Molecular Interactions in Liquid Mixture of 2-Hydroxy-5-Sulpho Benzoic Acid in 50% Ethanol.

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Abstract

The study of behaviour of propagation of ultrasonic waves in liquid system and solids is now rather well established as an effective means for examining certain physical properties of the materials. These physical properties, their dependence on the compositions, structure of the substance and other external factors, which affect the dielectric liquid can be extensively studied using the theoretical evaluation of ultrasonic parameters, such properties can be studied by explaining the liquid or solid materials to ultrasonic vibrations.The system chosen for this study is solution of 2-hudroxy-5-sulpho benzoic acid(5-sulpho salicylic acid) in 50% ethanol with concentrations 0.1M,0.01M and 0.001M. at temperatures 298K,303K and 308K. the experimental value of ultrasonic velocity was measured at 4MHz frequency and density, viscosity were measured at different temperature for different concentration.and used for the calculations for various acoustical parameters like free length, acoustic impedance, Raos constant, Wadas constant, adiabatic compressibility etc. suitable interpretations are given based on the results obtained. The various results obtained show the molecular interactions of liquid mixture due to the hydrogen bonding and dipole interactive forces.

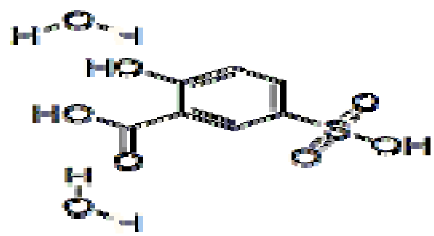
Keywords: Adiabatic compressibility, Rao's Constant, Wada's Constant, Ultrasonic velocity, etc.

Introduction:-

At present ultrasonic study is a subject of extensive research and finds its usefulness in the fields of geography, geology, medicine, polymers, industry etc. It has been applied to process monitoring and material characterizatioon[1-3]. Also the ultrasonic technique, due to its simplicity and accuracy is being most widely used in the study of liquid state, the most complicated among the three states of matter. Ultrasonic studies in binary solutions have drawn the attention of several researchers[4-5] in the recent years.

Ultrasonic velocity together with density, viscosity data furnish a wealth of information about the sum total of interactions between ions, dipoles, hydrogen bonding, multipolar and dispersion forces[6-9]. Now ultrasonic studies are very helpful to understand the structure of molecule and molecular interactions in solutions that provide the knowledge on the solvophilic and solvophobic nature of polymers [10-11].

The present paper deals with the study in the binary liquid mixture of 5-sulpho salicylic acid and ethanol, at 298K,303Kand 308 K. further the data has been obtained at different concentration with a view to understand the effect of temperature on these properties.



2-Hudroxy-5-Sulpho Benzoic acid

Experimental Section

Materials

Analytical Range (AR) 5-sulpho salicylic acid di hydrate is used in the present work. The solutions were prepared by using50% alcohol as solvent. Ethanol used to prepare solvent was 99.9% pure and double distilled water was used. The concentration range selected was 0.1M, 0.01M and 0.001M.

Methods

All the weighing was done on digital electronic balance Model-CB/CA/CT-Series Contech having accuracy ± 0.0001g.

The densities of the solutions were measured accurately using digital densitometer (Model-DMA Anton Paar). Viscosity of the solutions was measured by Ostwald's viscometer which was calibrated with benzene and double distilled water at all three temperatures. The values are accurate to±0.001 cp.

The ultrasonic velocity was measured by using ultrasonic multi frequency interferometer (Model- M-83) supplied by Mittal Enterprises New Delhi, operating at 4MHz frequency with an accuracy of ±2 m/s. the principle used in the measurement of ultrasonic velocity through medium is based on the accurate determination of wavelength of ultrasonic waves of known frequency produced by quartz crystal in measuring cell. The temperature of the solution was controlled by circulating water through the jacket of doubled walled cell. Measurements were made using constant temperature bath within ±0.01K.

