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Acoustical and Thermodynamic Investigation of The Binary Mixture of Acetic Acid And Propan-2-Ol At Different Temperatures

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Abstract

In the present study the density, velocity and viscosity of the binary mixture of Acetic Acid and Propan-2-ol was obtained experimentally obtained at various temperature and different concentration using specific gravity bottle, ultrasonic interferometer and Oswald's viscometer respectively. Using these experimental values various thermodynamical parameters are calculated which gave the insight of the intermolecular interactions and has solvent-solvent interactions.

Introduction

Under this branch comes a field namely ultrasonic dealing with the generation, propagation and use of inaudible acoustic waves. In these the ultrasound waves are observed. Ultrasounds are no different from the normal audible sound in the case of the physical properties except that these are not audible by humans. Ultrasounds have their applications and uses in variety of the fields [1-5].

Ultrasounds are used to detect the invisible flaws. These are used for cleaning, mixing, and acceleration of the chemical processes. Animals such as bats use these ultrasounds for locating the prey and the obstacles. Scientists today are studying ultrasound for the usage of graphene diaphragms for communication purposes [6-9].

Ultrasonic being a sub branch of acoustics and having a deal in the origination and orientation of the waves have a strong foot in the field of intermolecular interactions. From past many years many experiments and researches have been done in order to study the interactions of the molecules in any binary or ternary liquid mixtures being in any form (liquid - liquid, solid – liquid, solid-solid) with the help of respective experimental ways such as Pulse Echo Method, Raman Effect, Nuclear Magnetic Resonance and many other Ultrasonic methods [10-14]. Though the usage of these methods came into light in the early twenties, since then they have seen a great advancement in development

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of the determining methods. The computation of various thermo and acoustic parameters is being done with the above mentioned methods [15, 16].

Ultrasounds in the laymen language are the mechanical waves requiring a physical medium for its propagation. The different methods for its production are – Mechanical Methods, Piezoelectric Generator and Magnetostriction Generator. In the mechanical method, a Galton whistle of frequency 100 kHz is used for the production of the waves. This method has a rare use because of its limitation in the frequency range. The piezoelectric generator method, developed by Langevin in the year 1917 is based on the piezoelectric effect [17-19].

Experimental

Chemicals

The binary mixture of Acetic Acid and Propan-2-ol is used for the investigation of the intermolecular interactions. Acetic Acid (IUPAC name**:** Ethanoic Acid) having molecular weight 60.05 g/mole of Assay G. C. Grade and Propan-2-ol (IUPAC name**:** Isopropanol) having molecular weight 60.10 g/mole of Assay G. C. Grade were used for the experimental procedure.

Measurements

This paper focuses on the understanding of the intermolecular interactions taking place in the binary mixtures of Acetic Acid (molecular weight 60.05 g/mole) dissolved in Propan-2-ol (molecular weight 60.10 g/mole). The experimental work is performed with different concentrations (0:40, 4:36, 8:32, 12:28, 16:24, 20:20, 24:16, 28:12, 32:8, 36:4, 40:0) of the binary mixture at three different temperatures (303, 308, 313 K) at a constant frequency (2 MHz). The ultrasonic velocity is obtained by using ultrasonic interferometer. Density is computed with the help of 30ml specific gravity bottle and viscosity is determined with "Oswald's Viscometer" having capacity of 10ml. Various other thermo and acoustical parameters related to the mentioned quantities were computed using the experimental values of velocity, viscosity, density and some of the standard formulae. Distilled water has been used as standard liquid.

Ultrasonic velocity:

Ultrasonic velocity is defined as the value of the speed with which the sound travels through a given medium. The values for velocity are in **table 1**.

The velocity is calculated with a ultrasonic interferometer operating at a constant frequency of 2MHz.

Ultrasonic velocity is been calculated using the formulae:

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$$U = f \times \lambda \quad (1)$$

Where, U = ultrasonic velocity of the wave, λ = wavelength of the wave and f = frequency of the particle vibration.

Viscosity:

In **table 2** the values of Viscosity are defined which is the extent of the fluid to which it can restrict itself from flowing.

