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Thermo-Acoustical Study of Ascorbic Acid Interactions in Aqueous Solutions with Glycine and Glucose

Shrilekha S. Mutyala [a++], Urvashi P. Manik [a#] and Paritosh L. Mishra [a*]

[a] *Department of Physics, S. P. College, Chandrapur, Maharashtra, India.*

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The Manuscript aims to show the noticeable and remarkable nature of intermolecular interaction that exists in the aqueous solution of Vitamin C + Glucose/Glycine at 2 MHz frequency. The Major data of ultrasonic velocity and density in Vitamin C+ Glucose /Glycine at various temperatures like (283K-298K) at different concentrations ranging from (0.02 to 0.2 Mol/kg). Experiment data have been used to evaluate some important parameters like Adiabatic compressibility, acoustic impedance, Relative Association, Relaxation strength, Internal pressure, and solubility Parameters which provide valuable information. The result explains the structure-making breaking tendency and confirms the existence of solute-solvent interaction in (Vitamin C+ Glucose + H_2O) rather than (Vitamin C + Glycine + H_2O) because of the H-bonding present in their solution. A higher mass fraction is given stronger molecular interaction. According to these the proper combination of Vitamin C + glucose repair the human body cell and fast recovery from disease.

[++] P.G. Student;
[#] Professor;
**Corresponding author: E-mail: paritoshlmishra@gmail.com, pgphysicsapm@gmail.com;*

Keywords: Ultrasonic velocity; density; glucose; glycine; vitamin C; H-bonding.

1. INTRODUCTION

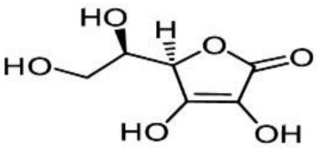
Today, one of the finest methods for physio-chemical, thermodynamical, and acoustical investigations in ascertaining the intermolecular interactions of the fluent is ultrasonic. Ultrasonic waves have emerged as a significant field of study for the structure and characteristics of matter in recent years. Waves are utilized in the technological sector for fault identification, material testing, mechanical surface cleaning, etc. Along with these waves are used in the course of drugs, agricultural manufacturing, chemical manufacturing, the IT industry, underwater communication, and other fields [1]. In the medicinal and pharmaceutical industry, amino acids and vitamins are the most important factors., vitamins are a wide part of organic essential compounds for balancing the normal cellular mechanism of the human and animal body. The deficiency of vitamins in our body causes unhealthy physical development. With the help of supplementation in the body which contains vitamins that can be rapidly noticed and supply extra nutrients for the remaining healthy body [2]. There are Several vitamins are present in nature, they are categorized into two types oil soluble and water-soluble vitamins but in this given research, we take water-soluble vitamins i.e. vitamin C. Vitamin C which is also called ascorbic acid is colourless. Ascorbic Acid plays an extremely significant role in the human body the ascorbic acid is necessary for the Healthy evolution of the brain and also physical progress [3]. The degradation of ascorbic acid is the main nutrition as it is associated with liquid and colour change and for this reason, it is of notice to know the effect of ascorbate ions on the structure of water in solution. It can stop and act against scurvy disease, and normal cold as well as it is needed for the synthesis of collagen, neurotransmitters, and creatinine [4]. Due to their wide application given study selected vitamin C as a solute in this work. A lot of research has been done by previous researchers on vitamins like vitamin C, and vitamin C with hydroxypropyl-β- cyclodextrin and triethanolamine (Claudia Garner, 2007) [5]. Vitamin C with Cardiovascular diseases (Ammar. w. Ashor,2014) [6]. they predicted the result of solute-solvent interaction present in their study and also said the structure-making tendency of vitamin C with another solvent. Variation of compound, concentration temperature sows the variant result. Therefore, keeping that study in mind, I have made a combination of some amino acids and saccharides with Vitamin C. Amino acids and saccharides are also useful for our body [2]. There are several amino acids and saccharides present in nature but among them in these, I used glycine-amino acid and glucose-saccharide as solvent in this work. our body needs a type of sugar called glucose to survive when the blood sugar rises in the body then we have to release insulin. Glycine has been shown to function in unlike structures and nerves in the system act as a neuroprotective agent in our body. The given ultrasonic research study shows the interaction between the mixture of vitamin C with an aqueous solution of glucose and glycine at different temp. and conc. When I was treated with the ultrasonic technique with Vitamin C + glucose/glycine mixture then we determined some parameters like Adiabatic compressibility, Acoustic impedance, specific heat ratio, Relative Association, Relaxation strength, change in Adiabatic compressibility, change in adiabatic compressibility, Thermal expansion Coefficient, Wada's constant, Rao's constant, intermolecular free length, Surface tension, internal pressure, Lennard Jones Potential, Enthalpy, It is also useful to understand acoustical properties, thermodynamic properties and interaction of compound mixture. It is evident from these cited parameters that the solute and solvent components exhibit considerable interaction. Consequently, it seems that at larger mass fractions and temperatures, vitamin C molecules bind to glucose molecules more firmly than glycine molecules. (Vit.C + glucose > Vit. C +glycine), indicating a stronger solute-solvent interaction.