Results and Discussion

The experimentally measured values of density, viscosity and sound speed of solutions of 5-sulpho salicylic acid di hydrate in 50% alcohol at 298K, 303K and 308K are given in **Table 1.**

The acoustical parameters were calculated from v, η and d values using standard formulae, and given in **Table 2,3 and 4.**

1) Adiabatic Compressibility - $\beta = 1/v^2 \rho_S$ …(1)

2) Intermolecular free length - $L_f = K \sqrt{\beta_S}$ …(2)

3) Specific acoustic impedance - $Z = v_s . \rho_S$ …(3)

4) Rao's Constant - $R = (M_{eff} / \rho_S) \times v^{1/3}$ …(4)

5) Wada's Constant - $W = (M_{eff} / \rho_S) \times \beta^{-1/7}$ …(5)

6) Relative Association - $R_A = \rho_S / \rho_O [v_o / v_s]^{1/3}$ …(7)

7) Relaxation time - $\tau = 4/3 \beta \times \eta$ …(8)

8) Free Volume - $Vf = M_{eff} \times v_s / k \times \eta$ …(9)

Where $k = 4.28\times10^9$, Temperature Independent Constant for all liquids.

9) Equivalent Conductance - $\mu = Kc[1000/M]$ ...(10)

Table 1: Density, Velocity and Viscosity at 298, 303, 308 K (At Frequency-4MHz)

Sr.No.	Temperature(K)	Concentration(M)	Density(ρ_S) (Kg/m3)	Velocity(v_s) (m/s)	Viscosity(η) (Pa.S.) or Kg m^{-1} s^{-1}
1	298	0.1	940	4887.2	2.39E-03
2		0.01	938.8	5987.2	2.20E-03
3		0.001	935	6334.4	2.16E-03
4	303	0.1	937.3	4884.2	2.13E-03
5		0.01	936	5615.1	1.99E-03
6		0.001	934.5	6838.4	1.98E-03
7	308	0.1	935.8	4867.6	1.88E-03
8		0.01	934.2	5004.6	1.71E-03
9		0.001	932.7	7344.8	1.69E-03

Table 2 :- Adiabatic Compressibility, Acoustic impedance and Free length at .298, 303, 3080 K.

Sr.No.	Temperature (K)	Concentration M	Adiabatic Compressibility (β_S)Pa^{-1}E-11	Acoustic Impedance Z ($Kgm^{-2}S^{-1}$)	Free length L_f (m)
1	298	0.1	4.45402E-11	4593968	1.31E-11
2		0.01	2.97152E-11	5620783	1.07E-11
3		0.001	2.66549E-11	5922664	1.02E-11
4	303	0.1	4.47234E-11	4577961	1.32E-11
5		0.01	3.38851E-11	5255734	1.15E-11
6		0.001	2.28829E-11	6390485	9.47E-12
7	308	0.1	4.51011E-11	4555100	1.34E-11
8		0.01	4.27387E-11	4675297	1.31E-11
9		0.001	1.98746E-11	6850495	8.92E-12

Table 3 : Relative association,and relaxation time

Sr.No.	Temperature(K)	Concentration(M)	Relative Association (R_A)	Relaxation Time τ
1	298	0.1	1.08E+00	1.42E-13
2		0.01	1.01E+00	8.72E-14
3		0.001	9.84E-01	7.68E-14
4	303	0.1	1.09E+00	1.27E-13
5		0.01	1.04E+00	9.00E-14
6		0.001	9.72E-01	6.03E-14
7	308	0.1	1.10E+00	1.13E-13
8		0.01	1.09E+00	9.77E-14
9		0.001	9.59E-01	4.48E-14

Table 4 : Rao's Constant, Wada's Constant, Free volume and Equivalent conductance.