Viscosity of the experimental liquid is determined with the help of "Oswald's Viscometer" having capacity 10ml.

It is computes using the formulae:

$$\eta_2 = \eta_1 (t_2/t_1)(\rho_2/\rho_1) \quad (2)$$

Where, η_2 = viscosity of the liquid, η_1 = viscosity of the distilled water, ρ_2 = density of the experimental liquid, ρ_1 = density of the distilled water, t_2 = time of flow of experimental liquid and t_1 = time of flow of distilled water.

Density:

Density (of solid, liquid, gases) is defined as the ratio of mass (in kilograms) to per unit volume (in cubic meters), provided in **table 3**.Density of the experimental sample is been calculated using a 30ml specific gravity bottle. Density is calculated as:

$$\rho_1 = \left(\frac{w_2}{w_1}\right)\rho_2 \quad (3)$$

Various thermo and acoustic parameters calculated by their dependency on velocity, density, viscosity and standard formulae.

1. Adiabatic Compressibility (β)

Adiabatic compressibility represented in **table 4**.

The relation is given as:

$$\beta = (1/V)(dV/\,d\rho) \quad (4)$$

It can also be computed from its relation with ultrasonic velocity (U) and density (ρ).

$$\beta = 1/(U^2 \times \rho) \quad (5)$$

2. Intermolecular Free Length (L_f)

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The intermolecular free length is given in **table 5** and is 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

3. Acoustic Impedance (Z)

Acoustic impedance is defined as the resistance felt by the waves during its propagation through the medium and is presented in **table 6**.

It is given as the product of density and velocity. Mathematically,

$$Z = \rho \times U \quad (8)$$

4. Ultrasonic Attenuation (α).

In **table 7** the ultrasonic attenuation is given and is defined as the rate of the decay of the energy when an ultrasonic wave travels through a medium. In simple words it means loss. This loss occurs because of absorption, scattering, reflection, refraction etc. fall in the intensity of wave is defined in terms of attenuation as:

$$\alpha / f^2 = 8 \pi^2 \eta / 3 \rho U^3 \quad (9)$$

Where, f = frequency of the wave.

Ultrasonic attenuation shows a growth in the graph as the frequency increases and is proportional to square of frequency (f) of the wave.

5. Relaxation Time (τ)

Relaxation time is defined as the time taken by the particles of the medium to come back to their mean position within the medium and is presented in **table 8**. Relaxation time is directly proportional to the absorption energy. Therefore more is the relaxation energy more is the absorption of the ultrasound energy.

Mathematically it is given as,

$$\tau = 4 \beta \eta / 3 \quad (10)$$

It is also represented as:

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$\tau = 4\,\eta / 3\,\rho\,U^2$ (11)

6. Effective Molecular weight (M_{eff})

In **table 9** effective molecular weight is evaluated as the sum of the atomic weights of all the constituent atoms. Mathematically,

$M_{eff} = X_1 M_1 + X_2 M_2$ (12)

7. Free Volume (V_f)

Free volume and is represented in **table 10**.

Mathematically, it is calculated as:

$V_f = [M_{eff}\, U / K\, \eta]^{3/2}$ (13)

Where, K = temperature dependent constant = 4.28×10^9

8. Molar Volume (V_m)

In **table 11** the Molar volume is provided which is defined as the volume occupied by the one mole of the respective chemical compound at any given temperature.

It is formulated as:

$V_m = M_{eff} / \rho$ (14)

Where, M_{eff} = effective molecular weight

ρ = density of sample.

9. Available Volume (V_a)

Available volume is formulated in terms of effective molecular weight, density and ultrasonic velocities, provided in **table 12**.

It is represented as:

$V_a = M / \rho\,(1 - U / U_\infty)$ (15)

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

ρ = density of sample liquid

U = ultrasonic velocity

U_∞ = velocity of sound at infinity = 1600 m / sec

10. Wada's Constant (W)

In **table 13** Wada's constant is defined which is calculate using the following formula,

$W = (\beta)^{-1/7}\, M_{eff} / \rho$ (16)

Where, W = Wada constant

β = Adiabatic Compressibility.

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11. 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)and the values are given in **table 14**.