2. MATERIALS

All Chemicals used in this experiment are compounds are AR grade with 99% purity of mass fraction, purchased from HI Media Private Limited, Mumbai.

1) **Ascorbic Acid:**

Molecular weight: 176.12(g/mol), CAS NO: 50-81-7, Molecular formula: $C_6H_8O_6$
Structure:

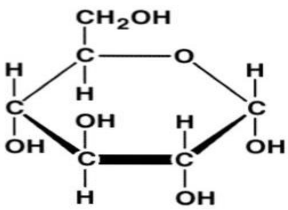


2) **Water:**

Molecular weight: 18 (g/mol), CAS NO: 7732-18-5, Molecular formula: H_2O
Structure:

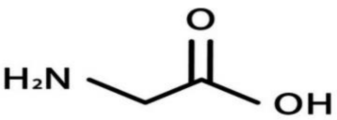
3) **Glucose:**

Molecular weight: 180.156(g/mol), CAS NO: 50-99-7, Molecular formula: $C_6H_{12}O_6$
Structure:



4) **Glycine:**

Molecular weight: 75.07 (g/mol), CAS NO: 56-40-6, Molecular formula: $C_2H_5NO_2$
Structure:



3. METHOD

This experiment was conducted utilizing a computerized water bath to maintain various temperatures (viz. 283,288,293 & 298K). An accurate digital scale by a ±0.1 mg exactness remained used to measure the weight. Some fundamental characteristics, such as ultrasonic velocity and density (the ultrasonic basic parameter velocity and density of this solution is exactly observed with the help of a 10ml density gravity bottle and digital ultrasonic interferometer at 2MHz frequency kept constant with H_8O_6 accuracy of 0.1%). Other thermos-acoustical characteristics have been computed using the normal relative and the observed data.

3.1 Synthesis

We used, the mass fraction method. According to the mass fraction formula weight of corresponding substance can be easily determined.

$$\text{Weight of Substance} = \text{Molecular Weight} \times \text{Molality} \times \text{Volume} * 1000 \quad (1)$$

The following amount of weight obtained in grams for different concentrations of materials which we had to be synthesised.

After weighing the amount of solute and solvent, a stock solution of solvent is prepared by of Glucose and Glycine in 550 ml of double distilled water. Later different solute concentrations (0.02-0.2mol/kg) of solution synthesised using 50-50ml of stock solution by adding various amount of solute. And then this solution characterized by ultrasonic interferometer.

3.2 Define Relations

1. Adiabatic compressibility (β)= $\frac{1}{\rho \times U^2}$ -------- (m^2N^{-1}) [7]

2. Acoustic Impedance (Z) = Uρ ------- ($Kg\text{-}m^2s^{-1}$) [8]

3. Specific heat ratio (γ) = $\frac{17.1}{T^{\frac{4}{9}} \times \rho^{1/3}}$ ---------($(K^{4/9})^{-1}(kg^{1/3}m^{-1})^{-1}$) [9]

4. Relative Association (R_A) = $\{\frac{\rho}{\rho_0}\}\{\frac{U_0}{U}\}^{\frac{1}{3}}$ [10]

5. Relaxation Strength(r) = 1- $(\frac{U}{U_\infty})^2$ [11]

6. Change in Adiabatic Compressibility (∆β) = β-β0 -------- (m^2N^{-1}) [12]

7. Relative Change in Adiabatic Compressibility =∆β/β

8. Isobaric Thermal Expansion Coefficient (α): = $\frac{75.6\times10^{-3}}{T^{\frac{3}{10}} \times U^{\frac{1}{2}} \times \rho^{1/4}}$ ------- (K^{-1})

