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Ultrasonic Studies on Non-Aqueous solutions of Toluene in Carbon Tetra Chloride

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Abstract: Ultrasonic studies are extensively used in the conformational analysis of organic molecules. The ultrasonic study can give the indication of complex formation through hydrogen bonding in the system. Recently researchers suggested that adiabatic compressibility also used for detecting hydrogen bond formation in solutions. The ultrasonic velocity measurement is a unique tool in characterizing the structure and properties of the system and provides significant information on the arrangement of matter in solutions and also finds an extensive application in studying the nature of intermolecular forces. In the present work, attempts have been made to investigate the behavior of Toluene and Carbon Tetra Chloride at various concentrations also at different temperatures. The Ultrasonic velocity, viscosity and density are measured experimentally. In order to get more information on the nature and strength of molecular interaction, we have calculated the other related acoustical parameter such as adiabatic compressibility, intermolecular free length, Rao's constant, internal pressure, and free volume. The non-linear variations of these derived acoustical parameters with different concentration of the solute explained on the basis of structural changes occurring in a solution.
Keywords: Toluene, Carbon Tetra Chloride, Ultrasonic Velocity, Rao's Constant, adiabatic compressibility.

MATERIALS AND METHODS

EXPERIMENTAL PROCEDURE:

The pure chemicals Toluene and Carbon Tetra Chloride were used as such without any purification. Measurement of Ultrasonic Velocity is generally made either by continuous wave method or by pulse methods. In the present study, continuous wave variable path interferometer is used. The ultrasonic velocity was measured using a multi variable frequency interferometer working at 1,3,5 MHz by standard procedure .The accuracy of ultrasonic velocity determination in non–aqueous solutions is 0.001%

The constant temperature was maintained by circulating water from the thermostatically controlled ($\pm$ 0.1^{o}C) water bath. The density at room temperature was measured using specific gravity bottle and single pan microbalance. The viscosity at different temperature was measured using Oswald's Viscometer and stop clock. Acoustical parameters were calculated using the measure values of velocity, viscosity and density. The values of ultrasonic velocity, viscosity, Adiabatic compressibility, Free volume, intermolecular free length, Rao's Constant, Internal pressure of Toluene in Carbon Tetra Chloride for various concentration (0.0 to 1.0) at different temperatures (303K, 308K, 313K, 318K and 323K) are given in Table 1 to Table 2.

Table :1

concentration	Temperature in K	Density in Kgm^{-3}	Viscosity $\eta \times 10^{-3} Nsm^{-2}$	Velocity in Ms^{-1}	Adiabatic Compressibility $\times 10^{-10} m$
0.0	303	1542	2.16	1590	2.57
	308	1542	1.85	1560	2.66
	313	1542	1.55	1545	2.72
	318	1542	1.24	1515	2.83
	323	1542	1.06	1485	2.94
0.2	303	1367	1.91	1560	3.00
	308	1367	1.64	1530	3.12
	313	1367	1.37	1515	3.19
	318	1367	1.09	1585	3.32
	323	1367	0.94	1455	3.46
0.4	303	1244	1.74	1530	3.43
	308	1244	1.50	1500	3.58
	313	1244	1.25	1485	3.65
	318	1244	0.99	1455	3.80
	323	1244	0.80	1440	3.88
0.8	303	999.78	1.38	1500	4.45
	308	999.78	1.18	1455	4.72
	313	999.78	0.99	1440	4.82
	318	999.78	0.79	1410	5.03
	323	999.78	0.68	1395	5.14
1.0	303	913.14	1.27	1470	4.96
	308	913.14	1.09	1425	5.39
	313	913.14	0.91	1410	5.75
	318	913.14	0.73	1380	5.87
	323	913.14	0.63	1365	6.00