It is given as,

$R = U^{1/3} M_{eff} / \rho$ (17)

Rao's constant is a temperature independent quantity.

12. Vander Waal Constant (b)

In **table 15** Vander Waal constant is given which is derived using the relation given by Vander Waal hence named after him. The equation is given as:

$b = V_m [1 – (RT / MU^2) \{(1 + (MU^2 / 3RT))^{1/2} – 1\}]$ (18)

Where, V_m = molar volume

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

13. Internal Pressure (π_i)

The forces of attraction and repulsion among the molecules of the liquid mixtures define the internal pressure. It is a measure of cohesive force which is a basic measurement for any liquid model. It has sensitive nature towards temperature, concentration and external pressure and the values are defined in **table 16**. Its value changes readily even with a small change in the mentioned quantities.

It is given as:

$\pi_i = b\ R\ T\ [(k\ \eta / U)^{1/2} (\rho^{2/3} / M^{7/6})]$ (19)

Where, b = cubic packing with value = 2 for liquids

R = gas constant = 8.31451

T = temperature at which experiment has been performed

k = dimensionless constant = 4.281×10^9

14. Enthalpy (H)

In **table 17** the values for Enthalpy are given, which is thermodynamic quantity including internal energy of the system and the product of the pressure and the volume possessed by the system. It is the total energy measurement of the system.

Enthalpy of any given system is given as:

$H = V_m \times \pi_i$ (20)

Where, V_m = molar volume

π_i = internal pressure

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15. Gibb's Free Energy

Gibb's free energy (IUPAC name) is also termed as free enthalpy.

Gibb's free energy= enthalpy of any given system–(product of entropy and absolute temperature)

It is also defined as the energy associated with any chemical reaction taking place that can be used to do the work and is represented in **table 18**.

The change in Gibb's free energy is given as:

$$\Delta G = K_B T \ln (K_B T \tau / h) \quad (21)$$

Where, K_B = Boltzmann constant

T = 295 K

h = Planck's constant = 6.634×10^{-34} J s

Result and Discussions:

Table 1: The experimental values of **Ultrasonic velocity against Mole Fraction** of binary mixture of Acetic Acid + Propan-2-ol at 303, 308, and 313 K at 2MHz.

Mole Fraction		303 K	308 K	313 K
X_1	X_2			
0.0	1.0	1092.8	1120.4	1140.5
0.1	0.9	1125.3	1155.6	1182.0
0.2	0.8	1120.5	1138.8	1154.8
0.3	0.7	1149.7	1160.4	1189.0
0.4	0.6	1135.0	1145.6	1165.0
0.5	0.5	1150.0	1163.1	1198.0
0.6	0.4	1140.6	1154.5	1179.2
0.7	0.3	1177.4	1196.7	1234.1
0.8	0.2	1152.8	1169.4	1218.5
0.9	0.1	1190.3	1232.5	1269.5
1.0	0.0	1167.5	1195.0	1243.5

Table 2: The experimental values of **Viscosity against Mole Frac**tion of binary mixture of Acetic Acid + Propan-2-ol at 303, 308, and 313 K at 2MHz.

Mole Fraction	303 K	308 K	313 K

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X_1	X_2	$\times 10^{-6}$	$\times 10^{-6}$	$\times 10^{-6}$
0.0	1.0	1.901	1.380	1.06
0.1	0.9	1.500	1.065	0.90
0.2	0.8	1.587	1.153	0.96
0.3	0.7	1.242	1.000	0.89
0.4	0.6	1.339	1.075	0.95
0.5	0.5	1.208	1.000	0.89
0.6	0.4	1.349	1.041	0.94
0.7	0.3	1.188	1.005	0.90
0.8	0.2	1.246	1.032	0.93
0.9	0.1	1.145	0.908	0.85
1.0	0.0	1.171	0.912	0.84

Table 3: The experimental values of **Density against Mole Fraction** of binary mixture of Acetic Acid + Propan-2-ol at 303, 308, and 313 K at 2MHz.

Table 4: The experimental values of **Adiabatic Compressibility against Mole Fraction** of binary mixture of Acetic Acid + Propan-2-ol at 303, 308, and 313 K at 2MHz.