9. Wada's constant (W) = $V_m\beta^{-1/7}$ [13]

10. Rao's constant (R) = ($V_mU^{1/3}$) ------- (m^3mole^{-1}) (ms^{-1})$^{1/3}$ [14]

11. Intermolecular Free Length (Lf) = K $(\beta a)^{1/2}$[15]

12. Internal Pressure (π_i): $\frac{\alpha T}{K_T}$ ------(Nm^{-2}) [16]

13. Leonard jones potential (n)= {6($\frac{V_m}{V_a}$) - 13…………………. (J mol^{-1})[17]

14. Enthalpy (H): $V_m \times \pi_i$………………………………… {J/Kg} [18]

4. RESULTS AND DISCUSSION

Diversity for systematic study volumetric and thermoacoustic parameter of an aqueous solution of (Vitamin C + Glucose/Glycine) at different concentrations and temperatures plotted in Fig. (1-16)

In the present study one can observe that the Ascorbic acid with the addition of an aqueous solution of glycine and glucose under the ultrasonic practice is observed in Fig.1. It remains shows the ultrasonic velocity rise with rising in concentration temperature which is recommended that intermolecular attraction between them. These increasing trends show the association carried out in the ions of given solutions, which shows the presence of strong intermolecular interaction among the solutions [19]. Density is noted as a measurement of the weight of material to its size the density of solute rises with rising molal concentration. As shown in Fig.2 Solute molecules are combined or added with the solvent to improve the packing structure of the solvent these require the association between solute and solvent [20].

From this analysis, the adiabatic compressibility is falling along with the rising concentration of the solution mixture. Because the solute-solvent solution has strong solidity in bonding of molecules. From Fig. 3, it is clear that the falling of adiabatic compressibility through rising concentration indicates that strong intermolecular forces are present which gives powerful association is carried out in the solution mixture [21]. Acoustic impedance depends on the velocity and density of the solution mixture. From Fig 4, it is clear that the acoustic impedance of ascorbic acid in an aqueous solution is found to rise the rising in molal concentration of ascorbic acid. Molecules of the solution are powerfully associated with each other because of the presence of hydrogen bonding or dipole-dipole forces [22].

Fig. 5 shows that the specific heat ratio values rise with rising concentration and fall with temperature rise. The temperature of the specific heat ratio in the container decreases which is visible in the intermolecular interaction. It shows that there is a nearer packing of the molecule in the solution because of hydrogen attraction between them [23]. Fig.6 shows that the increase of Relative Association through concentration recommends that near relation of constituent of molecular and with intermolecular forces the solution. Hence observed that the sequence of rising relative association of Vitamin C in water also in both glucose and glycine in the following manner, Vitamin C+ Glucose + H_2O > Vitamin C + Glycine + H_2O > Vitamin C + H_2O [24].

