\frac{\rho}{\rho_0})(\frac{u_0}{u})^{1/3}$$

$$S_n = \frac{n_1}{n_2}\left(1 - \frac{\beta_{ad}}{\beta_{ad}^0}\right)$$

$$\Delta E = Slope \times R \times 2.45$$

$$\beta_{ad}^E = \beta_{(Expt)} - \beta_{(Ideal)}$$

$$V_a^E = V_{(Expt)} - V_{(Ideeal)}$$

$$L_f^E = L_{f(Expt)} - L_{f(Ideal)}$$

III. RESULT AND DISCUSSION

The apparent molar compressibility (ϕ_K) which decreased linearly with percentage volume concentration of mixtures at all five different temperatures have been shown in fig. 1.The positive value of ϕ_K shows strong electrostatic force in the vicinity of ion, causing electrostatic solution in ions. Fig.2 reveals the variation of relative association (R_A) with percentage volume of mixture at five different temperatures which increased linearly. The increase in R_A with concentration suggests that salvation of ions predominates over the breaking up of the solvent aggregates on addition substance. The variation of salvation number (S_n) with percentage volume concentration of mixture at five all five temperatures exhibit in fig. 3. The value S_n decrease with increase in percentage volume and temperatures. The positive salvation number of solution suggests that the compressibility of the solution will be less than that of solvent.

The free energy of activation (ΔE) varies with percentage volume of mixtures shown in Fig. 4. It has been found that ΔE increase nearly exponential as increase of percentage volume of mixture. Fig. 5 and 6 showed the variation of excess adiabatic compressibility and excess volume with percentage volume of mixture at five different temperatures. The figure show variation of $\beta_{ad}{}^E$ negative and V^E positive with increase of percentage volume of mixture at all temperatures indicate an attractive interaction between two component liquid molecules in the mixture leading to an association between them. Fig.7 showed the variation of excess free length L_f^E. The symmetrical positive variation of L_f^E at all temperatures supports attractive interaction.

Table 1 : Apparent Molar Compressibility (ϕ_K) cm³ mol⁻¹

x %	298.15 K	303.15 K	308.15 K	313.15 K	318.15 K
1	3.828E-08	4.005E-08	4.211E-08	4.423E-08	4.648E-08
2	3.812E-08	3.988E-08	4.192E-08	4.404E-08	4.627E-08
3	3.796E-08	3.971E-08	4.174E-08	4.384E-08	4.607E-08
4	3.780E-08	3.954E-08	4.156E-08	4.365E-08	4.587E-08
5	3.764E-08	3.938E-08	4.139E-08	4.347E-08	4.567E-08
6	3.748E-08	3.921E-08	4.121E-08	4.328E-08	4.547E-08
7	3.733E-08	3.905E-08	4.104E-08	4.310E-08	4.528E-08
8	3.718E-08	3.889E-08	4.087E-08	4.292E-08	4.509E-08
9	3.703E-08	3.873E-08	4.070E-08	4.274E-08	4.490E-08
10	3.688E-08	3.858E-08	4.054E-08	4.256E-08	4.471E-08

Table 2 : Relative Association (R_A)

x %	298.15 K	303.15 K	308.15 K	313.15 K	318.15 K
1	1.002488	1.002343	1.002609	1.002315	1.002581
2	1.003649	1.003492	1.003737	1.003423	1.003673
3	1.004810	1.004641	1.004864	1.004532	1.004764
4	1.005971	1.005789	1.005991	1.005640	1.005855
5	1.007131	1.006937	1.007118	1.006748	1.006945
6	1.008290	1.008084	1.008244	1.007855	1.008036
7	1.0094	1.0092	1.0093	1.0089	1.0091

(Table continued)

	49	31	70	63	26
8	1.010607	1.010378	1.010496	1.010070	1.010216
9	1.011765	1.011524	1.011621	1.011176	1.011305
10	1.012923	1.012670	1.012746	1.012282	1.012395

Table 3 : Solvation Number (S_n)

x %	298.15K	303.15K	308.15K	313.15K	318.15K
1	0.334896	0.334331	0.348606	0.343639	0.359397
2	0.298314	0.299256	0.308440	0.307930	0.317591
3	0.283456	0.284866	0.292296	0.293218	0.300796
4	0.274055	0.275677	0.282187	0.283787	0.290285
5	0.266861	0.268590	0.274515	0.276491	0.282312
6	0.260786	0.262572	0.268081	0.270283	0.275629
7	0.255368	0.257181	0.262370	0.264714	0.269700
8	0.250372	0.252195	0.257125	0.259557	0.264256
9	0.245670	0.247491	0.252203	0.254688	0.259150
10	0.241183	0.242994	0.247518	0.250032	0.254291

Table 4 : Free Energy of Activation (ΔE) J mol⁻¹

x %	ΔE
1	7387.734
2	7422.859
3	7455.061
4	7484.692
5	7512.041
6	7537.370
7	7560.890
8	7582.790