Mole Fraction		**303 K**	**308 K**	**313 K**
X_1	X_2			
0.0	1.0	760.21	748.350	737.210
0.1	0.9	793.36	780.440	764.580
0.2	0.8	823.76	809.500	791.250
0.3	0.7	852.25	837.610	815.498
0.4	0.6	880.53	868.680	845.800
0.5	0.5	904.21	888.090	869.410
0.6	0.4	932.15	916.100	898.010
0.7	0.3	955.53	944.998	932.170
0.8	0.2	977.62	965.438	951.780
0.9	0.1	1006.22	991.790	983.910
1.0	0.0	1031.61	1022.100	1011.710

Mole Fraction		**303 K** $\times 10^{-10}$	**308 K** $\times 10^{-10}$	**313 K** $\times 10^{-10}$
X_1	X_2			
0.0	1.0	11.0150	10.6451	10.4284

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0.1	0.9	9.9539	9.5950	9.3614
0.2	0.8	9.6688	9.5255	9.4770
0.3	0.7	8.8769	8.8663	8.6738
0.4	0.6	8.8158	8.7715	8.7112
0.5	0.5	8.3624	8.3235	8.0142
0.6	0.4	8.2460	8.1897	8.0083
0.7	0.3	7.5493	7.3892	7.0437
0.8	0.2	7.6970	7.5744	7.0764
0.9	0.1	7.0144	6.6375	6.3063
1.0	0.0	7.1116	6.8512	6.3922

Table 5: The experimental values of **Intermolecular Free Length against Mole Fraction** of binary mixture of Acetic Acid + Propan-2-ol at 303, 308, and 313 K at 2MHz.

Mole Fraction		303 K	308 K	313 K
X_1	X_2	$\times 10^{-11}$	$\times 10^{-11}$	$\times 10^{-11}$
0.0	1.0	6.52278	6.41231	6.34672
0.1	0.9	6.20064	6.08783	6.01327
0.2	0.8	6.11122	6.06574	6.05029
0.3	0.7	5.85561	5.85209	5.78824
0.4	0.6	5.83542	5.80272	5.80070
0.5	0.5	5.68339	5.67015	5.56379
0.6	0.4	5.64370	5.62438	5.56175
0.7	0.3	5.40000	5.34243	5.21605
0.8	0.2	5.45257	5.40897	5.22813
0.9	0.1	5.20519	5.06341	4.93548
1.0	0.0	5.24113	5.14429	4.96897

Table 6: The experimental values of **Acoustic Impedance against Mole Fraction** of binary mixture of Acetic Acid + Propan-2-ol at 303, 308, and 313 K at 2MHz.

Mole Fraction		303 K	308 K	313 K
X_1	X_2	$\times 10^{6}$	$\times 10^{6}$	$\times 10^{6}$
0.0	1.0	0.83075	0.83845	0.84078
0.1	0.9	0.89276	0.90187	0.90373
0.2	0.8	0.92302	0.92185	0.91373

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0.3	0.7	0.97983	0.97196	0.96962
0.4	0.6	0.99940	0.99515	0.98535
0.5	0.5	1.03984	1.03294	1.04155
0.6	0.4	1.06321	1.05766	1.05893
0.7	0.3	1.12504	1.13088	1.15039
0.8	0.2	1.12700	1.12892	1.15974
0.9	0.1	1.19770	1.22238	1.24907
1.0	0.0	1.20440	1.22141	1.25806

Table 7: The experimental values of **Ultrasonic Attenuation against Mole Fraction** of binary mixture of Acetic Acid + Propan-2-ol at 303, 308, and 313 K at 2MHz.

