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Liquid State Studies Of Lactose And D-Fructose At Various Temperatures

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Abstract:

The study of molecular interactions in liquids provides information regarding the behavior of liquids and solutions. The thermodynamic and acoustical study elucidates the nature of interactions between molecules in liquids and solutions. Also ultrasonic parameters are directly related to a number of thermodynamic parameters. As the different liquid state theories are based on thermodynamic considerations, the study of propagation of ultrasonic waves in liquid systems is established as a simple and effective tool in determining the nature of interactions between molecules in liquids and solutions. Using ultrasonic velocity measurements, adiabatic compressibility, intermolecular free length, Free Volume for Lactose and D-Fructose are evaluated and the variations are analyzed. Structure making and Structure breaking nature of solution is studied.

Key words: Compressibility, free Length, Free Volume, Velocity,Relaxation Time.

INTRODUCTION

The number of water molecules that interact with the solute at one time is the measure of the hydration number. Internal pressure though a single factor appears to vary due to all the internal interactions such as hydration of solute solvent interactions. Even microscopic changes occurring in the medium like in molecular orientations or in temperature will change the value of internal pressure. The free volume is broadly defined as the averages volume in which the center of the molecule can move inside the hypothetical cell due to the repulsion on the surrounding molecules.

EXPERIMENTAL STUDY

Computation of the acoustical parameters require measurement of ultrasonic velocity(U),viscosity(η) and density(ρ). Aqueous solutions of lactose,D-Fructose of different concentrations were prepared with AR grade salts with double distilled water.Ultrasonic velocity through the solutions were measured with a Mittal type ultrasonic interferrometer with an accuracy 0f ± 2 m/s. The cell temperature was

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maintained with a circulating ultrathermostat accurate to within 0.1° c. The viscosity of the solutions were measured using a Cannon Fensky viscometer. The density of the solutions were measured with 10 ml specific gravity bottle.

1.14)COMPUTATION

Compressibility measurements yield interesting information. They are also highly accurate. Here we assume that the bound water molecules are highly compressed by the intense field of the ion and that further compression affects only the unbound water. The adiabatic compressibility is the fractional decrease of volume per unit increase of pressure, when no heat flows in or out. If these is no heat flow, the entropy is unchanged in a reversible process, is one at constant entropy. Then we have,

Adiabatic compressibility can be determined with the measurement of density and ultrasonic velocity U as

$\beta = (1/u^2p)$ $cm^2/$ dyne

Thermodynamic importance of internal pressure is shown by bringing out its quantitative relationship with entropy and the partition function of the system. Free volume is shown to be

$$V_f = \left[\frac{Mu}{K\eta}\right]^{3/2}$$

related to the transport properties in liquids and solutions.

the free volume plays an important role in ultrasonic propagation in liquids, and $V_f^{1/3}$ is very small in the case of solids. The relation between free volume and viscosity has been derived by Bingham and McLeod .

Intermolecular free length (L_f): $L_f = \left(\frac{K}{U_P^{1/2}}\right) = K(\beta_{ad})^{1/2}$

Relaxation time(τ)= $\frac{4\eta}{3\rho U^2}$

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RESULTS AND DISCUSSION

The experimentally determined values of ultrasonic velocity for Lactose, D-Fructose at temperatures at,303K, 313K and 323Kare summarized in the table.

The measurement of ultrasonic velocity is an important tool to study the physical & chemical properties of the liquid. Ultrasonic velocity and allied parameters of Lactose, D-Fructose for various concentrations, at different temperatures are presented in tables and represented graphically in figures.

Ultrasonic velocity, adiabatic compressibility, free length and Free volume for Lactose, D-Fructose were determined at different temperatures.

The plots between the ultrasonic velocity and concentration potential shows that the ultrasonic velocity is found to linearly increase with temperatures. This linear increase suggests that there are strong solute-solvent interactions in the liquid solution. These interactions are both concentration and temperature dependent. The effects of temperature on the interactions are more than that of concentration. At low concentrations, the number of hydrogen bonds formed may be less and at higher concentrations, it may be more due to solute-solute interactions.Ultrasonic velocity is found to linearly increase with temperature as reported in literature for other carbohydrates[Graph1].

The compressibility is a macroscopic observable, which is sensitive to solute-solvent interactions. Any modifications induced by the solute on the local structure of the solvent generate changes in the adiabatic compressibility of the solutions and therefore compressibility can be used to characterize solvated properties of solute in dilute solutions.

The decrease in the values of adiabatic compressibility with increase in ultrasonic velocity indicates that there is a significant interaction between solute and solvant molecules due to which the structural arrangement in the neighbourhood of constituent ions is considerably affected[Graph2]. The variation in compressibility values of the carbohydrates is found to be in good agreement with the reported values for electrolyes.[11]. The change in Free volume was noted for Lactose,D-Fructose changes significantly with respect to both temperature and concentration[graph4].