Sr.No.	Temperature(K).	Concentration (M)	Rao's Constant (R)	Wada's Constant (W)	Free Volume(V_f)	μ=Kc[1000/ M] mhos mol
1	298	0.1	1.75E-03	3.11E-03	3.169E-07	115.4
2		0.01	1.86E-03	3.27E-03	4.79E-07	155
3		0.001	1.90E-03	3.33E-03	5.344E-07	193
4	303	0.1	1.76E-03	3.11E-03	3.746E-07	131.1
5		0.01	1.82E-03	3.21E-03	5.029E-07	180
6		0.001	1.95E-03	3.40E-03	6.841E-07	220
7	308	0.1	1.75E-03	3.11E-03	4.471E-07	160.4
8		0.01	1.76E-03	3.11E-03	5.287E-07	207
9		0.001	2.00E-03	3.47E-03	9.589E-07	260

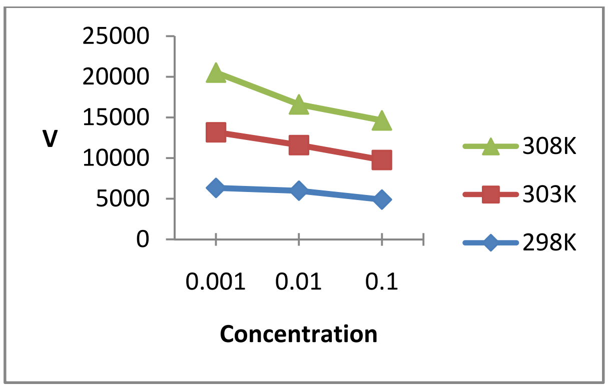


Fig-1 Velocity vs conc.

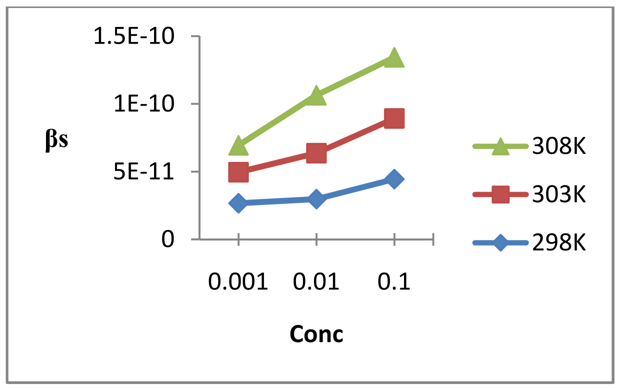


Fig-2 Adiabatic compressibility vs conc.

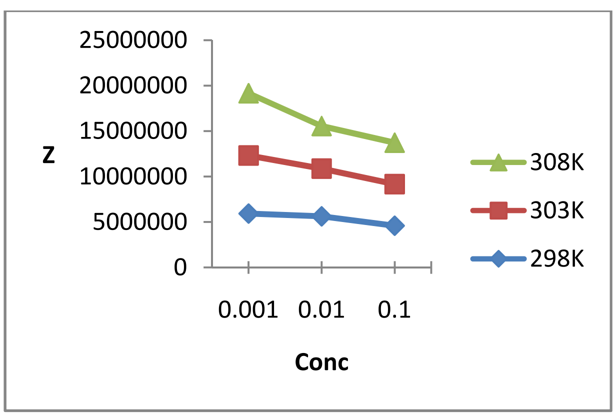


Fig-3 Acoustic Impedance vs conc.

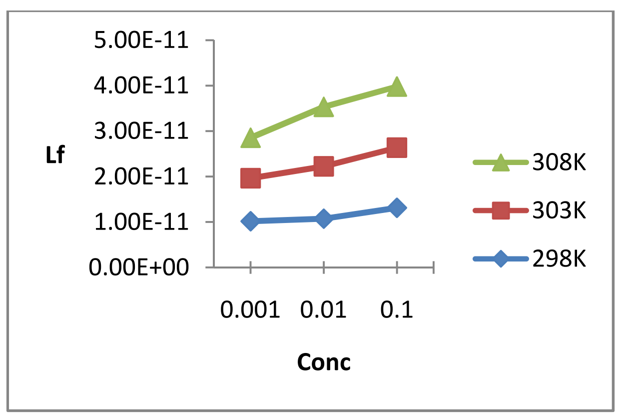


Fig-4 Free length vs conc.

