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Thermoacoustical Study of the Binary Mixture of L-Asparagine With Water at Different Temperatures

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ABSTRACT

The ultrasonic velocity (u), density (ρ) and viscosity (η) have been measured at 2 MHz frequency in the binary mixtures of L-Asparagine with water over entire range concentration at temperature range 293-323K using ultrasonic Pulser Receiver technique. The experimental data have been used to calculate acoustical parameter namely adiabatic compressibility (βa), acoustic impedance (z), free length (Lf) with a view to investigate the nature and strength of molecular interaction in the binary liquid mixture. The obtained result support the occurrence of complex formation through intermolecular hydrogen bonding in there binary liquid mixtures.

KEYWORDS : Ultrasonic velocity, adiabatic compressibility, molecular interaction, hydrogen bonding.

INTRODUCTION

Ultrasonic studies have always played an important role in understanding the nature of intermolecular interaction in pure liquid and liquid mixtures. They find application in several industrial and technological processes. Because the ultrasonic velocity is highly sensitive to molecular structures [1-4] and Ultrasonic investigations of liquid mixtures consisting of polar and non polar components are of highly importance in understanding the physical nature and strength of molecular interaction in the liquid mixtures [5]. For the better understanding of the physical and chemical properties and the inter-molecular interactions between the molecules of the mixture, ultrasonic velocity with density and the viscosity are measured at different concentration. The ultrasonic velocity of liquid is basically related to the bonding forces between the atoms and molecules; it helps to understand the nature of molecular interactions in pure and binary mixtures of the liquids [6-8].

In the present study the ultrasonic velocity, density and viscosity measurements have been carried out for binary mixture of L-asparagine and water for various concentrations at different temperatures. The variations of different ultrasonic parameters with concentrations and temperatures of binary liquid mixtures are studied to understand molecular interactions between molecules of the mixtures.

EXPERIMENTAL SECTION

L-Asparagine used in the present work was of Analytic Reagent (AR) grades with minimum assay of 99.9%, they are used without purification. The various concentration of solution was prepared by adding sufficient amount of solvent water to L-Asparagine.

The ultrasonic velocity (u) has been measured by ultrasonic Pulser Receiver MHF-400 supplied by Roop Telesonix, Mumbai operating at a frequency of 2 MHz with an accuracy of 0.1%. The viscosities (η) of binary mixtures were determined using Ostwald's viscometer by calibrating with distilled water. The density (ρ) of these binary solution were measured accurately using 25 ml specific gravity bottle in an electronic balance precisely and accurately using weighting is 0.1mg. These basic parameter u, η, ρ were measured at different temperature ranging from 293K-323K and at various concentration (0.00M to 0.1 M). The acoustical parameters were calculated from u, η, ρ value using standard formulae [9].

Adiabatic compressibility (β_a)

When acoustical wave passes through a medium, adiabatic compression and rarefaction takes place. This results in a change in pressure and a corresponding change in volume. Hence, the adiabatic compressibility is the fractional decrease of volume per unit increase of pressure, when no heat flows in or out. It can be calculated from the speed of sound (u) and the density of medium (ρ) using the equation of Newton and Laplace as

$$\beta_a = (u^2\rho)^{-1}$$

Intermolecular free length (L_f)

In the liquid state of matter, molecules are loosely packed, leaving free space among them. The free length is the distance between the surfaces of the neighbouring molecules. Determination of intermolecular free length in liquids and in liquid mixtures has been a subject to a semi-empirical relation to achieve the concept of intermolecular free length in order to explain the ultrasonic velocity in liquids.

Lf = KT(β_a)^(1/2)

Where K_T is a temperature dependent constant.

RESULTS

The ultrasonic velocity, adiabatic compressibility, free length and acoustic impedance of binary mixtures of L-Asparagine with water at 293K- 323K were shown graphically in following figures.

