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Ultrasonic Behaviour of Diethylene Triamine in n-Butyl Alcohol at 3 MHz Frequency

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Abstract: ***Ultrasonic velocity (U) and density (ρ) for the binary liquid mixtures of Diethylene triamine (DETA) with n-Butyl alcohol (nBA) have been measured for 3MHz ultrasonic frequency at 297 K. The experimental data have been used to calculate acoustic parameters such as Adiabatic compressibility (β_{ad}), Intermolecular free length (L_f),Acoustic impedance(Z) and Relative association (R_A). The results are interpreted in terms of molecular interaction between the components of the mixture.***

Keywords: Diethylene triamine, adiabatic compressibility, intermolecular free length, acoustic impedance,

1. Introduction

In recent years the measurement of ultrasonic velocity has been adequately employed in understanding the nature of molecular interaction in pure liquids and liquid mixtures. Ultrasonic propagation parameters yield valuable information regarding the behavior of liquid systems, because intra- molecular and intermolecular association, dipolar interactions, complex formation and related structural changes affect the compressibility of the system which in turn produces corresponding variation in ultrasonic velocity. The acoustical and thermo dynamical parameters obtained in ultrasonic study show that the ion salvation is accompanied by the destruction or enhancement of the solvent structure[1]. Ultrasonic studies provide wealth of information about the state of any solution[2].The propagation of ultrasonic waves in a substance has become a fundamental test to investigate its properties[3]. Ultrasonic velocity have been successfully employed to detect and assess weak and strong molecular interactions present in binary[4,5] liquid mixtures.

Diethylene triamine (DETA) is used to sensitize nitro methane, making a liquid explosive compound. It is mixed with unsymmetrical dimethyle hydrazine. It was used as Hydyn, a propellant for liquid-fuel rockets.It is also used in countermine system where it would be used to ignite and consume the explosive fill of land mines in beach and surf zones.

n-butyl alcohol is a primary alcohol with a four carbon structure. It occurs naturally as a minor product of the fermentation of sugars and other carbohydrates. It is also a permitted artificial flavoring in the United States used in butter, cream, fruit, rum, whiskey, ice cream, ices, candy, and baked goods. It is also used as an ingredient in perfumes and as a solvent for the extraction of essential oils. Therefore, it seemed important to study the ultrasonic behavior of n-butyl alcohol (nBA) with Diethylene triamine (DETA).

2. Experimental

n-Butyl Alcohol (nBA) and Diethylene triamine (DETA) used were of AR grade with minimum assay of 99.9% procured form S.D. fine chemicals and Spectrochem Pvt. Ltd. Mumbai. These chemicals are used without further purification. Samples of solution with different mole fraction DETA were prepared. The density (ρ) and viscosity (η) of pure liquids and liquid mixtures were determined by using Pycknometer and Ostwald's viscometer respectively. The Ultrasonic velocity (U) in the liquid and liquids mixtures have been measured using an Ultrasonic Fixed-frequency interferometer (Mittal type Model F-05.)

3. Theory

The experimental values of density (ρ), viscosity (η) and ultrasonic velocity (U) were used to calculate various acoustical parameters such as adiabatic compressibility (β_{ad}), free length (L_f), Acoustical impedance (Z), Relative association (R_A), relaxation time (τ) by the following relations[7].

$$\beta_{ad} = \frac{1}{\rho U^2} \quad \ldots (1)$$

$$L_f = K\,(\beta_{ad})^{1/2} \quad \ldots (2)$$

$$Z = U\rho \quad \ldots (3)$$

$$R_A = \frac{\rho_s}{\rho_0}\left(\frac{U_0}{U_s}\right)^{1/3} \quad \ldots (4)$$

Where, K is temperature dependent constant, ρ_0 and U_0 are the density and ultrasonic velocity of the solute DETA.
The strength of interaction between the component molecules is well reflected in the deviations, in excess viscosity ($\Delta\eta$) Excess Adiabatic compressibility ($\Delta\beta_{ad}$), Excess intermolecular free length (ΔL_f), Excess Acoustic impedance (ΔZ) etc. These parameters were calculated using the relation.

$$\Delta Y = Y_m - (X_1Y_1 + X_2Y_2) \quad \text{---(5)}$$

Where, Δy is any excess parameter, and y refers to above mentioned parameter. The subscripts m, 1 and 2 used in the above equation are respectively for the mixture, component

(1) and component (2). X_1 and X_2 are the mole fractions of two components in the liquid mixture.

