Abstract

Ultrasonic spectroscopy is an excellent nondestructive technique for probing the structure of material. The ultrasound waves when applied to liquid give information about molecular motion. In solutions with small molecules, it is possible to obtain information regarding conformational changes.

In most of the studies so far, the ultrasonic attenuation of vegetable oils has been linked with high frequency. The velocity and attenuation depends on the frequency of operation and temperature. The viscosity of oils decreases with increase in temperature.

In recent years, ultrasonic velocity studies in many of the aqueous, pure non aqueous, mixed electrolytic solutions, polymer solutions, binary mixtures, ternary mixtures etc. have led to new insights into the process of ion-ion and ion-solvent interactions.

In the present work, ultrasonic velocity, density and viscosity of the following three liquid mixture systems have been studied for various mole fraction.
1. Urea + water
2. Gelatin + water
3. Gelatin + urea + water

The density ($\rho$), viscosity ($\eta$) and ultrasonic velocity ($u$) for urea + water binary liquid system and ternary liquid system have been
measured at temperatures 298.15K, 303.15K, 308.15K and 313.15K for wide range of composition. These experimentally measured properties were used to evaluate various acoustic and thermodynamic properties such as adiabatic compressibility (β), acoustic impedance (z), intermolecular free length (L_d), relaxation time (τ), classical absorption factor (α/f^2), surface tension (σ) etc.

**Results and discussion:**

**Urea+Water**

The ultrasonic velocity (u) of binary liquid system (urea+water) at different temperature and for varying concentrations have been obtained using ultrasonic interferometer at a fixed frequency of 2MHz. The values of Ultrasonic velocity (u) for (urea+water) and their variation with different concentration shows that ultrasonic velocity (u) increases with increases in concentration from 1% to 10%, whereas viscosity (η) tends to increase up to 5% concentration and at 6% concentration it decreases and again after 7% concentration values of viscosity go on increasing with increase in concentration. Similar trend of ultrasonic velocity (u), density (ρ) and viscosity (η) was observed for all temperatures.

The results are attributed to the maximum association among the molecules of the solution. The maximum association is
due to the hydrogen bonding between the solute and solvent molecules.

Using the values of ultrasonic velocity (\(u\)), density (\(\rho\)) and viscosity (\(\eta\)) the adiabatic parameters adiabatic compressibility (\(\beta\)), acoustic impedance (\(z\)), intermolecular free length (\(L_f\)) and surface tension (\(\sigma\)) were obtained. The variation of these parameters with temperature and concentration has been reported in the present work.

**Gelatin+Water:**

The ultrasonic velocity (\(u\)) for gelatin+water binary liquid system has studied as a function of temperature and concentration both. The variation of ultrasonic velocity with temperature indicates that the velocity goes on increasing as temperature increases. The variation of ultrasonic velocity with concentration shows abnormal behaviour.

The values of ultrasonic velocity (\(u\)) slowly increases up to to 6% concentration. At 6% concentration ultrasonic velocity (\(u\)) suddenly increases and after reaching a maximum value it start decreasing with further increase in concentration. This behaviour indicates that some molecular interaction exists in binary mixture of gelatin+water system.

Density of gelatin+water was obtained at different temperature and at different concentration by using specific gravity
bottle. The variation of density with concentration shows that as concentration increases density increases. Beyond 6% concentration density increases slowly may be due to saturation. The variation of density with temperature reflects that density decreases as temperature increases. It is true for all the concentrations. Further it is noticed from the graph of density versus temperature that the rate of decrease of density with temperature is very slow.

The acoustical parameter adiabatic compressibility ($\beta$), acoustic impedance ($z$), intermolecular free length ($L_f$) and surface tension ($\sigma$) were obtained with the help of ultrasonic velocity ($u$) and density ($p$) values at different temperature and for varying concentration.

**Urea+Gelatin+Water:**

To understand the molecular interaction in Urea+gelatin+water ternary system, ultrasonic velocity ($u$) and density ($p$) have been measured at different temperature and for various concentration. The dependence of ultrasonic velocity ($u$) with concentration indicates that the ultrasonic velocity ($u$) increases from 1% concentration to 4% concentration. For above 4% concentration the ultrasonic velocity ($u$) decreases up to 6% concentration. Above 6% concentration the ultrasonic velocity ($u$) is suddenly increases up to 7% concentration. Above 7%
concentration the ultrasonic velocity \( (u) \) slowly. The variation of ultrasonic velocity \( (u) \) with temperature showed increasing trend.

The density \( (p) \) Urea+gelatin+water ternary system increases as concentration increases and is true for all the temperatures under investigation. The variation of density \( (p) \) with temperature has also been studied and it is noticed from the plot of density versus temperature that density decreases slowly with temperature.

These studies are important in understanding the molecular interactions present in these liquid mixtures. As gelatin is a protein and urea is a denaturation agent, when urea is added in gelatin then denaturation is occur at 6% concentration which breaks the structure of gelatin i.e. conjugated to simplest one by breaking the polypeptide bonds among amino-groups. This shows the influences on ultrasonic velocity and density and consequently the other acoustical and thermodynamic parameters as the molecular interaction exist in the liquid mixture systems under investigation.

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