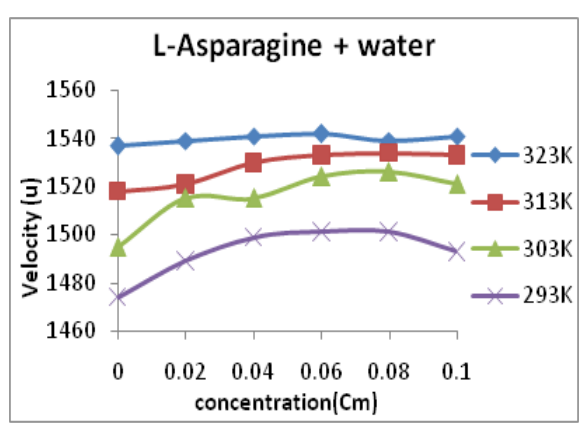

fig.1 variation of u with temp. & Cm

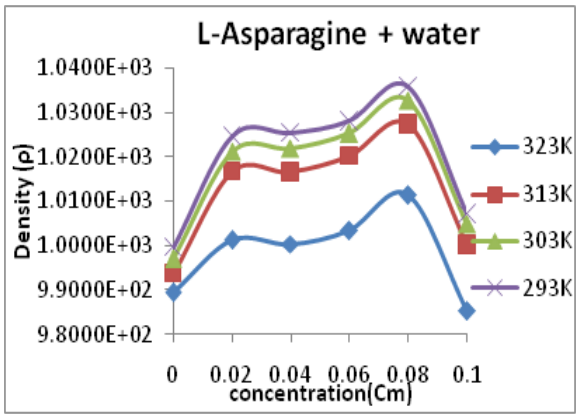

fig. 2 variation of ρ with temp. & Cm

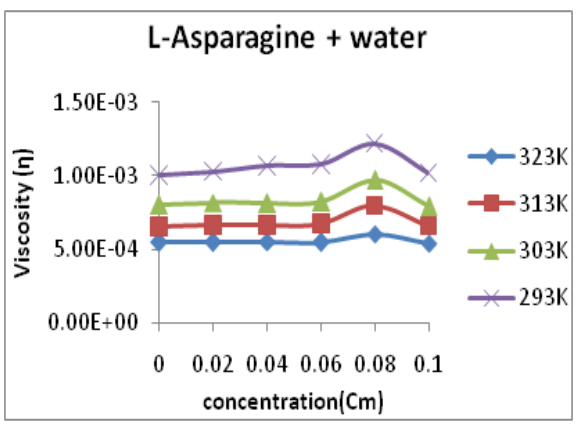

fig. 3 variation of η with temp. & Cm

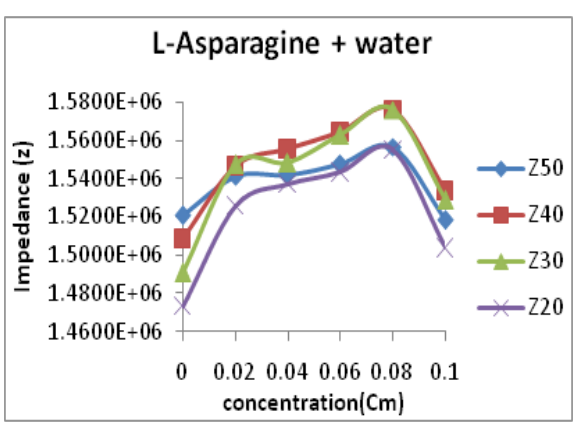

fig.4 variation of z with temp. & Cm

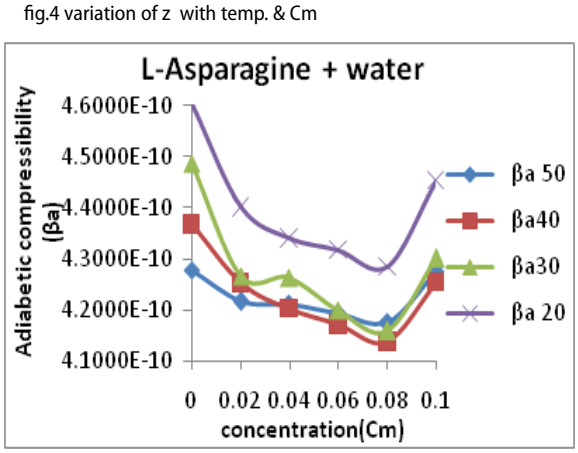

fig.5 variation of β_a with temp. & Cm

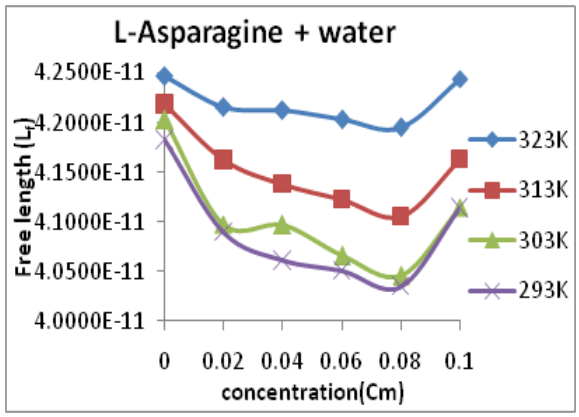

fig.6 variation of L_f with temp. & Cm

In the system of water+L-asparagine, ultrasonic velocity (u) and viscosity (η) increases with increase in concentrations and temperatures whereas the density (ρ) and acoustic impedance (z) variation with molar concentration of L-asparagine in water shows slightly maximum at molar concentration 0.08 while the adiabatic compressibility (β_a) and free length (L_f) shows dip at molar concentration 0.08 are represented above graphically.

DISCUSSION

In the present study the ultrasonic velocity slightly increases and adiabatic compressibility slightly decreases at particular molar concentration. This shows the association between the solute and solvent molecules. i.e. the solute solvent interaction and weak association due to hydration. It may also be due to the larger probability of amino acids molecules forming hydrogen bond with water molecules and association through the formation of hydrogen bonding. The resulting intermolecular forces are therefore stronger. The initial increase in ultrasonic velocity with molar concentration may be attributed to the breaking of clusters by the amino acid molecules resulting in enhancing the closed packed structure of water. This provides cohesion between water molecules to increase. Hence the adiabatic compressibility decreases. Similarly the ultrasonic velocity decrease nonlinearly with molar concentration in the aqueous amino