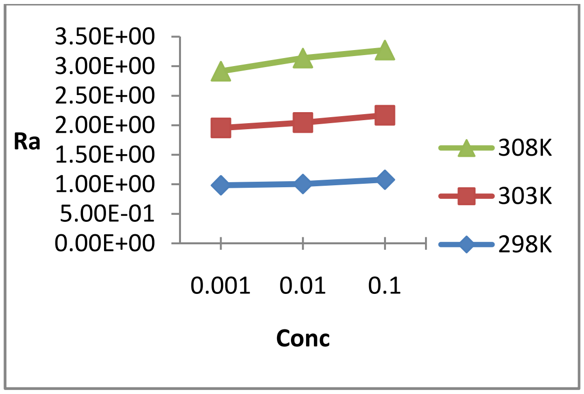


Fig-5 Relative association vs conc.

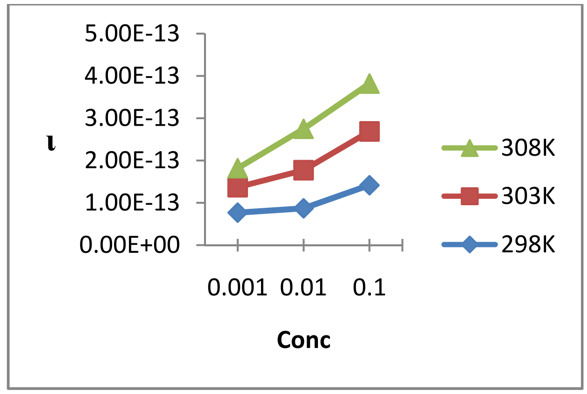


Fig-6 Relaxation time vs conc.

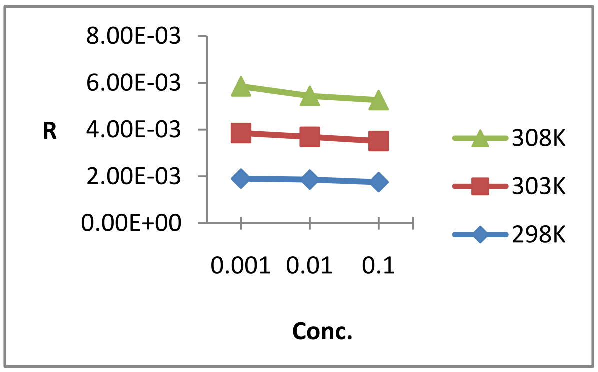


Fig-7 Rao's Constant vs conc.

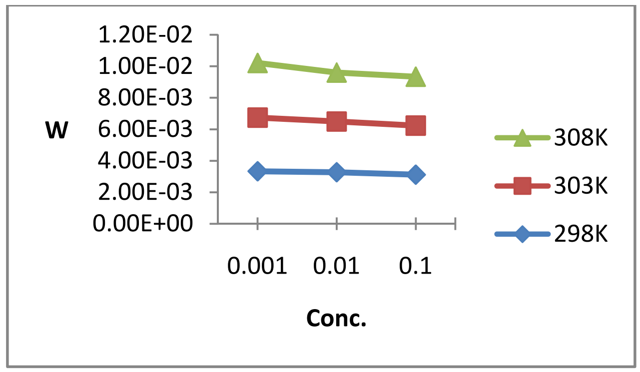


Fig-8 , Wada's Constant vs conc

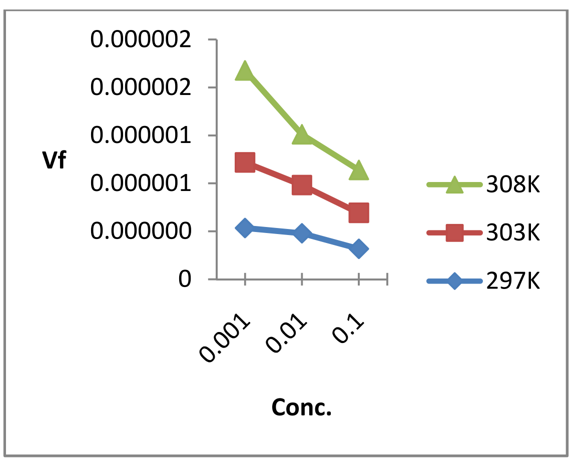


Fig-9 Free volume vs conc.

