UNDERSTANDING ANOMALOUS BEHAVIOUR OF WATER BY ULTRASONIC MEASUREMENTS IN AQUEOUS AND 10% ETHANOL-WATER SOLUTIONS OF DEXTROSE AT DIFFERENT TEMPERATURES

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Abstract: Ultrasonic velocity(U) and density have been measured experimentally for aqueous solution of dextrose and 10% ethanol-water solutions at concentration range(0.1M-0.9M) and at temperatures (298.15, 303.15 and 308.15K).The acoustic parameter such as adiabatic compressibility(β)has been worked out. The results are correlated in terms of anomalous behaviour of water related to the cage like structures of water and noncovalent molecular interaction between the constituents of solutions.

KEYWORDS: Ultrasonic velocity, Adiabatic compressibility, Dextrose, Ethanol-water

INTRODUCTION:

Ultrasonic velocity of pure liquids and liquid mixtures are basically related to the noncovalent molecular interaction (hydrogen bonding, Vander Waal's forces and dispersion forces) between molecules and atoms (Coupland et al., 2001). The speed and efficiency of the transmission is sensitive to the nature of the bonds and the masses of the molecules present in the liquid mixtures and hence composition of system (MaClement., 1995). During the last two decades the ultrasonic study of the carbohydrates in aqueous electrolytic medium, has gained much importance in assessing the nature of molecular interaction present in the mixture. The study of the carbohydrates or saccharides has become a subjects of growing interest because of multidimensional, physical, biochemical and scientifically useful molecule (Golberg et al.,1989, Goates,1991, Tewari et al,1991,Birch et al,1998) Due to composite molecular structure of polysaccharides, direct study is difficult. Therefore, the useful approach is to study simpler form compounds, such as Dextrose, which is building block of most of the polysaccharides. Most of the studies on carbohydrates have been carried out in pure and mixed solvent (Pandey et al,1992, Franks et al,1972, Kaulgud,1976).

Carbohydrates displayed on the surface of cells play critical roles in cell-cell recognition, adhesion, signalling between cells, and as markers for disease progression. Neural cells use carbohydrates to facilitate development and regeneration (Kleene et al,2004); cancer cell progression is often characterized by increased carbohydrate-dependent cell adhesion and the enhanced display of carbohydrates on the cell surface (Hakomori et al,2002); viruses recognize carbohydrates to gain entry into host cells (Smith et al,2004); and bacteria bind to carbohydrates for host cell adhesion (Karlsson,1999). Recognition of the specific saccharides involved in these processes is important to better understand cell-cell recognition at the molecular level and to assist the design of therapeutic and diagnostic tools.

The ultrasonic study of this molecule in aqueous and aqueous alcoholic medium is very important for understanding the behaviour water structures, biomolecular recognition and medicinal use.

MATERIALS AND METHODS :

The solutions of Dextrose were prepared by dilution method. All the chemicals are of AR grades of 99.99 % purity. Composition range of dextrose is from 0.1 M to 0.9M in water and in 10% ethanol-water solvent systems.

The ultrasonic velocity in the liquid mixtures have been measured by means of ultrasonic interferometer (Mittal type: Model: M-83) functioning at frequency 2MHz with an overall accuracy of ±0.1 m/s, an electronically digital operate constant temperature water bath has been used to flow water through the double walled measuring cell, made up of a steel containing the experimental solution at the preferred temperature. For weighing, an electronic digital balance having an accuracy of ±0.1 mg was used. Densities were determined using specific gravity bottle by relative measurement method with accuracy of ±0.1 $kg.m^{-3.}$

RESULTS AND DISCUSSION :

Density:

From Figs.1.1 and 2.1. (a), it is observed that the density of aqueous and 10% ethanol-water solution of dextrose is found to increase with increase in concentration of solute (dextrose). Density of aqueous and 10% ethanol-water solution of dextrose is found to decrease with increase in temperature. As the temperature increases, kinetic energy of the molecules increased (Dhondge et al,2013). And spacing among the components of the system increases and this leads to decrease the number of molecules per unit area and hence density of the solution.

Ultrasonic velocity:

From Figs. 1.2and 2.2(b), it is found that the values of speed of sound for aqueous and10% ethanol-water solution of dextrose is found to increase with increase in concentration of solute. It can be observed that the ultrasonic velocity is found to increase with increase in solute concentration. As concentration of solute increases, the number of the molecules in the solution increases. This makes the medium denser and leads to the lesser compressibility and hence the ultrasonic velocity increases (Nithiyanatham et al 2009, Pal,et al, 2010). The increase in ultrasonic velocity in any solution suggests the greater association among the components of the solution. The greater association is due to the intermolecular hydrogen bonding and dispersion forces between solute and solvent molecules.

