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Ultrasonic Velocity and Viscosity of Glucose in Ethanol + Water Solution At 308 K And 313 K

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Abstract: **Studies of ultrasonic velocity, viscosity and density of Glucose have been carried out in ethanol + water solvent at different temperatures of 308.15 K and 313.15 K. The variations in Ultrasonic velocity with concentrations in the system show a trend of increasing ultrasonic velocity, viscosity and density of the constituents at different temperatures, but decrease with increase in temperature for the same concentration.**

Keywords: **Ultrasonic velocities, glucose, viscosity, ethanol, density, concentration, temperature.**

1. INTRODUCTION

Glucose is a sugar with the molecular formula $C_6H_{12}O_6$. The suffix "-ose" is a chemical classifier, denoting a carbohydrate. It is also known as dextrose orgrape sugar. With 6 carbon atoms, it is classed as a hexose, a sub-category of monosaccharides. α-D-glucose is one of the 16aldose stereoisomers. The D-isomer occurs widely in nature, but the L-isomer does not. Glucose is made during photosynthesis from water and carbon dioxide, using energy from sunlight. The reverse of the photosynthesis reaction, which releases this energy, is a very important source of power for cellular respiration. Glucose is stored as a polymer, in plants as starch and in animals as glycogen.[1]

Glucose is the most widely used aldohexose in living organisms. One possible explanation for this is that glucose has a lower tendency than other aldohexoses to react non-specifically with the amine groups of proteins.[2] This reaction - glycation - impairs or destroys the function of many proteins.[4] Glucose's low rate of glycation can be attributed to it having a more stable cyclic form compared to other aldohexoses, which means it spends less time than they do in its reactive open-chain form.[2] The reason for glucose having the most stable cyclic form of all the aldohexoses is due it having all of its hydroxy groups (with the exception of the hydroxy group on the anomeric carbon of D-glucose) in the equatorial position. Many of the long-term complications of diabetes(e.g., blindness, renal failure, and peripheral neuropathy) are probably due to the glycation of proteins or lipids.[3] In contrast, enzyme-regulated addition of sugars to protein is called glycosylation and is essential for the function of many proteins.[4]

Glucose is a ubiquitous fuel in biology. It is used as an energy source in most organisms, from bacteria to humans, through either aerobic respiration, anaerobic respiration, or fermentation. Glucose is the human body's key source of energy, through aerobic respiration, providing about 3.75 kilocalories (16 kilojoules) of food energy per gram.[5] Breakdown of carbohydrates (e.g. starch) yields mono- and disaccharides, most of which is glucose. Through glycolysis and later in the reactions of the citric acid cycle and oxidative phosphorylation, glucose is oxidized to eventually form CO_2 and water, yielding energy mostly in the form of ATP. The insulin reaction and other mechanisms regulate the concentration of glucose in the blood.

Glucose is a primary source of energy for the brain, so its availability influences psychological processes. When glucose is low, psychological processes requiring mental effort (e.g., self-control, effortful decision-making) are impaired.[6][7][8]

When oxidized in the body in the process called metabolism, glucose produces carbon dioxide, water, and some nitrogen compounds and in the process provides energy which can be used by the cells. The energy yield is about 686 kilocalories (2870 kilojoules) per mole which can be used to do work or help keep the body warm. This energy figure is the change in Gibbs free energy ΔG in the reaction, the measure of the maximum amount of work obtainable from the reaction. As a primary energy source in the body, it requires no digestion and is often provided intravenously to persons in hospitals as a nutrient.[9]

Energy from glucose is obtained from the oxidation reaction $C_6H_{12}O_6 + 6O_2$ --> $6CO_2 + 6H_2O$ where a mole of glucose (about 180 grams) reacts with six moles of O_2 with an energy yield ΔG = 2870 kJ. The six moles of oxygen at STP would occupy 6 x 22.4L = 134 liters. The energy yield from glucose is often stated as the yield per liter of oxygen, which would be 5.1 kcal per liter or 21.4 kJ per liter. This energy yield could be measured by actually burning the glucose and measuring the energy liberated in a calorimeter. But in living organisms, the oxidation of glucose contributes to a series of complex biochemical reactions which provides the energy needed by cells. The first step in the breakdown of glucose in all cells is glycolysis, producing pyruvate which is the starting point for all other processes in cellular respiration. In cells where oxygen is present (aerobic respiration) these processes have been modeled in the TCA or Krebs cycle. A major part of the use of the energy from glucose oxidation is the conversion of ADP to ATP, with the energy-rich molecule ATP being subsequently used as the energy currency of the cell.[9].