acids which may be due to the weakening of the intermolecular forces in the aqueous bio-solution. This gives decrease in close packed water content i.e. enhancement of the open structure. Hence the cohesion between water molecules decreases. This results in the increase of adiabatic compressibility with molar concentration. This may also be due to the redistribution of charged or the hydration of the charged groups.

Free length [10] shows similar effect as adiabatic compressibility. Free length and adiabatic compressibility shows an opposite effect to ultrasonic velocity. The increase in free length with molar concentration may be due to loss of dipolar association, breaking up of hydrogen bonding and difference in size and shape of the component molecules. This results in the observed decrease in ultrasonic velocity and corresponding increase in adiabatic compressibility. The decrease in free length with molar concentration may thus be attributed to dipole-dipole interaction, H-bonding association and complex formation between the component molecules. This effect shows increase in ultrasonic velocity and decrease in the adiabatic compressibility.

CONCLUSIONS

The nonlinear variation of ultrasonic velocity related thermo acoustic parameters with molar concentrations of component constituents provide useful information about nature of intermolecular forces existing in the bio-mixture. The dipole-dipole, ion-ion, ion-solvent and hydrogen bonding interactions are the responsible for the observed hetero molecular interaction in these bio-liquids. The observed complex formation and molecular association in these bio-liquid mixtures may be due to the formation of hydrogen bonding in the molecules and the tendency of solute – solvent interaction and weak association arising due to hydration.

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