4. Result and Discussion

The experimental values of ultrasonic velocity(U), viscosity(η), adiabatic compressibility(β_{ad}),intermolecular free length(L_f), acoustical impendence(z), relative association(R_A), Rao's constant(R), and Wada's constant(W) of the binary mixture of Diethylene triamine and n-butyl alcohol with mole fraction of Diethylene triamine at 297K are listed in table (1) and the values of excess adiabatic compressibility($\Delta\beta_{ad}$), excess intermolecular free length(ΔL_f), excess acoustic impendence(Δz) are reported in table (2).

The variation of ultrasonic velocity(U) with mole fraction (X) of Diethylene triamine in the mixture is shown in fig(1). It is observed that the ultrasonic velocity increases non linearly with molar concentration which indicates that there is intermolecular interaction exists in the binary mixture[6]. The maximum deviation from the linearity is at a point of mole fraction, where change in slope is maximum indicates the complex formation[7]. In the present system, the formation of the complex occurs at 0.5 mole fraction of Diethylene triamine.

Eyring and Kincaid suggested that the ultrasonic velocity increases with decrease in intermolecular free length and vice-versa[6] fig (2).Also the maximum deviation from linearity in the intermolecular free length curve occurs at 0.5 mole fraction of Diethylene triamine which supports earlier conclusion.

The variation of adiabatic compressibility decreases with the molar concentration of Diethylene triamine in the binary mixtures is shown in fig (3). The graph indicates that as concentration of Diethylene triamine increases, adiabatic compressibility decreases non linearly. The maximum deviation occurs at 0.5 mole fraction of DETA, which supports our earlier conclusions.

The acoustic impendence increases with increase in molar concentration of Diethylene triamine in the binary mixtures is shown in fig (4). The increase in acoustic impendence is non linearly. The deviation from linearity is maximum at 0.5 mole fraction of DETA. This indicates the significant molecul;ar interaction[8].

The excess intermolecular free length is negative over entire range of mole fraction of Diethylene triamine fig(5). It indicates the presence of intermolecular reactions in the system[9].The maximum negative value of excess intermolecular free length occurs at 0.5 mole fraction of DETA, at which complex may be formed.

The values of excess adiabatic compressibility with molar concentration are negative over entire range of mole fraction of DETA fig(6), which indicates that there is a strong molecular interaction between the unlike molecules of the component liquids[10].

5. Conclusions

1) There is a strong molecular interaction in the unlike molecules of the system in the given binary mixtures of Diethylene triamine and n-butyl alcohol.
2) The deviation from linear behavior of acoustic parameters suggests the formation of complex in the mixture.

Table 1: The values of density (ρ), ultrasonic velocity (U), adiabatic compressibility (β_{ad}), intermolecular free length (L_f), Acoustic impedance (Z) and relative association (R_A) of the binary liquid mixture of **Diethylene Triamine + n-Butyl alcohol** with mole fraction of **Diethylene Triamine.**

Mole fraction of Diethylene Triamine X	ρ ($Kg\ m^{-3}$)	U (ms^{-1})	ß$_{ad}$ ($10^{-10} m^2 N^{-1}$)	L_f (10^{-11}m)	Z ($10^6 kgm^{-2}s^{-1}$)	R_A
0	809	1308	7.22497	5.51698	1.058172	1
0.1072	829.98	1380	6.32666	5.16262	1.145372	1.0077713
0.2189	850.74	1406	5.9461	5.0049	1.196140	1.0265713
0.3353	870.11	1486	5.20461	4.68249	1.292983	1.0307546
0.4568	884.32	1546	4.7312	4.46446	1.367159	1.0338566
0.5863	902.12	1596	4.35181	4.28172	1.439784	1.0435359
0.7161	915.76	1656	3.98197	4.09574	1.516499	1.0463627
0.8547	928.57	1713	3.67004	3.93204	1.590640	1.0490984
1	955	1726	3.51492	3.84805	1.648330	1.0762433