Mole Fraction		303 K $\times 10^{-17}$	308 K $\times 10^{-17}$	313 K $\times 10^{-17}$
X_1	X_2			
0.0	1.0	5.03531	3.44733	2.54834
0.1	0.9	3.27458	2.32496	1.87828
0.2	0.8	3.45762	2.53570	2.06278
0.3	0.7	2.52133	2.00892	1.70898
0.4	0.6	2.73449	2.16410	1.86966
0.5	0.5	2.30958	1.88157	1.56363
0.6	0.4	2.56421	1.94157	1.68561
0.7	0.3	2.00276	1.63158	1.35810
0.8	0.2	2.18733	1.75749	1.42614
0.9	0.1	1.77407	1.28667	1.11802
1.0	0.0	1.87542	1.37476	1.13801

Table 8: The experimental values of **Relaxation Time against Mole Fraction** of binary mixture of Acetic Acid + Propan-2-ol at 303, 308, and 313 K at 2MHz.

Mole Fraction		303 K $\times 10^{-15}$	308 K $\times 10^{-15}$	313 K $\times 10^{-15}$
X_1	X_2			
0.0	1.0	2.79047	1.95870	1.47388
0.1	0.9	1.86868	1.36249	1.12587
0.2	0.8	1.96471	1.46439	1.20801
0.3	0.7	1.47002	1.18217	1.03046
0.4	0.6	1.57392	1.25725	1.10459
0.5	0.5	1.34692	1.10981	0.94995
0.6	0.4	1.48319	1.13673	1.00799

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0.7	0.3	1.19581	0.99015	0.84994
0.8	0.2	1.27873	1.04224	0.88124
0.9	0.1	1.07087	0.80420	0.71976
1.0	0.0	1.11037	0.83311	0.71763

Table 9: The experimental values of **Effective Molecular Weight against the Mole Fraction** of binary mixture of Acetic Acid + Propan-2-ol at 303, 308, and 313 K at 2MHz.

Mole Fraction		**303 K**	**308 K**	**313 K**
X_1	**X_2**			
0.0	1.0	60.100	60.100	60.100
0.1	0.9	60.095	60.095	60.095
0.2	0.8	60.090	60.090	60.090
0.3	0.7	60.085	60.085	60.085
0.4	0.6	60.080	60.080	60.080
0.5	0.5	60.075	60.075	60.075
0.6	0.4	60.070	60.070	60.070
0.7	0.3	60.065	60.065	60.065
0.8	0.2	60.060	60.060	60.060
0.9	0.1	60.055	60.055	60.055
1.0	0.0	60.050	60.050	60.050

Table 10: The experimental values of **Free Volume against the Mole Fraction** of binary mixture of Acetic Acid + Propan-2-ol at 303, 308, and 313 K at 2MHz.

Mole Fraction		**303 K**	**308 K**	**313 K**
X_1	**X_2**			
0.0	1.0	22.93422	38.49347	58.72597
0.1	0.9	34.18672	59.46737	78.92385
0.2	0.8	31.20973	51.63746	69.84108
0.3	0.7	46.84658	65.74989	81.08484
0.4	0.6	41.04423	57.85835	71.30949
0.5	0.5	48.84514	65.96303	82.26358
0.6	0.4	40.87925	61.40951	73.40810
0.7	0.3	51.87140	68.31175	83.71807
0.8	0.2	46.78065	63.40703	78.33040

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0.9	0.1	55.71018	83.02477	94.92848
1.0	0.0	52.31833	78.82491	94.32013

Table 11: The experimental values of **Molar Volume against the Mole Fraction** of binary mixture of Acetic Acid + Propan-2-ol at 303, 308, and 313 K at 2MHz.

Mole Fraction		**303 K**	**308 K**	**313 K**
X_1	**X_2**			
0	1	0.07906	0.08031	0.08152
0.1	0.9	0.07575	0.07700	0.07860
0.2	0.8	0.07295	0.07423	0.07594
0.3	0.7	0.07050	0.07173	0.07368
0.4	0.6	0.06823	0.06916	0.07103
0.5	0.5	0.06644	0.06765	0.06910
0.6	0.4	0.06444	0.06557	0.06689
0.7	0.3	0.06286	0.06356	0.06444
0.8	0.2	0.06143	0.06221	0.06310
0.9	0.1	0.05968	0.06055	0.06104
1	0	0.05821	0.05875	0.05935

Table 12: The experimental values of **Available Volume against the Mole Fraction** of binary mixture of Acetic Acid + Propan-2-ol at 303, 308, and 313 K at 2MHz.

