Thermodynamic Study of Binary Mixture of Tannic Acid and Acetone at Different Tempratures and Concentration

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Abstract: ***Tannins are of great importance in medicines and chemical industry. Tannins due their significant importance require the deep studies of their structural behavior. Ultrasonic parameter measurements reveal the thermodynamic properties of the liquid mixture. Here we have used the binary mixture of tannic acid in acetone. The study carried out at 298K, 303K & 308K temperature for measurement of acoustic impedance (z) adiabatic compressibility (βa) relaxation time (τ) for different concentration of binary solution of tannic acid and acetone. The variation in ultrasonic velocity and other parameters play a significant role in understanding solute-solvent interaction between the constituent molecules. The variation of ultrasonic velocity, density(ρ), viscosity(η), relaxation time(τ) and acoustic impedance(z) indicate the presence of strong intermolecular interaction between the components of constituents' molecules. Increase in velocity and decrease in adiabatic compressibility shows strong association and dipole- dipole interaction in the constituents' molecules.*** ***Keywords: - adiabatic compressibility, relaxation time***

1. Introduction

Ultrasonic investigations of liquid mixtures consist of polar and non-polar components are of considerable importance in understanding intermolecular interactions between the component molecules and find applications in several industrial and technological processes. The ultrasonic studies in binary liquids are essential for utilizing them in medical technology. Such studies as functions of concentration are useful in giving insight into the structural and bonding of associated molecular complexes and other molecular processes. The variation of ultrasonic velocity and other acoustical properties provide valuable information about the molecular environments and are helpful assessing the degree of association between the molecules. Scientific and practical interest has been stimulated by investigation of organic liquids by ultrasonic measurements. Studies involving density & viscosity measurements are important for revelation of ion-solvent, ion-ion & solvent-solvent interaction in mixed solvent systems. Therefore it was though worthwhile to understand ultrasonic study on some binary liquids & their mixtures. Ultrasonic parameters are extensively being used to study molecular interaction in pure liquids, binary mixtures & ionic interaction in single & mixed solution of tannins. Tannic acid is not a single constituent but a type of hydrolysable tannin that contain several units of Gallic or ellagic acid esterifies with glucoses -OH to produce complex tannin compounds [16].

Here the attempts have been made for experimental investigations of derived parameters such as the ultrasonic velocity(u), adiabatic compressibility (βa), density(ρ), and viscosity(η) of pure binary liquid tannic acid in acetone at various molar concentrations in the range of 0.1mol to 0.09 mol. The ultrasound frequency used was 2MHz at 298K, 303Kand 308K. Tannic acid is not a single constituent but a type of hydrolysable tannin that contain several units of Gallic or ellagic acid esterifies with glucoses -OH to produce complex tannin compound[16].

Adiabatic compressibility has been calculated from the ultrasonic velocity (u) and density (ρ) of the medium using the equation as

$$\beta_a = 1 / u^2\rho \ kg^{-1}ms^2 \quad \ldots\ldots\ldots (1)$$

It is a measure of solvent-solute chemical interaction and the point of reference for the molecular orientation. We have also calculated intermolecular free length as

$$L_f = K_T (\beta_a)^{1/2} \ m \quad \ldots\ldots\ldots\ldots (2)$$

Where K_T is Jacobson's constant.

Beyer and Letcher considered the case of plane harmonic wave & obtained a relation for acoustic impedance (Z) as

$$Z = \rho u \quad \ldots\ldots\ldots\ldots\ldots.. (3)$$

2. Materials and Methods

The liquid mixture of various concentrations in mole fraction was prepared by taking AR grade chemicals. The study was carried out for the temperatures 298K, 303K & 308K at fixed frequency 2MHz. The temperature of the liquid mixture was kept constant within an accuracy of $\pm 0.1^0$C by using thermostat U-10. The experimental temperature was maintained constant by circulating water with the help of thermostatic water bath .Viscosity measurements were taken using Ostwald's viscometer with an accuracy of $\pm 0.1 Kg/m^3$.The flow of time was measured by a digital stop watch capable of registering time accurate to ±0.1sec.An average of three sets of flow of time for each solution was taken for the purpose of calculation of viscosity. The density of the solution was determined accurately using 10 ml specific gravity bottle and electronic balance and accuracy in the density measurement is $\pm 1x10^{-5} gm/cm^3$.An average of triple measurements was taken into account.