It is observed from Figs. 1.2(b), ultrasonic velocity is found to increase with increase in temperature for both the solutes. This may be due to formation cage like structures of water. As temperature increases, the hydrogen bonds among water molecules disassociate and more monomeric water molecules are produced. These freed water molecules enter into the vacant space present in the cage like water structures and thus get 'trapped'. As a result, the number of close-packed water structures increases with the increase in temperature. This increase in close-packed water structures forms the stiff material medium for the propagation of ultrasonic waves (Povey,1997). Thus, the ultrasonic velocity increases with the increase in temperature for pure water as well as for aqueous solutions of dextrose

It is observed from Figs. 2.2(b), for 10% ethanol-water solution of dextrose, ultrasonic velocity is found to decrease with increase in temperature. In this solvent system, water and ethanol molecules released from complex clusters at 308K. The disassociation rate of ethanol and water molecules in this temperature range (298-303K) may be poorer and it may be enhanced at 308K. Percentage of disassociation of ethanol molecules may be greater than water molecules due to higher dipole moment and dielectric constant of water. Its association with solute and with themselves is stronger than ethanol molecules. Hence, number of ethanol molecules freed may be greater. The freed ethanol molecules can't enter into the empty space of cage like water structures due to greater molecular size as compare to water molecule. Thus, medium become loosely packed. Hence, the speed of sound dropped in 10% ethanol-water solvent system at higher temperature (308K).

Adiabatic compressibility:

From Figs. 1.3 and 2.3(c) it is observed that decrease in compressibility implies that there is enhanced molecular association in this system upon addition of solute and less available free space between the components of the solution (Chang,1987). The new complexes formed due to molecular association become more compact and less compressible. These also suggest that the compressibility of the solution is less than that of solvent. The magnitude of compressibility depends on the electrostriction

As temperature increases of dextrose solution, compressibility is found to decrease. Compressibility decreases with increase in temperature from 298K to 303K. At 308K, adiabatic compressibility increases. As explained earlier about the speed of sound. As the temperature increases, speed of sound increases and compressibility is inversely related to the speed of sound (Ravichandran et al,2008). Hence, compressibility of solution at high temperature decreased. In 10% ethanol-water system, compressibility increases at 308K. The explanation is already given in the discussion of ultrasonic velocity.

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Graphs:- Graphs of aqueous and 10% ethanol-water solutions of dextrose.

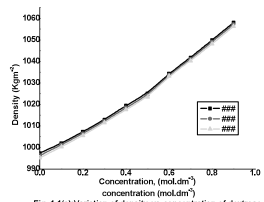

Fig. 1.1(a):Variation of density *vs.* concentration of dextrose in water at Different temperature.

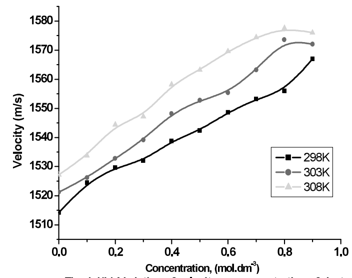

Fig. 1.1(b):Variation of velocity *vs.* concentration of dextrose in water at Different temperature.

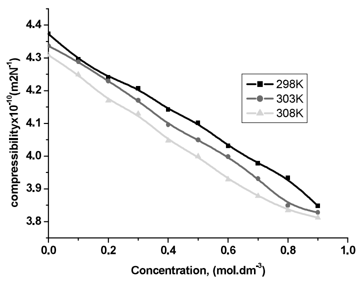

Fig. 1.1(c):Variation of compressibility *vs.* concentration of dextrose in water at Different temperature.

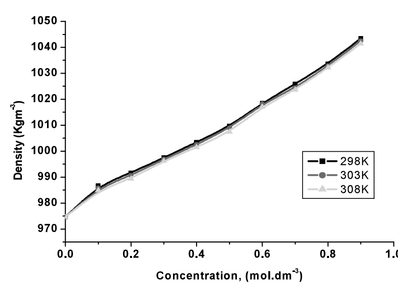

Fig. 2.1(a):Variation of density *vs.* concentration of dextrose in 10% ethanol-water at Different temperature.

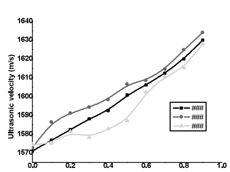

Fig. 2.1(b):Variation of velocity *vs.* concentration of dextrose in 10% ethanol-water at Different temperature.

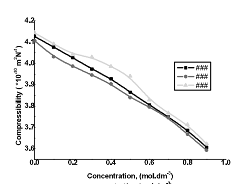

Fig. 2.1(c):Variation of compressibility *vs.* concentration of dextrose in 10% ethanol-water at Different temperature.