There are many approaches [10] used to determine the structure and function relationship of molecules. Among these approaches, ultrasonic velocity measurements provide and important tool to study the liquid state. Ultrasonic and thermodynamic parameters derived from these measurements are widely used to study the molecular interactions in pure liquid, aqueous solutions and liquid mixtures. Ultrasonic study on the glucose with aqueous solution of electrolytes and non-electrolytes provide useful information in understanding the behaviour of liquid systems, intra-molecular and intermolecular associations, complex formation and related structural changes. The physical properties of dilute aqueous solutions of non electrolytes depend solute is a water structure maker or structure breaker. The influence of small quantity of glucose on the hydrogen bonded structure of water in the solution of water; ethanol-water system is quite different from that in the absence of glucose in order to study the nature of molecular interactions in the above solutions. Ultrasonic velocity, density and viscosity studies were carried out in aqueous solution of ethanol containing glucose.

2. MATERIALS AND METHOD

The alcohol used in the present work was analytical reagent (AR) grade of minimum assay of 99.4%. Doubly distilled, degassed water was used for preparation of the solutions. Aqueous ethanol (10% v/v) binary mixtures were used as solvents to prepare solutions of (0.02, 0.04, 0.06, 0.08, 0.10, 0.12, 0.14, 0.16, 0.18, 0.20 M) glucose. All the solutions were prepared on molarity basic and were kept in air tight bottles.

The densities of mixed solvents and solutions of glucose in these solvents were measured using a specific gravity bottle by relative measurement method with an accuracy of ±0.01 Kg.m-3. An Oswald’s viscometer was used for viscosity measurement and efflux time was determined using a digital stopwatch to within ±0.01s. Ultrasonic velocity was determined using a single crystal variable path ultrasonic interferometer operating at 4 MHz. During the measurements, the temperature of the test solution was maintained to an accuracy of ±0.01K in a controlled thermostatic water bath.

3. RESULTS AND DISCUSSION

The variation of density, viscosity ultrasonic velocity with the concentration of glucose in the solution of ethanol + water is presented in Table 1. Observing Fig. 1, it is seen that, the density of solutions increases with increase in the concentration of glucose in the solution of ethanol + water at different temperatures, but decreases with increase in temperature for the same concentration. The relationship between concentration and density for this particular solution is a linear one.

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Table 1 Density (Kg/m^3) of glucose concentrations in ethanol + water at 308 K and 313 K

Mol/L	308 K	313 K
0.02	1.0164	1.0087
0.04	1.0170	1.0095
0.06	1.0176	1.0102
0.08	1.0182	1.0108
0.10	1.0187	1.0113
0.12	1.0194	1.0119
0.14	1.0201	1.0123
0.16	1.0208	1.0130
0.18	1.0213	1.0134
0.20	1.0218	1.0141

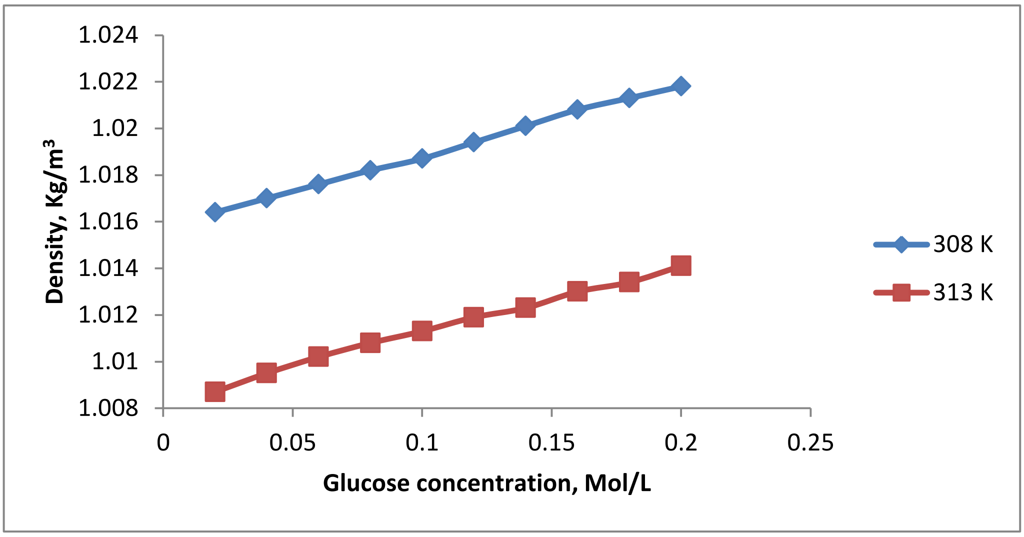

Fig.1 Variation of density of glucose in ethanol + water solution at 308 K and 313 K

Similarly, looking at Fig. 2, it is seen that, the viscosity of solutions increases with increase in the concentration of glucose in the solution of ethanol + water at different temperatures, but decreases with increase in temperature for the same concentration. The concentration and density also have a linear trend.