Table :2

Concentration	Temperature in K	Inter molecular Free length $L_F \times 10^{-10} m$	Free Volume $V_F \times 10^{-9} m^3 mol^{-1}$	Internal Pressure $\pi_i \times 10^{-6} pa$	Rao's Constant
0	303	0.3197	4.3029	640.090	113.60
	308	0.3286	5.2757	636.417	112.89
	313	0.3345	6.7803	594.858	112.53
	318	0.3439	9.2011	545.883	111.81
	323	0.3423	12.5167	500.408	111.07
0.2	303	0.3460	5.0231	587.593	127.24
	308	0.3558	6.1320	558.864	126.43
	313	0.3624	7.9135	521.648	126.02
	318	0.3726	10.8213	477.481	125.19
	323	0.3835	13.1049	455.000	124.34
0.4	303	0.3699	5.6111	532.288	138.81
	308	0.3805	6.7969	507.369	137.91
	313	0.3876	8.8010	473.053	137.46
	318	0.3987	12.1102	432.103	136.53
	323	0.4062	16.4141	396.588	136.06

0.6	303	0.3947	6.4912	471.316	154.30
	308	0.4061	7.9127	448.491	153.28
	313	0.4137	10.1986	418.801	152.77
	318	0.4257	13.9589	383.226	151.73
	323	0.4338	17.0757	363.961	151.20
0.8	303	0.4208	7.6838	414.587	171.33
	308	0.4376	9.2839	395.676	169.61
	313	0.4458	11.8946	370.220	169.03
	318	0.4567	16.1668	339.555	167.86
	323	0.4677	19.9923	321.699	167.27
1.0	303	0.4493	8.3582	381.193	185.07
	308	0.4675	10.0330	364.594	183.19
	313	0.4725	12.9454	340.336	182.55
	318	0.4906	17.4455	313.041	181.26
	323	0.5001	21.4061	297.002	180.60

RESULTS AND DISCUSSION:

Ultrasonic velocity measurements in liquids and liquid mixtures were carried out by many researchers [1-24]. In our present work, ultrasonic velocity on non-aqueous solutions of Toluene in Carbon Tetra Chloride at different concentration and temperature were studied. The concentration ranges from 0.0 to 1.0 were prepared by adding known weight of the Toluene in Carbon Tetra Chloride.

From figure 1 we have concluded that the value of density decreases with the increasing value of concentration that means the morality of Toluene in Carbon Tetra Chloride decreases with the increasing value of density. [5,6]

Figure 2 shows the variation of viscosity with concentration and temperature. It is almost reflected the behavior of the variation of velocities as discussed [15-19] it is observed that the increase of absorption and viscosity with concentration and their decrease with increase in temperature.

Figure 3 has been drawn for various velocities, which are varying with different concentration and temperature. From the graph it is observed that the velocities are decreases with the increasing value of concentration.[9,23,24]B.Sundaresan[24]et al., found that the increase in Ultrasonic velocity at higher concentrations may be due to polymer-polymer interaction and decrease in velocity with increase in temperature may be due to the weakening of intermolecular forces between the molecules. It was concluded that the non-linear variations of Rao's constant with concentration of one of the components generally indicates strong association between the molecules. [11,12,13]

Figure 4 describes the variation of adiabatic Compressibility with different values of temperature as well as concentration. It was found that adiabatic compressibility increases with the increasing value of concentration[6,10,14] S.K.Kor[14]et al was concluded that the velocity in general decreases with increase of temperature irrespective of its molecular weight and concentration.

From figure 5 describes the variation of Rao's Constant with various temperature and concentration. Since Rao's Constant is independent of temperature there is no appreciable variation of Rao's Contant with the effect of temperature. However it slowly increases with the increasing value of concentration.[1,2,3,4,7]

From figure 6 describes the variation if free length for different value of temperature and concentration. Since the free length L_f is proportional to the adiabatic compressibility β_{ad} the same trend of variation similar to the variation of adiabatic compressibility has repeated in this graph.

Figure 7 the graph has been plotted for the variation of free volume at the various values of concentration and temperature. It is also that the free volume increases with increasing the value of concentration.[11] The absorption decreases almost linearly with increasing temperature at a given concentration and increases with concentration at a given temperatures. The velocity is a linearly increasing function of the temperature and also increases with concentration at a given temperature. In addition, the viscosity decreases linearly with temperature and increase with concentration. [20-22]

Figure 8 describes the variation of internal pressure with various temperature and concentration. It is observed that internal pressure is decreases with the increasing value of concentration.

