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ULTRASONIC INVESTIGATION OF DICHLOROMETHANE WITH ETHANOLAMINE AT VARIOUS TEMPERATURES

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Abstract

The Velocity of sound and density of binary liquid mixture of Dichloromethane with Ethanolamine have been calculated at different range of temperatures for various concentrations. Liquid-liquid interaction is confirmed by obtaining experimental values of fundamental parameters; ultrasonic velocity and density. Then these parameters are used to determine various other dependent parameters such as acoustic impedance (Z), intermolecular free length (Lf), adiabatic compressibility (β), Rao's constant (R), Wada's constant (W), Vander Waal's constant (b), effective molecular weight and Relative strength. Graphs are plotted for all parameters versus mole fraction. The linear variation of most of the acoustical parameters shows the absence of complex formation in the mixture. The decrease in ultrasonic velocity indicates that there is weak interaction between the molecules of the mixture.

Introduction

The research of the molecular behavior of liquids is no longer an ignored branch of Physics. A great deal of theoretical and observational work has been done on liquids and fluid mixtures. However a great deal of additional work needs to be done to test these hypotheses in order to provide full information on the forces keeping along the molecule assemblies. The distribution of ultrasonic waves in solids, fluid mixtures and solutions, liquids, polymers, soaps, etc. is currently well developed as an efficient means for the analysis of molecular interactions in these materials. Analysis of various thermo-acoustic parameters plays a very important role and puts a lot of light weight into understanding the powers of molecules. From the data of ultrasound speed and density numerous parameters like Acoustic impedance (Z), Adiabatic compressibility (β), Intermolecular free length (L_f), Effective mass (M_{eff}), Molecular adiabatic compressibility (W), Rao's constant (R), Vander Waal's constant (b), Relative strength (R) can be obtained.

In the present study several acoustic parameters of Dichloromethane and 2-aminoethanol have been reported.

Experimental

Chemicals

The binary liquid mixture of methylene chloride and ethanolamine is chosen for the study of molecular interaction. Methylene chloride (DCM) of HPLC grade having relative molecular mass 84.93 and formula CH_2Cl_2 is mixed in Ethanolamine of low frequency grade having relative molecular mass 61.08 g.mol^{-1} and formula C_2H_7NO is employed for the work. It's cosmopolitan in biological tissue and conjointly used as a wetting agent chemical agent.

Measurements

In the present work, I actually have calculated ultrasonic velocity and density at variable temperatures with different concentrations(36:4, 32:8, 28:12, 24:16, 20:20, 16:24, 12:28, 8:32, 4:36) of solution of methylene chloride and ethanolamine. The ultrasonic velocity are obtained by experimentation with the assistance of the ultrasonic interferometer at 2MHz. Density of the binary mixture is measured by employing a 25ml specific gravity bottle. The other parameters are calculated by using velocity and density, these parameters are as

Ultrasonic velocity

The ultrasonic interferometer is a device for determining the ultrasonic velocity in liquids with a large accuracy. The principle used for measuring the velocity (v), based on the exact calculation of wavelength in a medium. Then the wavelength is calculated as:

$$\lambda = 2d/n \quad ...(1)$$

$$U = f \times \lambda \quad ...(2)$$

Density

Density of liquid mixtures, pure liquid and solution can be calculated using relative measurement method. The density of liquid has measured by a bottle of 10ml specific gravity at different concentration. The bottle of specific gravity with liquid deep at a temperature precise water bath. The measured density is measured with a formula,

$$\rho_1 = \left(\frac{W_2}{W_1}\right)\rho_2 \quad ...(3)$$

Acoustics impedance:

It is the resistance which is offered to the propagation of ultrasonic wave in a material,

$$Z = \rho \times U \quad ...(4)$$

This impedance is used for determining the acoustic reflection and transmission at the boundary of 2 materials having different acoustics impedances.

Adiabatic compressibility:

This can be determined by density of medium and speed of sound using equations of Newton's which are:

$$\beta = {}^{1}/_{[\rho(U^2)]} \quad ...(5)$$

Intermolecular Free Length (L_f)

This can be calculated using Empirical Formulae suggested by Jacobson. Mathematical representation is given as:

$$Lf = K_T \times \beta^{1/2} \quad ...(6)$$

Where, K_T = Jacobson constant = 2.0965×10^{-6}
β = compressibility of the liquid

It can also be represented with another equation in terms of velocity and density as:

$$L_f = K/(U \times \rho^{1/2}) \quad ...(7)$$

Where; U = ultrasonic velocity of the experimental sample

ρ = density of the experimental sample

Wada's Constant (W)

Wada's constant is defined which is calculate using the following formula,

$$W = (\beta)^{-1/7} M_{eff}/\rho \quad ...(8)$$

Where, W = Wada constant

β = Adiabatic Compressibility.