Ultrasonic velocity has been measurement by Multi frequency interferometer (Mittal enterprises, M-83, New Delhi) operating at a frequency range 1MHz to 10MHz with an accuracy of ±0.01 m/s. The source of ultrasonic waves was a quartz crystal excited by a radio frequency oscillator. The cell was filled with desired solution and water at constant temperature was circulated in the outer jacket.

3. Results and Discussion

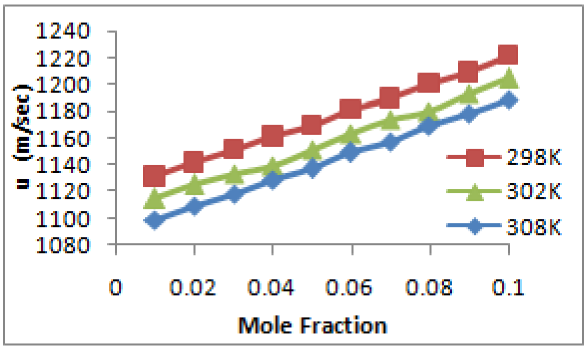

Figure 1: Variation of Ultrasonic Velocity versus molar concentration at different temperature

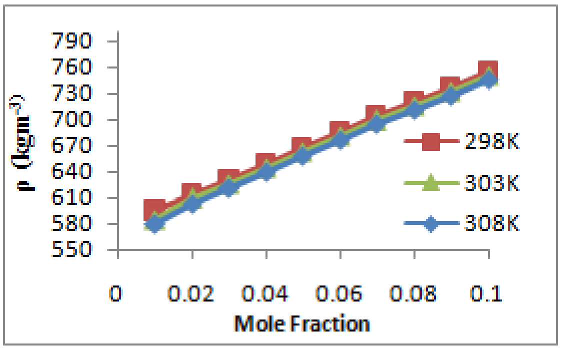

Figure 2: Variation of Density versus molar concentration at different temperature

It is observed that in fig.(1) velocity increases with concentration of Tannic Acid in acetone. This indicates that strong interaction observed at higher concentrations. With rise in mol concentration the number of particles in a given region increases and this leads to quick transfer of ultrasonic energy increasing ultrasound velocity .When temperature is increased the density of solution is decreased so that number of particles in a given region decreases hence there is no quick transfer of sound energy and thus velocity also decreases [10-13].

It is evident from fig. (2) that the density of solution increases continuously with the increase in mol concentration and decrease in temperature. When temperature is increased the density of solution is decreased so that number of particles in a given region decreases.

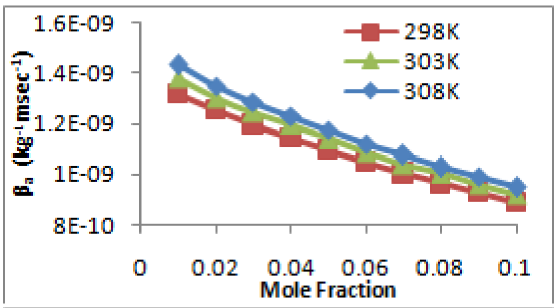

Figure 3: Variation of Adiabatic Compressibility versus molar concentration at different temperature

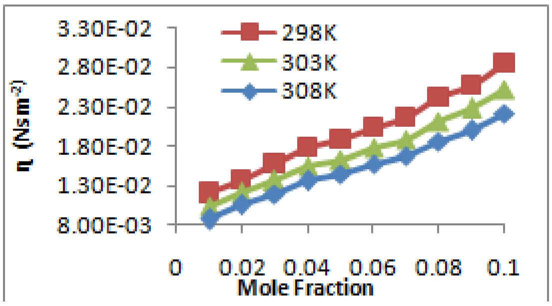

Figure 4: Variation of Viscosity versus molar concentration at different temperature

It is observed from fig. (3) that adiabatic compressibility decreases with decreasing temperature and increase of solute concentration for the systems. The decrease of adiabatic compressibility with increasing concentration clearly indicates the presence of solute-solvent interactions due to aggregation of solvent molecules around solute molecules. A strong intermolecular H-bonding interaction exists between Tannic acid and acetone.(11-13)

It is observed that in fig. (4) Variation in viscosity indicates the presence of intermolecular interactions between the Tannic acid and acetone. Viscosity of solution increases with the increase in molar concentration and decrease in temperature. The increasing concentration of solution supports non splitting of molecules hence there is increase in viscosity but when there is an increase in temperature of solution of molecules get apart hence viscosity decreases [14-15].