Figure 1 DENSITY VS CONCENTRATION

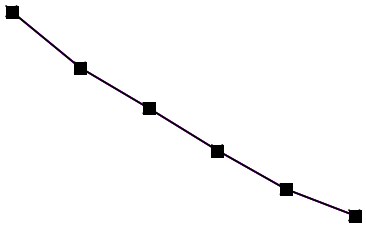


Figure 2: VISCOSITY VS CONCENTRATIPON

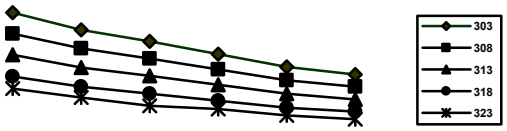


Figure 3: VELOCITY VS CONCENTRATION

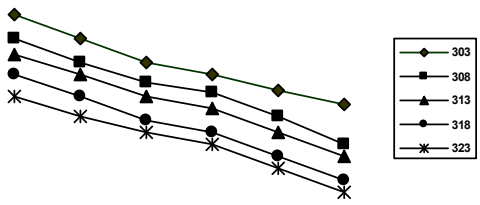


Figure 4: ADIABATIC COMPRESSIBILITY VS CONCENTRATION

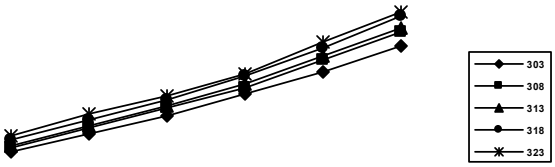


Figure 5: RAO'S CONSTANT VS CONCENTRATION

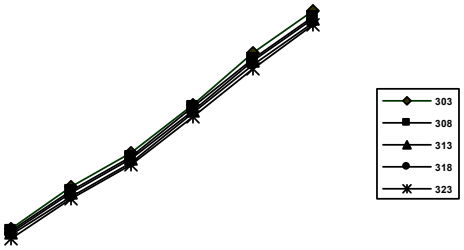


Figure 6: INTERNAL FREE LENGTH VS CONCENTRATION

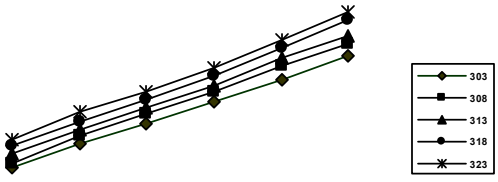


Figure 7 : FREE VOLUME VS CONCENTRATION

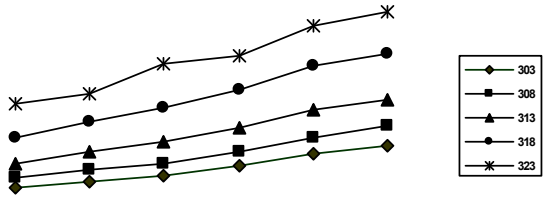
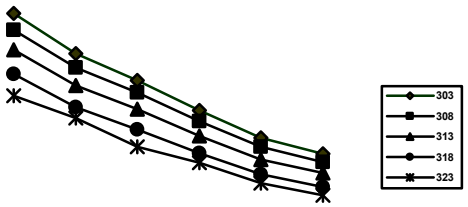


Figure 8: INTERNAL PRESSURE VS CONCENTRATION



CONCLUSION:

Ultrasonic studies have been carried out in the solutions of Toluene in Carbon Tetra Chloride at five different temperatures (namely 303k, 308k, 313k, 318 and 323k) for the concentration ranging from 0.0 to 1.0 in temperature of 0.2. There is an interaction between the solute (Toluene) and solvent (Carbon Tetra Chloride) molecules. At lower concentrations in the interaction are very less and the interaction is mostly between the solute and the solvent molecules. At higher concentration , the solute molecules are pushed closer to the solvent molecules, there by producing hydrogen bonds. The trend of increase in adiabatic compressibility and free length with increase of solute concentration further concludes the possibility of molecular interaction. This interaction indicates that there is a possibility of some complex formation such as hydrogen bond in the present system. As the temperature increases, the hydrogen bonds are broken up due to thermal agitations and hence the ultrasonic velocity decreases.

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