Rao's Constant (R)

Rao's constant is explained in terms of the relation between velocity of sound (U), effective molecular weight (M_{eff}) of the compound and the density (ρ)

It is given as,

$$R = U^{1/3} M_{eff}/\rho \quad ...(9)$$

Rao's constant is a temperature independent quantity.

Vander Waal Constant (b)

Vander Waal constant is given which is derived using the relation given by Vander Waal hence named after him. The equation is given as:

$$b = V_m [\, 1 - (RT / MU^2) \{(1 + (MU^2 / 3RT))^{1/2} - 1\}] \quad ...(10)$$

Where, V_m = molar volume

M = effective molecular weight (= M_{eff})

Result and Discussions

Table 1: Density(ρ), ultrasonic velocity(U) & acoustic impedance(Z) of Dichloromethane + ethanolamine at different concentration & varying temperature at 2 MHz.

Mole Fraction		Tempt.	ρ (kg/m^3)	U (m/s)	Z (kg/m^2/s)(10^5)
X1	X2	(°C)	(10^{-3})		
0.1	0.9	25	1.092	1740	19.00008
		30	1.058	1656	17.62628
		35	1.026	1601	17.77032
0.2	0.8	25	1.116	1580	17.63280
		30	1.085	1516	16.66560
		35	1.052	1452	16.45328
0.3	0.7	25	1.131	1480	16.73880
		30	1.097	1432	15.70904
		35	1.071	1379	15.76512
0.4	0.6	25	1.155	1410	16.28550
		30	1.125	1352	15.44625
		35	1.094	1303	15.10814
0.5	0.5	25	1.186	1368	16.22448
		30	1.165	1314	15.86730
		35	1.113	1258	14.86496
0.6	0.4	25	1.212	1280	15.51360
		30	1.186	1216	14.65896
		35	1.157	1164	13.69888
0.7	0.3	25	1.239	1190	14.74410
		30	1.212	1145	14.25312
		35	1.183	1096	13.82927
0.8	0.2	25	1.268	1132	14.35376
		30	1.252	1060	14.42304
		35	1.220	1004	13.46880
0.9	0.1	25	1.291	1038	13.40058
		30	1.274	967.0	13.09672
		35	1.245	907.0	12.52470

Table 2: Values of β, L_f and effective mass with different concentration & temperature at 2 MHz.

Mole Fraction		Tempt. (ºC)	β ($kg/m^2/s$)(10^{-10})	L_f (Å)	Effective Molecular Weight (gm)
X1	X2				
0.1	0.9	25	3.02468	0.108677	63.465
		30	3.44662	0.117056	63.465
		35	3.80251	0.124050	63.465
0.2	0.8	25	3.58940	0.118388	65.850
		30	4.01025	0.126265	65.850
		35	4.50870	0.135079	65.850
0.3	0.7	25	4.03658	0.125547	68.235
		30	4.44536	0.132939	68.235
		35	4.91001	0.140963	68.235
0.4	0.6	25	4.35492	0.130403	70.620
		30	4.85570	0.138939	70.620
		35	5.38386	0.147608	70.620
0.5	0.5	25	4.50550	0.132638	73.005
		30	4.97145	0.140585	73.005
		35	5.5771	0.150234	73.005
0.6	0.4	25	5.03590	0.140229	75.390
		30	5.70228	0.150564	75.390
		35	6.37912	0.160673	75.390
0.7	0.3	25	5.69947	0.149182	77.775
		30	6.29342	0.158176	77.775
		35	7.03711	0.168756	77.775
0.8	0.2	25	6.15443	0.155021	80.160
		30	7.10860	0.168109	80.160
		35	8.13154	0.181405	80.160
0.9	0.1	25	7.18917	0.167547	82.545
		30	8.39417	0.182678	82.545
		35	9.76374	0.198779	82.545

Table 3: Experimental values of R, W, b and relative strength at varying concentration & temperature at 2 MHz.

