International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064, Impact Factor (2013): 4.438
www.ijsr.net

Thermo-Acoustical Studies on Biologically Active Compound Pantothenic Acid at 298 K

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Abstract: ***Density, viscosity and ultrasonic velocity have been measured for binary liquid mixtures at 298 K. Acoustical parameters provide information about various intra and intermolecular interactions in solution. The pantothenic acid (vitamin B_5) occurs in all types of animal tissues as a component of coenzyme-A and of acryl carrier proteins (ACP). The richest sources of vitamin are liver, kidney, heart, spleen, brain, pancreas, tongue and spleen. So, it was thought better to study intermolecular interaction and thus behavior of pantothenic acid under varied conditions such as temperature, concentration etc. Ultrasonic velocity, adiabatic compressibility and other related parameters of the solution are computed on the basis of these measurements. The observed and calculated thermo-acoustical parameters are analyzed.***

Keywords: Ultrasonic velocity, Compressibility, Thermo-acoustical parameters

1. Introduction

Recently, considerable interest has been developed in the ultrasonic studies of biologically active materials[1-3] and drugs[4]. The pharmaceutical industry, medicinal drugs used for the prevention and control of disease is one of the strongest fields of 21st century. Millions of people worldwide depend on the prescript drug in their daily lives. Drug action has been widely recognized to be the ultimate consequence of physico-chemical interactions between the drug and functionally important molecules in the living organism known as receptors[5]. Drugs receptor interaction is necessarily complex involving a number of physico-chemical interactions like ionic and covalent bonding, dipole-dipole, ion-dipole interaction, charge transfer, hydrogen bonding, and hydrophobic interaction[6-10] etc.

Pantothenic acid is important for every metabolism in the initiation of nerve impulses. Naturally occurring bi-material found in some animal organs. The symptoms of vitamin B_5 deficiency in man are not known with certainty. However, its deficiency in man may cause burning sensation, muscle weakness, abdominal disorder and general depression. Vitamin B_5 is also capable of promoting the growth of yeast and of bacteria[11].

In the present paper, various ultrasonic parameters in aq. solution of Pantothenic acid at various concentrations have been evaluated at 298 K. The results obtained are analyzed.

2. Experimental

Computation of the acoustical parameters require measurement of ultrasonic velocity (u), viscosity(η) and density (ρ). Analar grade Pantothenic acid was used and aq. solutions with different concentration were prepared using double distilled water. Ultrasonic velocity at a frequency of 5 MHz was measured by using an automatic ultrasonic attenuation recorder (AUAR-102) and frequency counter APLAB-1116. The measurements were carried out by pulse echo overlap (PEO) technique. A specially designed glass cell along with monopan balance permitted to achieve accuracy of 1 in 10^4 gm in density measurement. Viscosity was measured by Ostwald's viscometer. The temperature was maintained constant at 298 K during period by a water circulation system from thermostat U-10 with thermal stability of $\pm$ 0.01 ^{0}C.

3. Formulation

1) Ultrasonic velocity(u) is determined by :
   $U = 2d / t$
2) Adiabatic compressibility(β_a) is evaluated by :
   $\beta_a = 1/u^2 \rho$
3) Internal pressure(P_i) is determined by:
   $P_i = b\, RT\, (K_j.\eta_s/ u)^{1/2} (\rho^{2/3}/M^{7/6})$
4) Specific heat (C_p) is given by :
   $C_p = T\, V\, \alpha^2 / (\beta_i - \beta_a)$
5) Sharma constant can be expressed as:
   $S_o = 3.\delta.S^*$
6) Free volume (V_f)is determined by :
   $V_f = (M\, u / K_j\, \eta_s)^{3/2}$

Where, d – distance between reflector & transducer , η - viscosity, M- molecular weight , K– temp. dependent constant b - packing fraction, R - gas constant, β_a- isothermal compressibility, T- temp. in Kelvin, α - volume expansivity, δ- Anderson – Gruneisen parameter, S*- Sharma parameter .

4. Results and Discussion

In this system the variation of ultrasonic velocity (u) shows a maximum (peak) at the molar concentration 3 x 10^{-4} and

minimum (dip) at 7 x 10^{-4}, while variation of adiabatic compressibility (β_a), shows exactly reverse trend, with a minimum (dip) at 3 x 10^{-4} and maximum (peak) at 10^{-4} (Fig.1). Increasing ultrasonic velocity signifies interaction between solute & solvent molecules and dips in velocity signifies weak association. This is due to the formation of more hydrogen bonds with increase in concentration as a result of solute-solvent interaction. Non-linearity in velocity against concentrations suggests the complex formation.