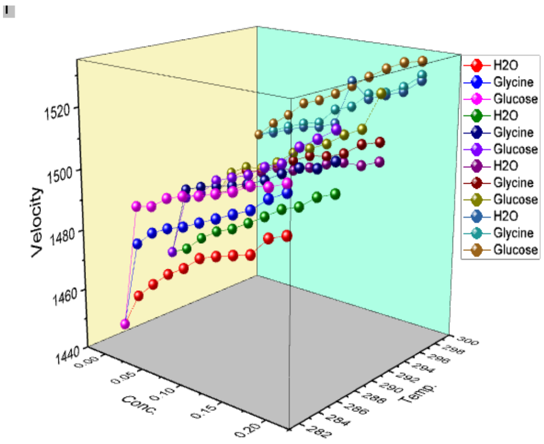


Fig. 1. Ultrasonic velocity

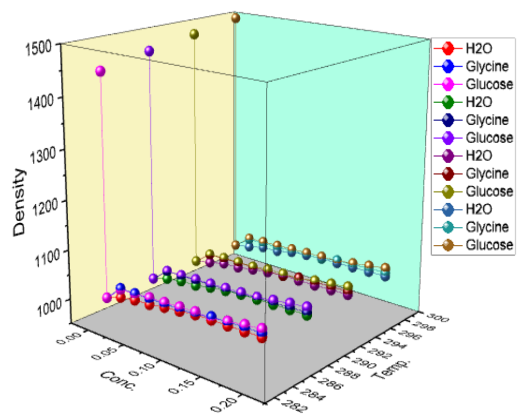


Fig. 2. Density

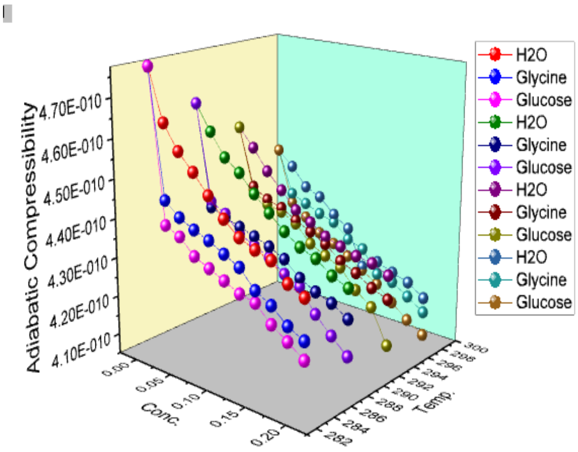


Fig. 3. Adiabatic compressibility

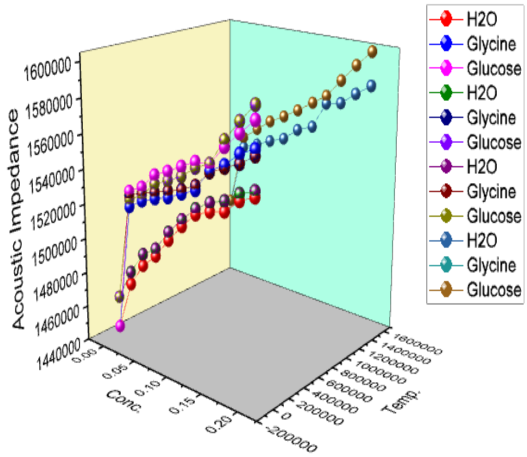


Fig. 4. Acoustic impedance

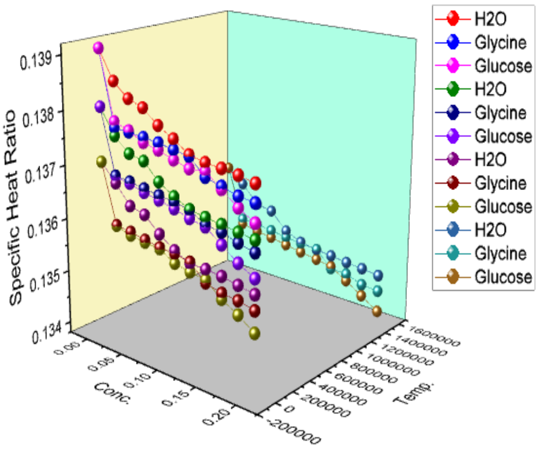


Fig. 5. Specific heat ratio

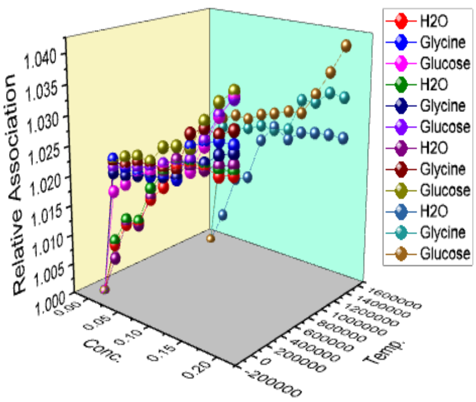


Fig. 6. Relative association

Relaxation strength in Fig. 7. it is completely depending on the factor 1- $(\frac{U}{U_\infty})^2$. Now U is the ultrasound velocity of the mixture and U_∞ is continual and has a volume of 1600m/sec. value of relaxation strength is decreased in molar concentration and a temperature indicates solute–solvent attraction is present in the solution [25]**.** After analyzing the graph of the change in adiabatic compressibility opposed concentration is expressed in Fig. 8. The negative values of change in adiabatic compressibility are due to the solute-solvent attraction like rising in the change in adiabatic compressibility along with rising concentration. might be described as a rise in the cohesive forces in the mixture. This analysis indicates that the hydrogen attraction among the different compounds in the solution increases [26].