9	7603.232
10	7622.358

Table 5 : Excess Adiabatic Compressibility ($\beta_{ad}{}^E$) cm² dyne⁻¹

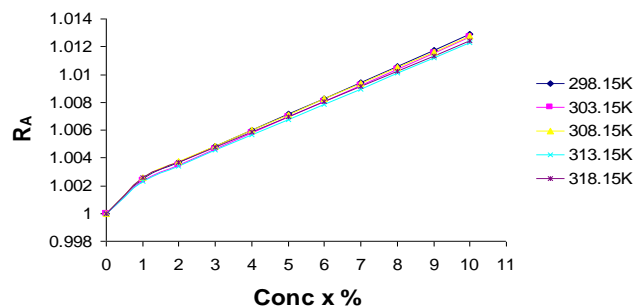| x %	298.15K	303.15K	308.15K	313.15K	318.15K
1	-4.77E-13	-4.91E-13	-5.54E-13	-5.56E-13	-6.32E-13
2	-7.51E-13	-7.81E-13	-8.65E-13	-8.89E-13	-9.88E-13
3	-1.02E-12	-1.06E-12	-1.17E-12	-1.21E-12	-1.33E-12
4	-1.28E-12	-1.33E-12	-1.46E-12	-1.53E-12	-1.67E-12
5	-1.53E-12	-1.60E-12	-1.74E-12	-1.83E-12	-1.99E-12
6	-1.77E-12	-1.86E-12	-2.02E-12	-2.12E-12	-2.31E-12
7	-2.00E-12	-2.10E-12	-2.28E-12	-2.41E-12	-2.61E-12
8	-2.23E-12	-2.34E-12	-2.54E-12	-2.68E-12	-2.91E-12
9	-2.45E-12	-2.58E-12	-2.79E-12	-2.95E-12	-3.19E-12
10	-2.66E-12	-2.80E-12	-3.03E-12	-3.21E-12	-3.47E-12

Table 6 : Excess Volume (V^E) cm³ mol⁻¹

x %	298.15K	303.15K	308.15K	313.15K	318.15K
1	1.008E+0	1.028E+00	9.921E-01	1.038E+00	9.978E-01
2	2.165E+0	2.193E+00	2.163E+00	2.215E+00	2.181E+0
3	3.256E+0	3.290E+00	3.266E+00	3.324E+00	3.296E+0
4	4.284E+0	4.325E+00	4.306E+00	4.370E+00	4.347E+0
5	5.252E+0	5.299E+00	5.285E+00	5.354E+00	5.337E+0
6	6.164E+0	6.215E+00	6.206E+00	6.281E+00	6.268E+0
7	7.021E+0	7.077E+00	7.073E+00	7.152E+00	7.144E+0
8	7.826E+0	7.888E+00	7.888E+00	7.971E+00	7.967E+0
9	8.582E+0	8.648E+00	8.652E+00	8.740E+00	8.740E+0
10	9.291E+0	9.362E+00	9.370E+00	9.462E+00	9.465E+0

Table 7 : Excess Free Length (L^E) cm

x %	298.15K	303.15K	308.15K	313.15K	318.15K
1	1.907E-11	2.109E-11	2.023E-11	1.949E-11	1.650E-11
2	4.229E-11	4.529E-11	4.522E-11	4.565E-11	4.350E-11
3	6.412E-11	6.804E-11	6.872E-11	7.025E-11	6.888E-11
4	8.464E-11	8.943E-11	9.080E-11	9.337E-11	9.272E-11
5	1.039E-10	1.095E-10	1.115E-10	1.151E-10	1.151E-10
6	1.220E-10	1.284E-10	1.310E-10	1.355E-10	1.361E-10
7	1.390E-10	1.461E-10	1.492E-10	1.546E-10	1.558E-10
8	1.549E-10	1.627E-10	1.663E-10	1.725E-10	1.743E-10
9	1.697E-10	1.782E-10	1.823E-10	1.893E-10	1.915E-10
10	1.837E-10	1.927E-10	1.973E-10	2.050E-10	2.077E-10

Figure 1 : Volume conc. x % versus Apparent Molar Compressibility (ϕ_K)

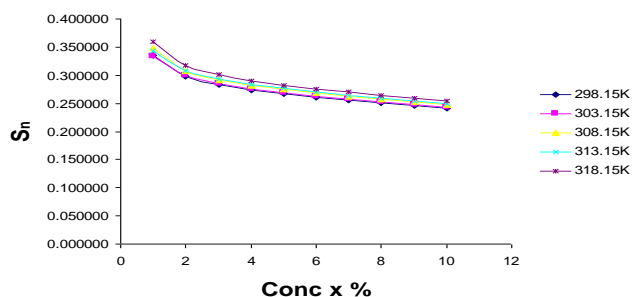**Figure 2 :** Volume conc. x % versus Relative Association (R_A)

Figure 3 : Volume conc. x % versus Solvation Number (S_n)
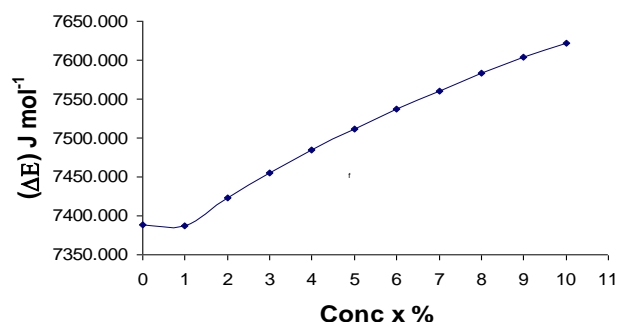