Mole Fraction		**303 K**	**308 K**	**313 K**
X_1	**X_2**			
0	1	0.02506	0.02407	0.02341
0.1	0.9	0.02247	0.02139	0.02053
0.2	0.8	0.02186	0.02140	0.02113
0.3	0.7	0.01984	0.01971	0.01893
0.4	0.6	0.01983	0.01964	0.01931
0.5	0.5	0.01869	0.01847	0.01736
0.6	0.4	0.01850	0.01826	0.01759
0.7	0.3	0.01660	0.01602	0.01474
0.8	0.2	0.01717	0.01674	0.01505
0.9	0.1	0.01528	0.01391	0.01261
1	0	0.01573	0.01487	0.01323

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Table 13: The experimental values of **Wada's Constant against the Mole Fraction** of binary mixture of Acetic Acid + Propan-2-ol at 303, 308, and 313 K at 2MHz.

Mole Fraction		303 K	308 K	313 K
X_1	X_2			
0.0	1.0	1.50542	1.53676	1.56457
0.1	0.9	1.46342	1.49547	1.53188
0.2	0.8	1.41516	1.44316	1.47753
0.3	0.7	1.38454	1.40898	1.45172
0.4	0.6	1.34128	1.36056	1.39874
0.5	0.5	1.31593	1.34071	1.37695
0.6	0.4	1.27894	1.30262	1.33312
0.7	0.3	1.26338	1.28138	1.30793
0.8	0.2	1.23132	1.24972	1.28002
0.9	0.1	1.21219	1.23957	1.25867
1.0	0.0	1.17994	1.19728	1.22162

Table 14: The experimental values of **Rao's Constant against the Mole Fraction** of binary mixture of Acetic Acid + Propan-2-ol at 303, 308, and 313 K at 2MHz.

Mole Fraction		303 K	308 K	313 K
X_1	X_2			
0.0	1.0	0.81431	0.83412	0.85176
0.1	0.9	0.78788	0.80804	0.83104
0.2	0.8	0.75766	0.77518	0.79675
0.3	0.7	0.73857	0.75381	0.78056
0.4	0.6	0.71173	0.72368	0.74743
0.5	0.5	0.69608	0.71139	0.73387
0.6	0.4	0.67331	0.68788	0.70671
0.7	0.3	0.66377	0.67482	0.69116
0.8	0.2	0.64417	0.65541	0.67400
0.9	0.1	0.63252	0.64922	0.66090
1.0	0.0	0.61294	0.62346	0.63827

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Table 15: The experimental values of **Vander Waal Constant against the Mole Fraction** of binary mixture of Acetic Acid + Propan-2-ol at 303, 308, and 313 K at 2MHz.

Mole Fraction		303 K	308 K	313 K
X_1	X_2			
0.0	1.0	0.07879	0.08005	0.08126
0.1	0.9	0.07550	0.07676	0.07835
0.2	0.8	0.07271	0.07399	0.07570
0.3	0.7	0.07028	0.07151	0.07345
0.4	0.6	0.06801	0.06894	0.07081
0.5	0.5	0.06623	0.06743	0.06889
0.6	0.4	0.06423	0.06536	0.06668
0.7	0.3	0.06266	0.06337	0.06424
0.8	0.2	0.06124	0.06201	0.06291
0.9	0.1	0.05950	0.06037	0.06086
1.0	0.0	0.05803	0.05857	0.05918

Table.16: The experimental values of **Internal pressure against the Mole Fraction** of binary mixture of Acetic Acid + Propan-2-ol at 303, 308, and 313 K at 2MHz.

Mole Fraction		303 K	308 K	313 K
X_1	X_2			
0.0	1.0	21.359020	18.513710	16.505900
0.1	0.9	329.24683	284.15016	260.36424
0.2	0.8	328.30085	284.92446	259.61929
0.3	0.7	281.65058	253.02284	238.07749
0.4	0.6	284.48393	254.87484	239.85717
0.5	0.5	260.74730	237.32576	222.06963
0.6	0.4	268.97579	236.22775	224.08180
0.7	0.3	242.43445	222.00392	208.41579
0.8	0.2	245.33266	222.61890	208.48244
0.9	0.1	217.65525	191.48413	183.61841
1.0	0.0	226.13826	197.87943	187.04091

Table 17: The experimental values of **Enthalpy against the Mole Fraction** of binary mixture of Acetic Acid + Propan-2-ol at 303, 308, and 313 K at 2MHz.