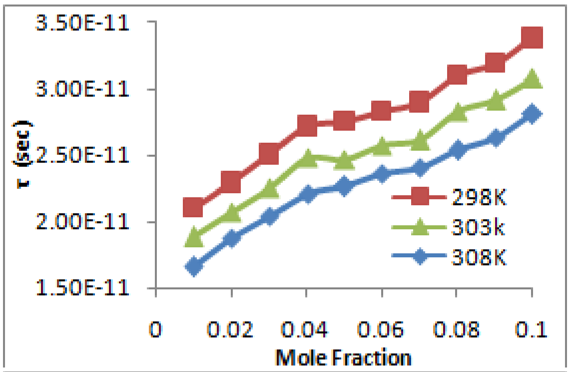

Figure 5: Variation of Relaxation Time versus molar Concentration at different temperatures

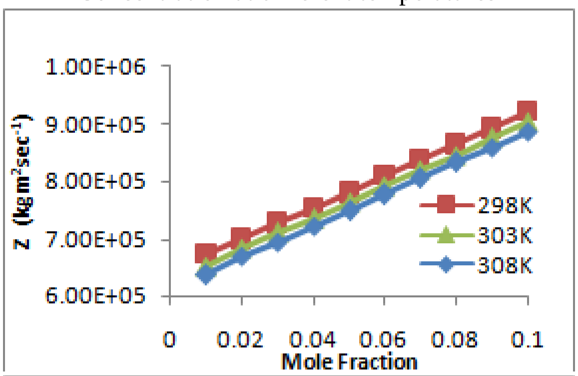

Figure 6: Variation of Acoustic Impedance versus molar concentration at different temperature

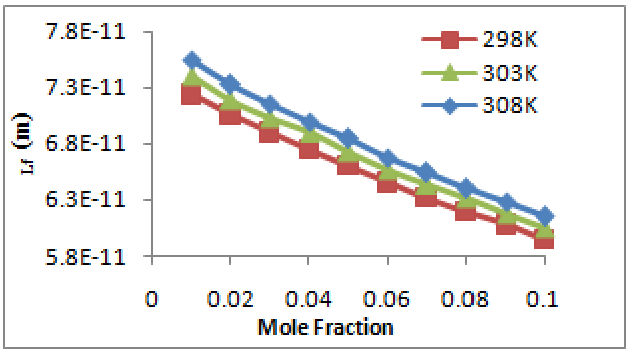

Figure 7: Variation of Free Length versus molar concentration at different temperatures

It is observed that in fig. (5) the relaxation time increases with increase in concentration and decrease in temperature of solution. The variation of relaxation time is a cumulative effect of the density ,viscosity and ultrasonic velocity.

It is evident from fig.(6) that the acoustic impedance increases with decrease in temperature and increase in concentration of solution. The increase of acoustic impendence with concentration is due to the effective solute-solvent interactions.

It is observed that in fig.(7) Ultrasonic velocity (u) is related to intermolecular free length. As the free length decreases due to the increase in concentrations of solutes, the ultrasonic velocity has to increase. that free length decreases with increase of mole fraction of the solute in system. This may lead to the presence of specific molecular interaction between the molecules of the liquid mixture. Intermolecular free length which is the distance between the surfaces of the neighboring molecules. The decrease in intermolecular free length indicates the interaction between the solute and solvent molecules due to which the structural arrangement in the neighborhood of constituent ions or molecules gets affected considerably. Decrease in intermolecular free length in system leads to positive deviation in sound velocity and negative deviation in compressibility. This indicates that the molecules are nearer in the system. (15-16)

Figures (1-7) represents the variation of ultrasonic velocity, density, viscosity, adiabatic compressibility, acoustic impedance, relaxation time and free length versus molar concentration of binary liquid mixtures of tannic acid with acetone at temperatures 298 K, 303K and 308K.

4. Conclusions

1. Increase in ultrasonic velocity with increase in molar concentration in this binary liquid system is due to molecular aggrigation between the constituents molecules.
2. Nonlinear variation of thermo acoustics parameters with molar concentration shows the strong intermolecular interactions between the constituent molecules. Decrease in adiabatic compressibility and increase in acoustic impedance with increase in molar concentration is due to association in the constituent molecules.
3. The nonlinear variation of thermo acoustic parameters with molar concentration provides useful information about nature of intermolecular forces existing in binary liquid mixtures.

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