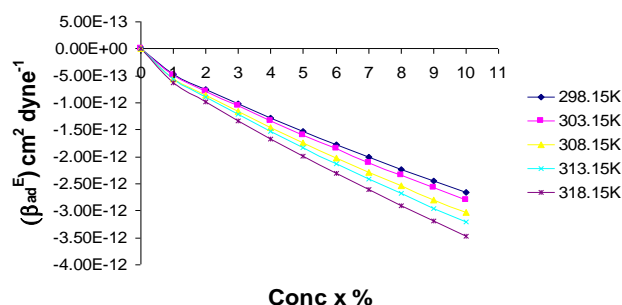**Figure 4 :** Volume conc. x % versus Free Energy of Activation (ΔE)

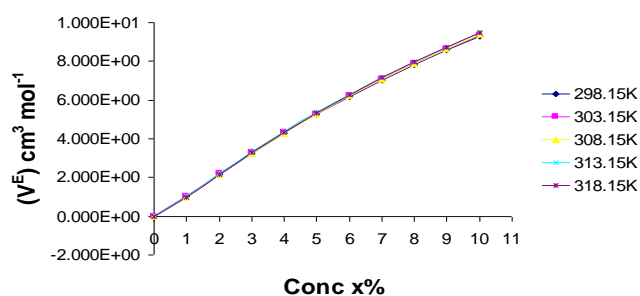Figure 5: Volume conc. x % versus β_{ad}^E
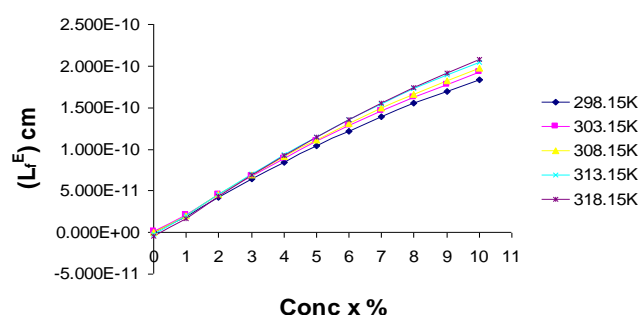

Figure 6: Volume conc. x % versus V^E

Figure 7 : Volume conc. x % versus L_f^E

IV. CONCLUSION

The 2T Oil (fuel oil's) which we used are non polar solvents and miscible in gasoline and there are weak interaction unto lower level of % concentration, the negative value of V^E show that the molecules set free from the original cluster and rate of broken of cluster depends on nature of β_{ad}^E and V^E. Free Length Theory works not so well when applied to mixtures.

V. REFERENCES

[1]. Hobbs, M.E. and Bates, W.W., J.Am. Chem. Soc., 74,746, (1952).

[2]. Negakuva., J.Am. Chem. Soc., 76,3070, (1954).

[3]. Freedman, E., J.Chem. Phys., 21, 1784, (1955).

[4]. Kannappan, A.N. and Rajendran, V., Indian J.Pure and Appl. Phys., 30,176, (1992).

[5]. Hyderkhan, V.and Subramanyam, S.V., Tras. Parad Soc. (GB) 67,2282, (1971).

[6]. Temperley, H.N.V., Rawlinson, J.S. and Rush brooke, G.S., Phys. of simple liquids (John wiley,Newyork), (1968).

[7]. Glasstone, S., Laidler, K.J., and Erying, H., Theory of Rate Processes.

[8]. Mc. Graw – Hill, Newyork, 478, 479, (1950). Erying, H.and Kincaid, J.F.J. Chem. Phy., 6,520,(1938).

[9]. Pino, Paulina Environmental Health, (2004)

[10]. Jacobson B. Acta Chem. Scand, 5 (1951) 1214.

[11]. Jacobson B. Acta Chem. Scand, 6 (1952) 1485.

[12]. Kitter C. J. J. Chem. Phys., 14 (1946) 64.

[13]. Schaaffs W. Z. Phys., 144 (1939) 100.

[14]. Schaaffs W. Ann-Phys. Lpz., 40 (1941) 393.

[15]. H. Reiss, H. L. Frisch and J. L. Lebowitz J. Chem. Phys., 31 (1959) 369.

[16]. H. Reiss, H. L. Frisch, E. Helfand and J. L. Lebowitzidbi., 32 (1960) 119.

[17]. H. Reiss, H. L. Frisch and J. L. Lebowitz idbi., 33 (1979) 1379.

[18]. H. Reiss, H. L. Frisch and J. L. Lebowitz idbi., 34 (1961) 1037

[19]. M. R. Rao Ind. J. Phys., 14 (1940) 109.

[20]. M. R. Rao J. Chem. Phys., 14 (1941) 682.

[21]. Nomoto O. J. Phys. Soc. Japan, 8 (1983) 553.

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