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Mole Fraction		303 K	308 K	313 K
X_1	X_2			
0.0	1.0	0.899080	0.791660	0.716470
0.1	0.9	16.91137	14.83665	13.87669
0.2	0.8	19.72770	17.42280	16.24159
0.3	0.7	19.25039	17.59599	17.00558
0.4	0.6	21.64654	19.65812	19.00027
0.5	0.5	21.84405	20.24280	19.34849
0.6	0.4	24.38283	21.78937	21.08541
0.7	0.3	23.65913	21.90678	20.84896
0.8	0.2	25.59679	23.52003	22.34257
0.9	0.1	30.18603	26.94281	26.04298
1.0	0.0	26.19548	23.13530	22.09268

Table 18: The experimental values of **Gibb's Free Energy against the Mole Fraction** of binary mixture of Acetic Acid + Propan-2-ol at 303, 308, and 313 K at 2MHz.

Mole Fraction		303 K $\times 10^{-20}$	308 K $\times 10^{-20}$	313 K $\times 10^{-20}$
X_1	X_2			
0.0	1.0	-1.68928	-1.83750	-1.95641
0.1	0.9	-1.83070	-1.98927	-2.06903
0.2	0.8	-1.81928	-1.95911	-2.03959
0.3	0.7	-1.95750	-2.04863	-2.10606
0.4	0.6	-1.92895	-2.02288	-2.07701
0.5	0.5	-1.99407	-2.07504	-2.14007
0.6	0.4	-1.95377	-2.06501	-2.11528
0.7	0.3	-2.04383	-2.12274	-2.18659
0.8	0.2	-2.01580	-2.10130	-2.17146
0.9	0.1	-2.08997	-2.20972	-2.25610
1.0	0.0	-2.07483	-2.19495	-2.25734

The Binary Mixture of Acetic Acid + Propan-2-ol is used to understand the intermolecular interactions occurring in the sample liquid. This work is done with some certain conditions. Values are obtained at three different temperatures and at a constant frequency (2MHz) using 11 different concentrations of the mixture.

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The values of Ultrasonic Velocity (U), viscosity (η) and density (ρ) are obtained experimentally. Other parameters as: Acoustic Impedance (Z), Adiabatic Compressibility (β), Intermolecular Free Length (L_f), Ultrasonic Attenuation (α), Relaxation Time (τ), Effective Molecular Weight (M_{eff}), Free Volume (V_f), Wada's Constant (W), Rao's Constant (R), Molar Volume (V_m), Vander Waal Constant (b), Internal pressure (π_i), Available Volume (V_a), Gibb's Free Energy (ΔG) and Enthalpy (H) are evaluated using the values of velocity, viscosity, density and some standard formulae.

The experimental values of **ultrasonic velocity (U), viscosity (η) and density (ρ)** for the binary mixtures of Acetic Acid and Propan-2-ol with respect to different concentrations at three different temperatures (303, 308, and 313) K are provided given in the following tables.

Conclusions

The ultrasonic investigation of binary mixture of Acetic acid and Propan-2-ol indicates the presence of Molecular Interaction***s*** among the molecules of the experimental liquid sample. Density showed a linear decrease with increasing time. Ultrasonic velocity, viscosity and various thermo and acoustical parameters depending on the mentioned quantities as relaxation time, acoustic impedance, intermolecular free length, adiabatic compressibility, ultrasonic attenuation, internal pressure and other theoretical variables as Gibb's energy, Vander Waal Constant etc. exhibited a zig-zag pattern concluding very strong molecular interactions between the molecules which goes in accordance with the theoretical explanation as well. These variable readings obtained from the parameters gives the evidence of the presence of hydrogen bonds and strong bond formation in the liquid. They also tell about the closely packed structure of the molecules as the interaction forces are found to be stronger for solute – solvent mixture.

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