Table 2: The values of excess adiabatic compressibility ($\Delta ß_{ad}$), excess intermolecular free length (ΔL_f), excess acoustic impedance (ΔZ) along with mole fraction of **Diethylene Triamine with n-butyl alcohol**

Mole fraction of Diethylene triamine (X)	$\Delta ß_{ad}$	ΔL_f	ΔZ
0	0	0	0
0.1072	-0.5003	-0.24575	0.02390
0.2189	-0.4665	-0.3303	0.00875
0.3353	-0.7761	-0.3692	0.03689
0.4568	-0.7989	-0.4146	0.03938
0.5863	-0.7174	-0.4675	0.03273
0.7161	-0.5860	-0.2641	0.03273
0.8547	-0.3835	-0.1113	0.03568
1	0	0	0

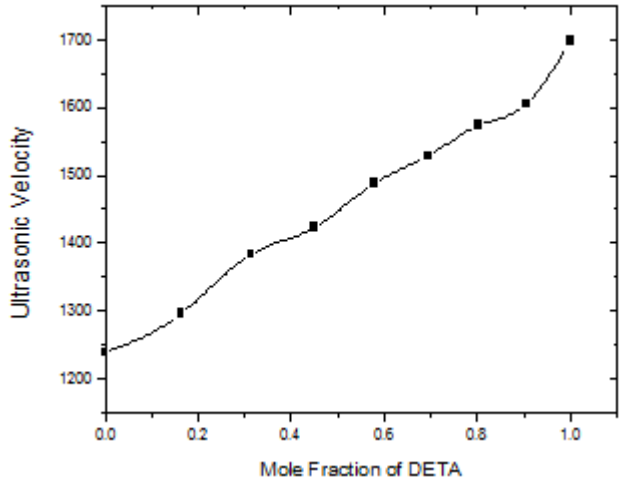

Figure 1: Variation of ultrasonic velocity with mole fraction of DETA