The graphical values of relative change in adiabatic compressibility are shown in Fig. 9 it is clear that opposing values of '$\Delta\beta/\beta$' arise and their values rise along with the concentration of the solution, which communicates that the presence of intermolecular forces in the solution mixture and gives rise to the value of bulk modulus of the system due to the hydrogen bonding execute in the solution [27]. Internal pressure is based on concentration, temperature, and internal of the system. From Fig. 10 it is seen that values of internal pressure fall with rising in concentration and temperature. These visible binding forces are cohesive in the middle of the solute-solvent [28].

Wada's constant is useful for studying the physiochemical behaviour of liquid and liquid mixtures. from Fig 11. the increasing trend of constant with rise in concentration as well as with temperature. indicate in the current system a greater number of components are available in a given volume of the medium and the presence of molecular association and close packing of the medium [29]. The Rao constant is also recognized as the molar sound velocity of the system. From Figure 12, it is confirmed that the Rao constant rises with rising in concentration and temperature, this increasing mode of the Rao constant expresses that there is less solute-solvent interaction in the medium due to additional components. It occurs. Medium is available [30].

From Fig. 13. Clearly shows that as the concentration of ascorbic acid Rises the value of the isobaric thermal expansion Coefficient falls which reveals the fall in the fluidity of the medium due to a large interaction between the constitution of Solute-solvent ion [31]. The decrease in free length from Fig .14. With the rise in the concentration of ascorbic acid in aqueous solution suggests the presence of notable attraction among solution mixtures. It is also indicating the structure encourages behaviour as well as the presence of specified dipole-dipole forces in the solution. with the rise in the temperature of the solution at the given concentration rising spacing between the molecules in the current in the examination is observed increasing the free length of the solution using increasing molecular motion [32].