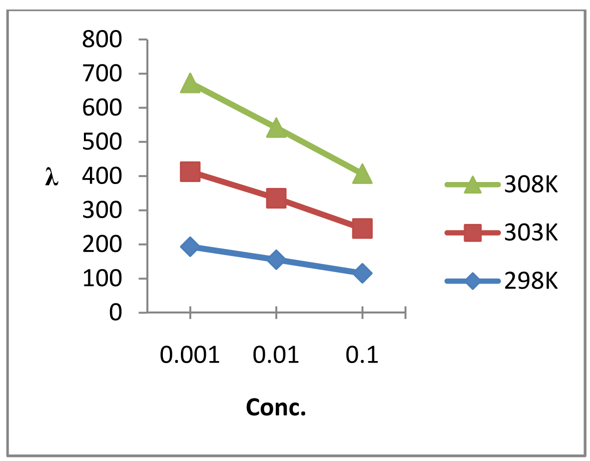


Fig-10 Molar conductance vs conc.

The plots of ultrasonic velocity against concentration at different temperatures are shown in **Fig 1.** These plots are almost linear with positive slope indicating the existence of very weak intermolecular attraction in this system. Adiabatic compressibility (βs), intermolecular free length (L_f) values are calculated for binary systems investigated and values are prepared in **Table 2**. Since adiabatic compressibility is inversely proportional to V^2, the trend in adiabatic compressibility with concentration is the reverse of the trend in ultrasonic velocity with concentrations in the binary systems.

Generally the interactions are very weak in dilute solutions and the interactions are strong in concentrated solutions. In this case, there is weak interaction in between the components. The decrease in the values of adiabatic compressibility and free length **(Fig-2 and 4)** indicates the closer packing of molecules inside the shield[12]. The intermolecular free length in binary liquid mixture can be used to assess the attraction between component molecules.

In general, when the value of the free volume (V_f) in liquid increases, the values of (L_f) also increases with decrease in ultrasonic velocity. Rate process in liquids is determined by the free volume. So the free volume plays an important role in ultrasound wave propagation. The values are reported in **Table 2 and 4**. Free volume increases with decrease in concentration and free length decreases with decrease in concentration showing weak molecular interactions.

Acoustic impedance values are found to increase with decrease in concentration Fig.3. The linear variation of Z with concentration confirms the presence of molecular association between the solute-solvent molecules.

Viscosity is an important factor to be considered for binary solution. It is observed that, the viscosity decreases linearly with decrease in concentration of solution, **Table 1**, The decrease in viscosity with concentration may be due to the interaction of 5-sulphosalicylic acid molecules with ethanol and water molecules. The viscosity decreases as a function of temperature for all concentrations due to thermal effect[13] .

Relative association is an acoustic property of understanding interaction, which is influenced[12] by two opposing factors 1) breaking of solvent structure on addition of solute to it, 2) solution of the solutes, those are simultaneously present, by the free solvent molecules. From fig-5, it is seen that relative association R_A decreases with decrease in concentration indicating that breaking of solvent structure predomites over the solvation of solute .The values of Rao's constant, Wada's constant for the present binary systems are shown in table **4** and the variations of these quantities with concentration are shown in figures **7 and 8.**

The variations in the values of Rao's constant, Wada's constant are found to be nonlinear and show the presence of solute-solvent interactions.

Conclusion

The derived acoustical parameters and their values hint to the presence of weak interactions and dispersive interactions between the component molecules in the mixture studied and the inherent nature of alcohols predominate the existing dispersive interactions.

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