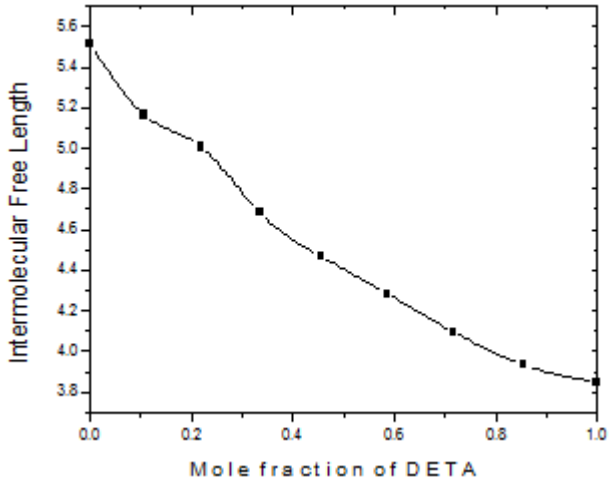

Figure 2: Variation of Intermolecular free length with mole fraction of DETA

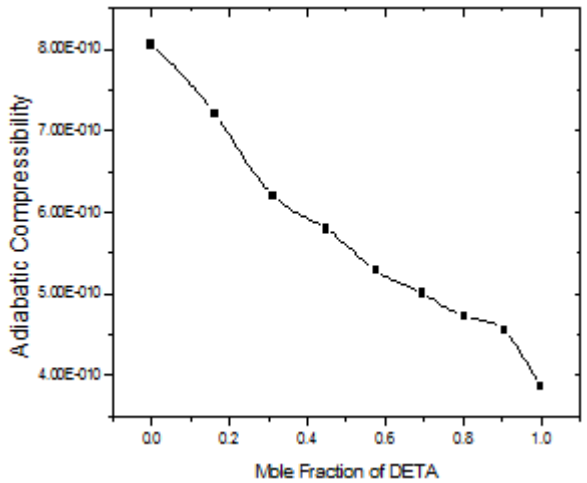

Figure 3: Variation of Adiabatic compressibility with mole fraction of DETA

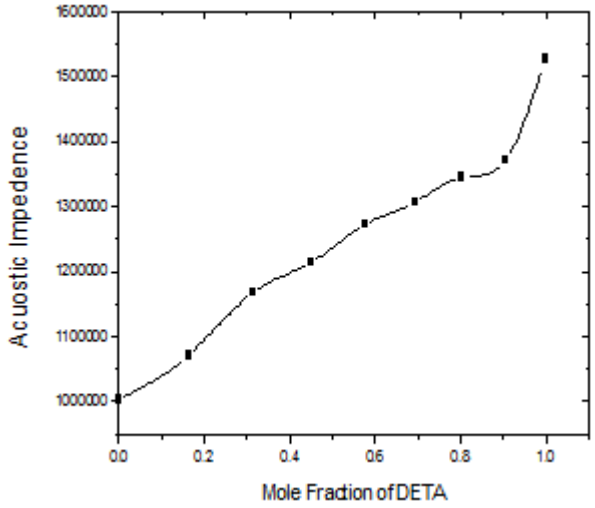

Figure 4: Variation of Acoustic Impedance with mole fraction of DETA

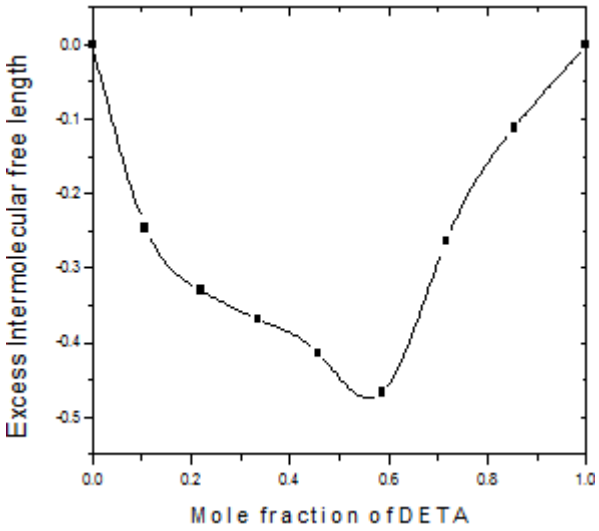

Figure 5: Variation of excess intermolecular free length with mole fraction of DETA

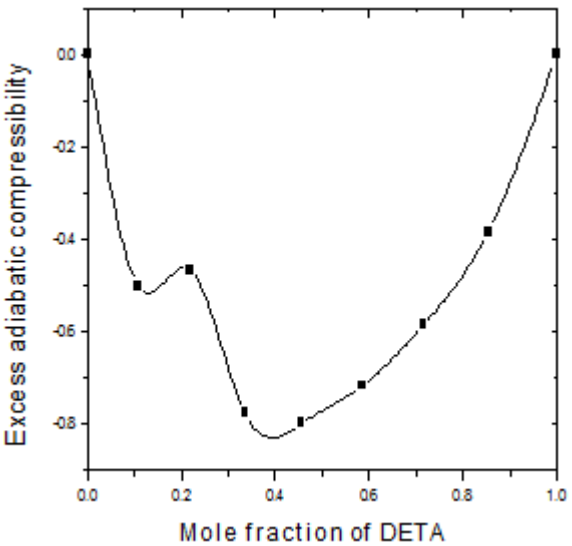

Figure 6: Variation of excess adiabatic compressibility with mole fraction of DETA

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