Table 2 Viscosity of glucose concentrations in ethanol + water at 308 K and 313 K

Mol/L	308 K	313 K
0.02	1.7187	1.4559
0.04	1.7153	1.4597
0.06	1.7218	1.4667
0.08	1.7262	1.4706
0.10	1.7315	1.4764
0.12	1.7370	1.4705
0.14	1.7423	1.4849
0.16	1.7479	1.4898
0.18	1.7532	1.4947
0.20	1.7589	1.4996

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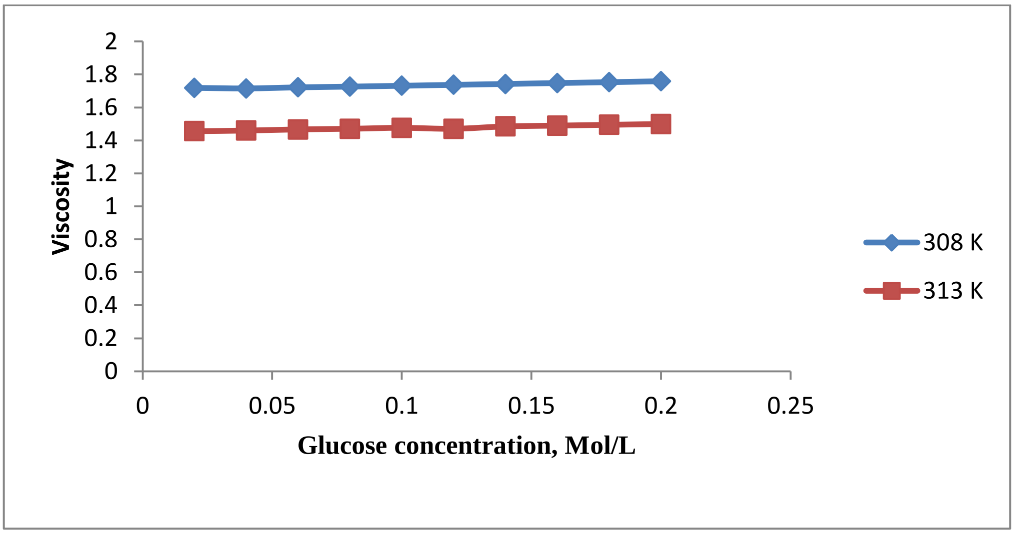

Fig.2 Variation of viscosity of glucose in ethanol + water solution at 308 K and 313 K

Again, it can be seen from Fig. 3 that, the ultrasonic velocity in solutions increases with increase in the concentration of glucose in the solution of ethanol + water at different temperatures, but decreases with increase in temperature for the same concentration.

Table 3 Ultrasonic Velocity in glucose concentrations in ethanol + water at 308 K and 313 K

Mol/L	308 K	313 K
0.02	1470	1467
0.04	1474	1471
0.06	1478	1473
0.08	1482	1478
0.10	1483	1481
0.12	1486	1483
0.14	1489	1486
0.16	1494	1490
0.18	1496	1493
0.20	1499	1496

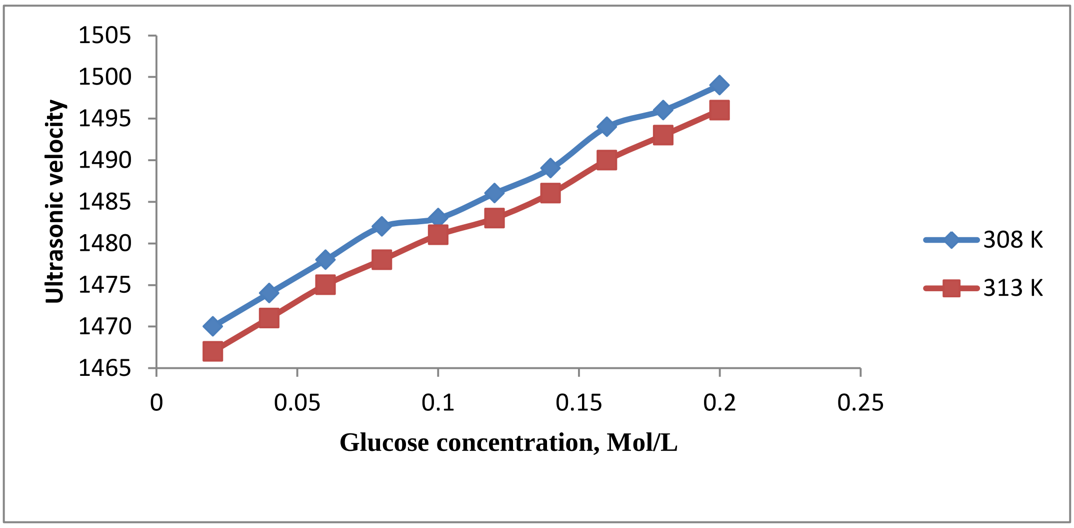

Fig. 3 Variation of ultrasonic velocity of glucose in ethanol + water solution at 308 K and 313 K

The ultrasonic parameters such as molar sound velocity, apparent molar compressibility, isentropic compressibility etc. can be computed in these solutions at all the concentrations using the standard formulae

4. CONCLUSION

The variations in Ultrasonic velocity, viscosity and density with concentrations in the system show a trend of increasing ultrasonic velocity, viscosity and density of the constituents at different temperatures. Density and viscosity exhibit more linearity than ultrasonic velocity in the systems

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