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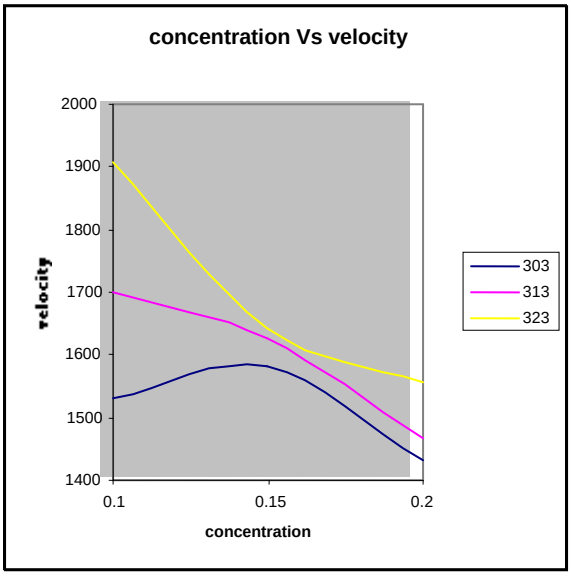
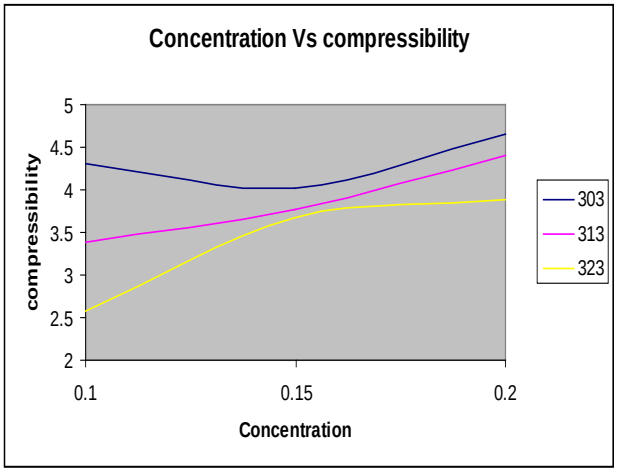
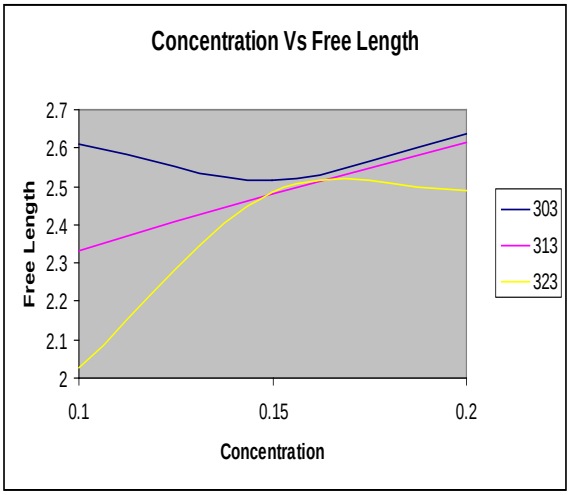
Free Length decreases with increase in temperature[graph3]. Relaxation Time decreases with increase in temperature[graph5].

