NONLINEAR ULTRASONIC PROPAGATION STUDY OF BINARY LIQUID MIXTURE AT 308K

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Abstract: The Ultrasonic velocity (u), density (ρ) and viscosity (η) measurement of binary liquid mixture of thiamin hydrochloride and methanol at 308 K were carried out using ultrasonic interferometer technique. From these basic experimental data, various acoustic and thermodynamic parameters were calculated, with a view to investigate the nature and strength of molecular interaction in the binary liquid mixture of thiamin Hydrochloride and methanol. The obtained results support the formation of complexes and molecular association through intermolecular hydrogen bonding in the binary liquid mixture.

IndexTerms **– Ultrasonic velocity, Binary liquid mixture, hydrogen bonding, molecular interaction.**

I. INTRODUCTION

In recent year, ultrasonic waves have acquired the status of and important probe for the structure and properties of matter in basic sciences [1-3]. Propagation of these wave can give important information about the Physico-chemical properties of the liquid medium [4-9]. Ultrasonic velocity measurements are useful to interpret the solute-solvent, solvent-solvent and ion-solvent interaction in aqueous and non-aqueous medium [10]. It also useful to give affirmative knowledge about the physical nature and stability of molecular interaction in various pure, binary as well ternary liquid system [11-13]. The variation of ultrasonic velocity and related parameters have shed much more light upon the structural properties of strongly [14-17]and weakly [18] interacting compounds of various liquid systems.

In this communication, we have reported the ultrasonic velocity, density and viscosity of thiamin hydrochloride with methanol at 308K over entire range of molar concentrations. From the experimental value a number of thermodynamic parameters namely adiabatic compressibility, free length, free volume and internal pressure have been calculated. The variation of these parameters with molar concentration was found to be useful in understanding the nature of interactions between the components.

II. MATERIALS AND METHODS

The chemical used in the present work was obtained from MERCK. Initially different concentrations of liquid mixture were prepared and used immediately for the measurement of basic experimental parameters. The first basic parameter i.e ultrasonic velocity of liquid mixture was measured using Ultrasonic interferometer (Mittal enterprises, India) operating at a fixed frequency of 2 MHz. Second basic parameter i.e viscosity of given liquid mixture was measured using Ostwald's viscometer. A digital electronic stopwatch with an accuracy of ± 0.01 Sec was used for time measurement. The third basic parameter i.e density was accurately measured using 25 ml Specific gravity bottle with an accuracy of ±0.5%. Digitally weighing balance with a precision of ± 0.1 mg was used for the measurements of mass of pure liquids or liquid mixtures. The temperature of the liquid mixture (308K) was maintained constant using constant temperature water bath with an accuracy of ±0.1K.

III. RESULTS AND DISCUSSION

The measured ultrasonic velocity and related thermoacoustic parameters such as adiabatic compressibility, free length, free volume and internal pressure of thiamin hydrochloride with methanol at 308K were shown in fig.1 to 5. It can be seen in Fig.-1 and 2 that, nonlinear variation of ultrasonic velocity and adiabatic compressibility with increase in molar concentration of thiamin hydrochloride illustrates the existence of molecular accumulation and development of complex formation between the component molecules may be due the formation of hydrogen bond [19-20]. This behavior shows the structural making and breaking effect of thiamin hydrochloride. This also indicates the hydrophilic and hydrophobic nature of thiamin hydrochloride with methanol. The inverse relationship exist between ultrasonic velocity and adiabatic compressibility clearly indicates association between the solute and solvent molecules. The Ultrasonic velocity and adiabatic compressibility shows relative peak and dip at 0.02M concentration. This means that at this particular concentration strong hydrogen bond can takes place between the solute and solvent molecules.

The methanol is monohydric alcohols having a hydroxyl group (OH), which may form hydrogen (O-H..O) bond with thiamin hydrochloride thus association may be possible between thiamin hydrochloride and methanol molecules through hydrogen bonding.