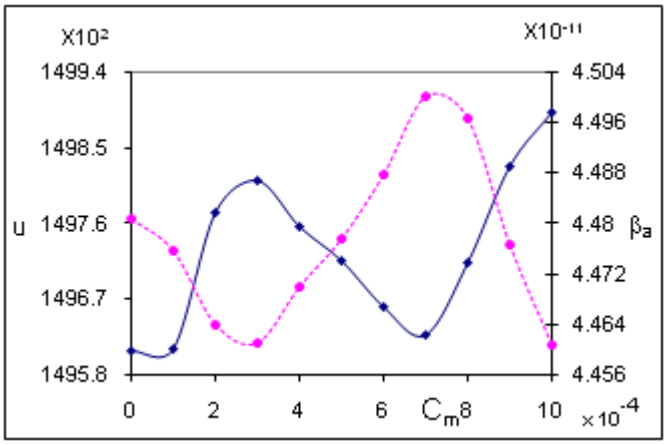

Figure 1

Internal pressure P_i values are found to increase at specific concentration. The increase in P_i with concentration indicates the orientation of solvent molecules around the ions. This may be due to the influence of electrostatic field of ions. The reduction in P_i with rise in concentration shows the dissociating tendency of molecules in the solution (Fig.2).

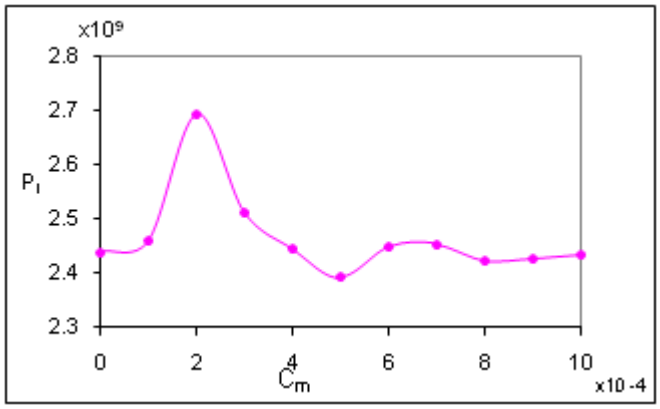

Figure 2

Generally, Sp. Heat C_p and Sharma constant S_0 values considered to be sensitivity to the arrangement of solvent molecules and the solute. Sp. Heat C_p and Sharma constant S_0 is found to increase or decrease with molar concentration. Decrease in C_p shows structure breaking tendency due to electrostriction. The increased value of C_p shows structure making ability (Fig. 3).

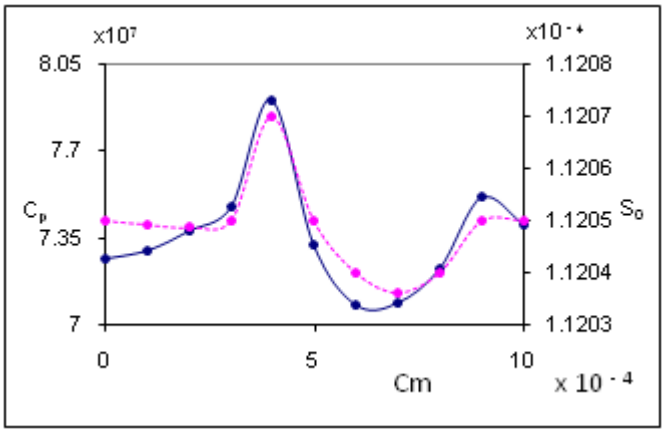

Figure 3

Free volume of binary liquid system shows non-linear behavior and shows peak at 0.0005 molar concentration. The increasing in the value V_f for higher concentration is due to dissociation of a closed packing of the molecules inside the shell, which may be brought about by the formation of associated complexes due to hydrogen bonding. The peak at 0.0005 molar concentrations in the present binary liquid system suggests loose packing of molecules. The variation of free volume V_f with concentration has the trend just opposite to that of internal pressure (fig. 4).

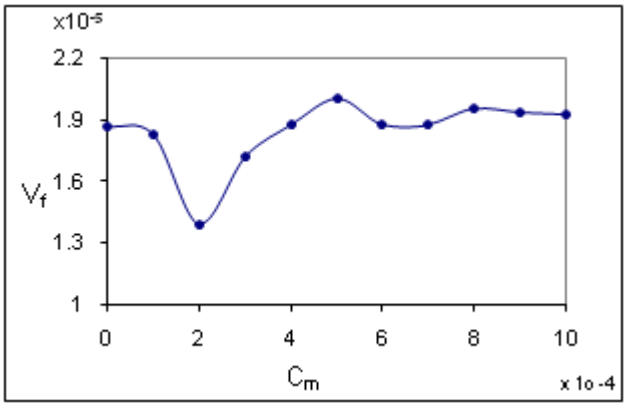

Figure 4

5. Conclusion

Pantothenic acid contains one-CH_2OH, one >CHOH , one –COOH, two $–CH_3$ groups. In water –COOH group from Pantothenic acid releases proton to form hydronium ion. Both primary alcoholic and secondary alcoholic groups are polar, so due to dipole-dipole interaction they form hydrogen bonds with water molecules. The variation of ultrasonic velocity and other related thermo-acoustical parameters with molar concentrations are found to show non-linear behavior which provides useful information about the nature of intermolecular forces existing in the mixture. The non-linearity confirms the complex formation, molecular association or dissociation in fluid mixture may be due to making or breaking of hydrogen bonds in water.

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