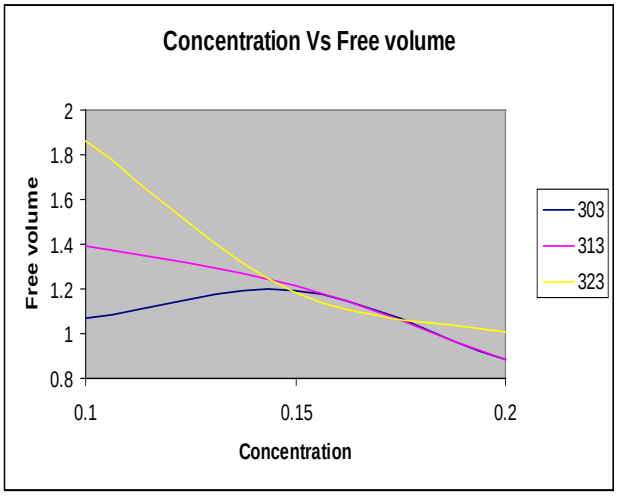
Graphs

Lactose









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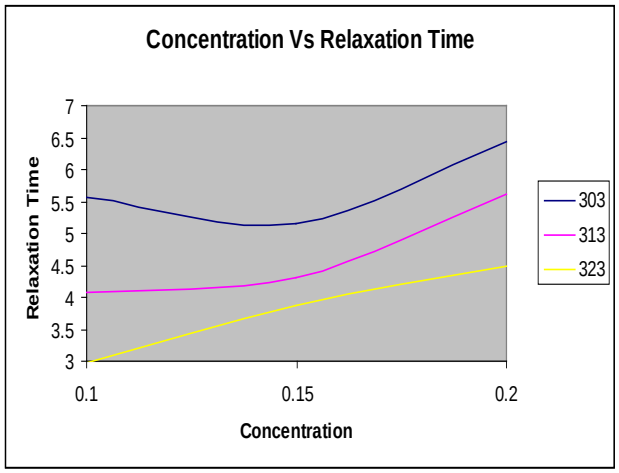
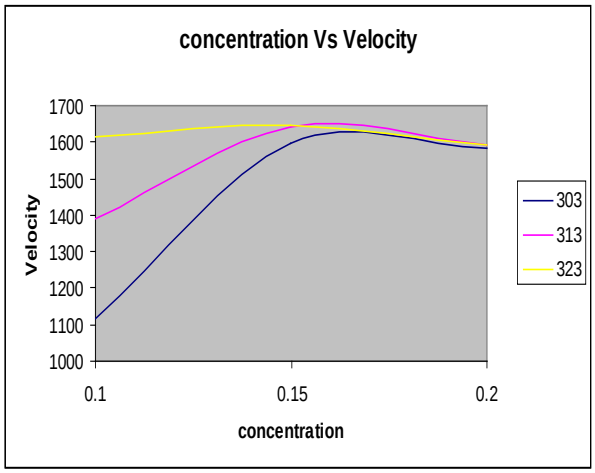
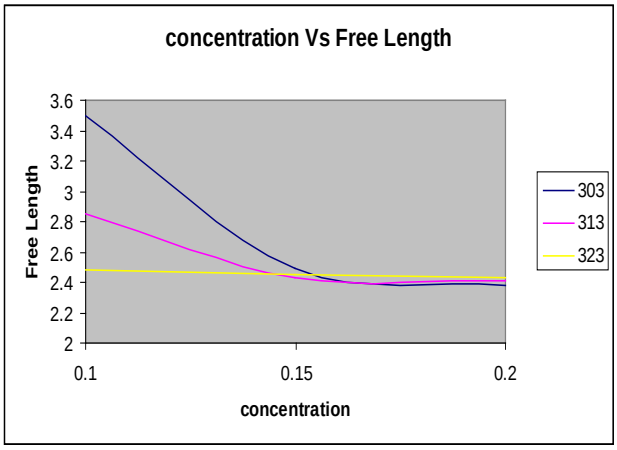
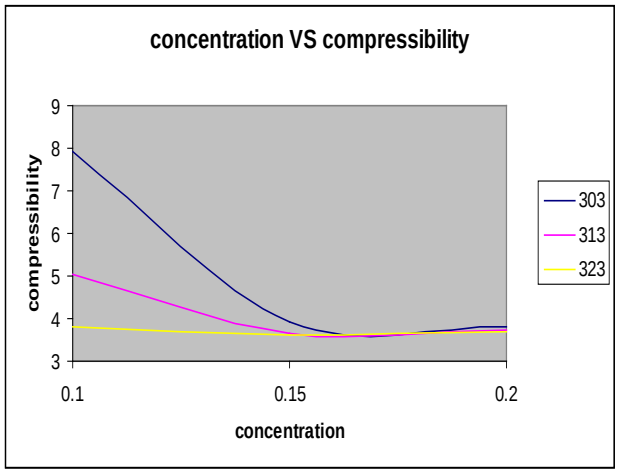


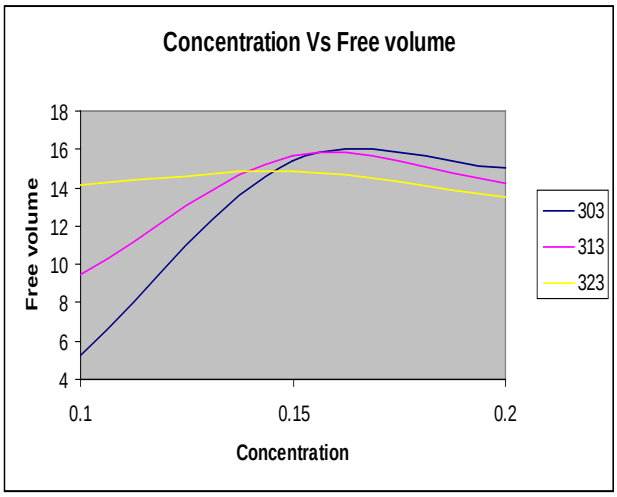
D-Fructose

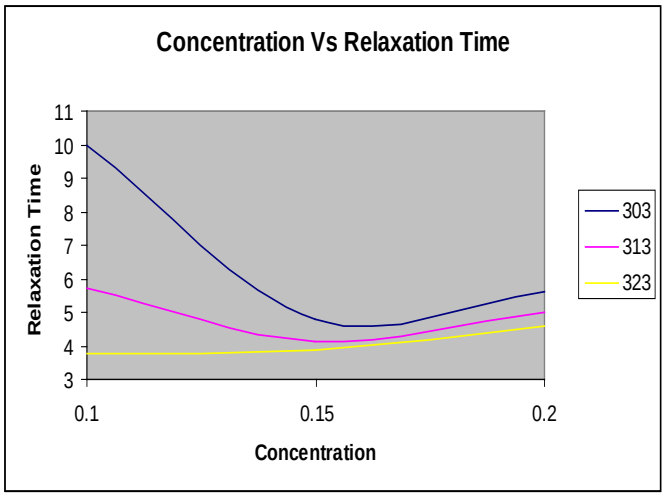


D-Fructose









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