Mole Fraction		Tempt. (ºC)	R (m^3/mole) ($m/s)^{1/3}$	W (m^3/mole) $(Pa)^{-1/7}$	b (m^3/mol)	Relative Strength (r)
X1	X2					
0.1	0.9	25	0.699	1.3311	0.048201	-0.08750
		30	0.709	1.3485	0.049988	-0.03500
		35	0.723	1.3712	0.051547	-0.00060
0.2	0.8	25	0.687	1.3248	0.049171	0.01250
		30	0.697	1.3391	0.050576	0.05250
		35	0.708	1.3582	0.052163	0.09250
0.3	0.7	25	0.689	1.3280	0.050276	0.07500
		30	0.701	1.3484	0.051835	0.10500
		35	0.709	1.3616	0.053093	0.13813
0.4	0.6	25	0.683	1.3293	0.050952	0.11875
		30	0.694	1.3437	0.052311	0.15438
		35	0.705	1.3616	0.053794	0.18563
0.5	0.5	25	0.678	1.3262	0.051296	0.14500
		30	0.686	1.3369	0.052221	0.17875
		35	0.695	1.3523	0.053696	0.21375
0.6	0.4	25	0.672	1.3166	0.051836	0.20000
		30	0.678	1.3298	0.052973	0.24000
		35	0.685	1.3415	0.054301	0.27250
0.7	0.3	25	0.663	1.3083	0.052311	0.25625
		30	0.671	1.3237	0.053476	0.28437
		35	0.677	1.3347	0.054787	0.31500
0.8	0.2	25	0.648	1.2932	0.052682	0.29250
		30	0.652	1.3059	0.053355	0.33750
		35	0.657	1.3166	0.054755	0.37250
0.9	0.1	25	0.635	1.2771	0.053283	0.35125
		30	0.640	1.2826	0.053994	0.39563
		35	0.643	1.2945	0.055252	0.43312

The experimental values of velocity of sound, density and impedance (Z) at 2MHz by varying concentration at different temperatures are provided in table 1.

Ultrasound velocity decreases with increasing concentration. But with the temperature rise, the velocity shows a decreasing trend. Variation in acoustic impedance indicates the lack of specific interactions such as complex formation in binary liquid mixtures. With an increase in concentration, the acoustic impedance decreases and shows linear variation with an increase in temperature. Simply this linear variation confirms that there is no complex formation in this mixture. According to the relations, coustic impedance(Z) and adiabatic compressibility(β) in table 2 must show opposite behavior. Thus it is in agreement with the experimental observations. Acoustic impedance decreases with increase in concentration while adiabatic compressibility decreases which is also in agreement with the calculated results. The mathematical relations of adiabatic compressibility and intermolecular free length, it is seen that they should exhibit same behavior. And from these graphs it is proved that adiabatic compressibility and intermolecular free length have same variations and thus in agreement with the relations. It is calculated from the mole fraction and molecular weight of dichloromethane in ethnolamine. It is observed that the molecular, as increases with the increase in concentration of dichloromethane. Thus the increase in effective mass shows the presence of heavier molecules in the liquid mixture used. Rao's constant (R), Wadda's constant (W), Vanderwaal's constant (b) and relative strength have been calculated from the experimental values of density, velocity and other derived parameters and are shown in table 3. Three constants show linear variation with increase in concentration. Thus this investigation leads to the idea that there is absence of complex formation in the binary mixture of dichloromethane and ethanolamine. The linear variation shows that the molecules are not very close and hence the interaction is decreasing and shows the presence of weak interaction between the molecules.

Conclusions

The solution tested, consisting of Dichloromethane and Ethanolamine, was selected in order to obtain data on the molecular interaction between their constituent particles. Variation of experimentally measured and derived parameters shows evidence of molecular interaction between the molecules of the sample. The ultrasonic study of the binary liquid mixture of dichloromethane and ethanolamine shows the presence of molecular interactions between the molecules of the mixture. Ultrasound velocity decreases with an increase in concentration due to an increase in the free intermolecular length of the solution. All derived acoustic parameters, such as acoustic impedance, adiabatic compressibility, intermolecular free length Vanderwaal constant, Wadda constant, Rao constant and relative strength, show linear variation with increased concentration that indicates the lack of complex mixture formation. Thus the result shows that there is weak interaction between the molecules of the mixture of dichloromethane and ethanolamine.

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