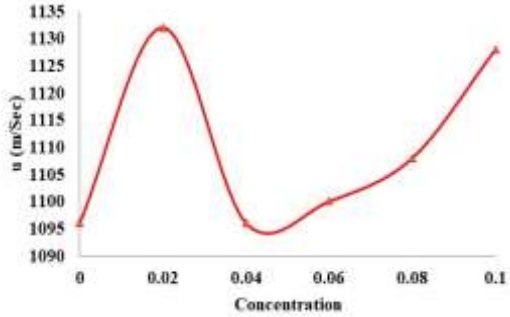

Fig. 1. Variation of Ultrasonic velocity with Concentration

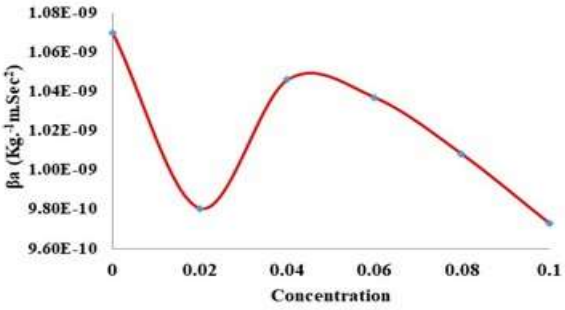

Fig.2. Variation of adiabatic Compressibility with concentration

The intermolecular free length (L_f) gives the distance between the surfaces of the neighbouring molecules which mainly affects the sound velocity [21]. From Fig. 3 free length shows nonlinear variation with increase in molar concentration of thiamin hydrochloride. The increase in free length with concentration increases the distance between the surfaces of the two molecules, whereas decrease in free length with concentration indicates the presence of molecular interactions between the components of the mixture.

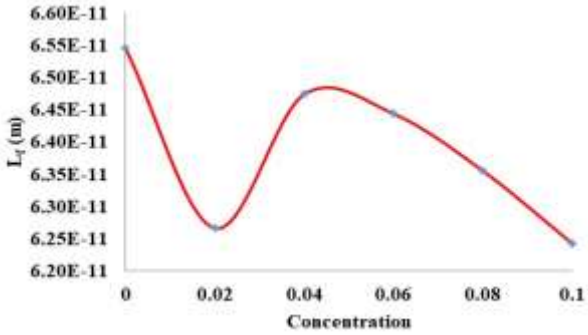

Fig.3- Variation of Free length with concentration

Free volume gives the measure of cohesive or binding forces between the solute and solvent molecules [22] and internal pressure gives significant information about structural changes in solution. It has been observed from Fig 4 and 5, that at higher concentration free volume increases whereas internal pressure decreases. This is due to the fact that at higher concentration molecules get disordered due to increasing entropy of the system which lead to decrease interactions between molecules of thiamin hydrochloride and methanol. The reverse trend observed in free Volume and internal pressure indicates the associative nature of interacting molecules [23].

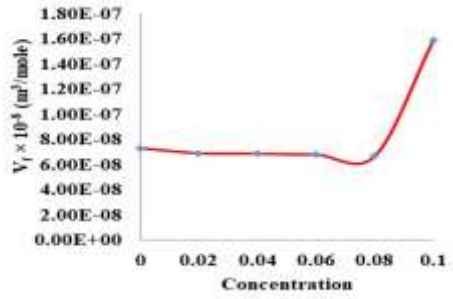

Fig.4- Variation of Free volume with concentration

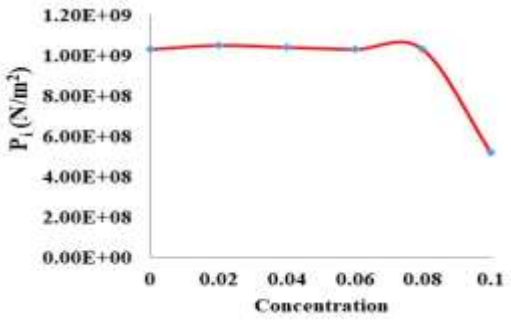

Fig.5- Variation of Internal pressure with concentration

IV. CONCLUSION

The nonlinear variation of thermo-acoustical parameters with molar concentration reveals the existence of intermolecular forces in the binary liquid mixture of thiamin hydrochloride and methanol. The complex formation and molecular association in the mixture may be due to formation of hydrogen bond in the component molecules.

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