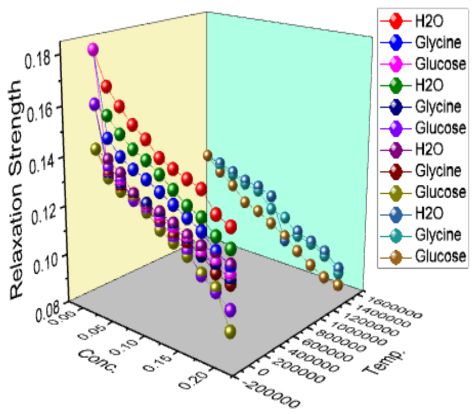


Fig. 7. Relaxation strength

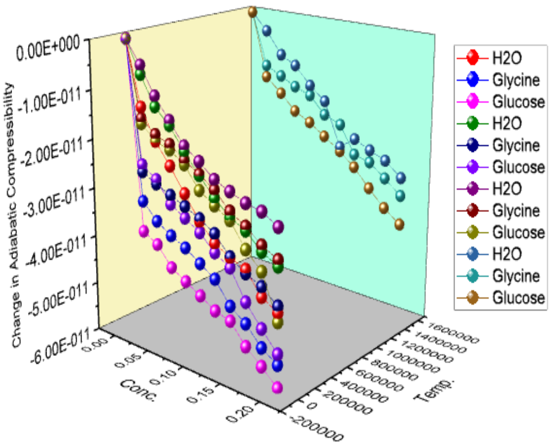


Fig. 8. Change in adiabatic compressibility

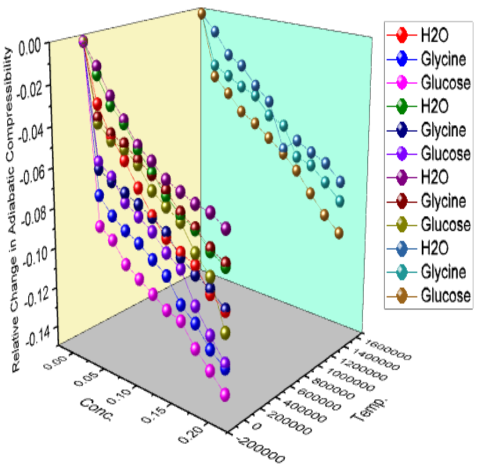


Fig. 9. Relative change in adiabatic compressibility

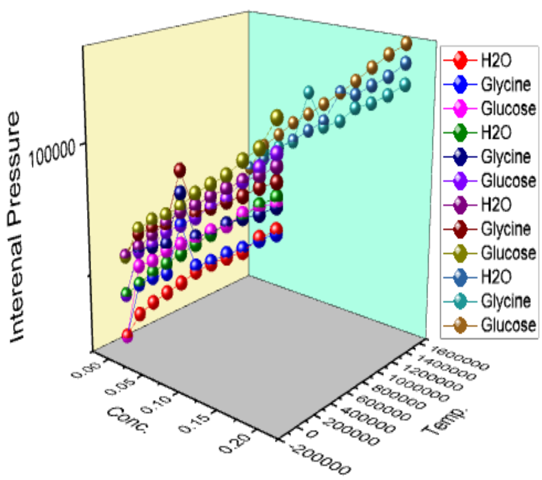


Fig. 10 Internal pressure

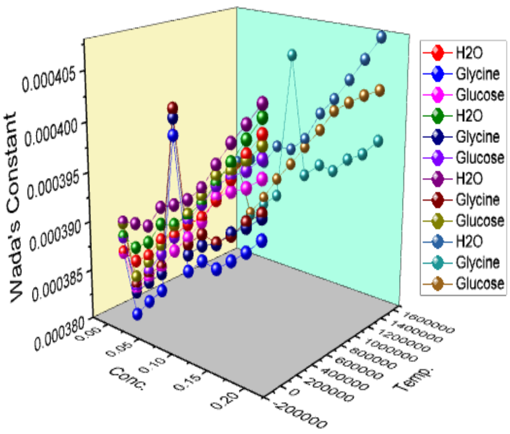


Fig. 11. Wada's constant

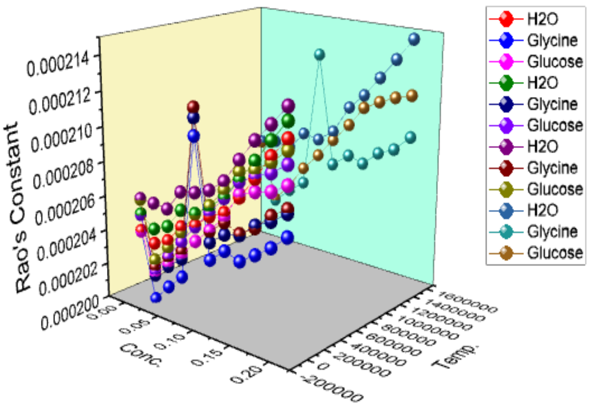


Fig. 12. Rao's constant

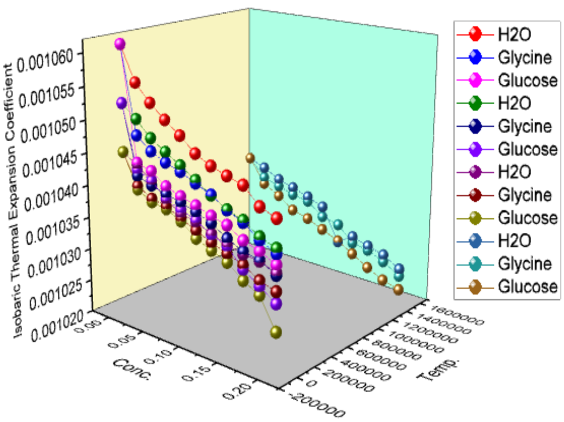


Fig. 13. Isobaric thermal expansion coefficient

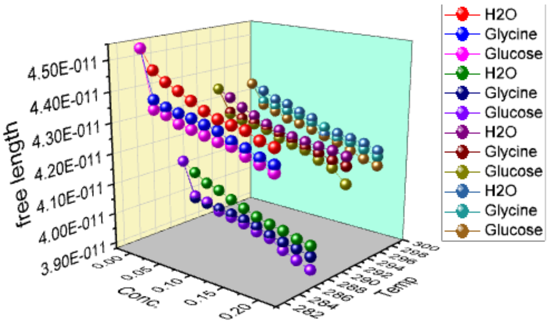


Fig. 14. Intermolecular Free length

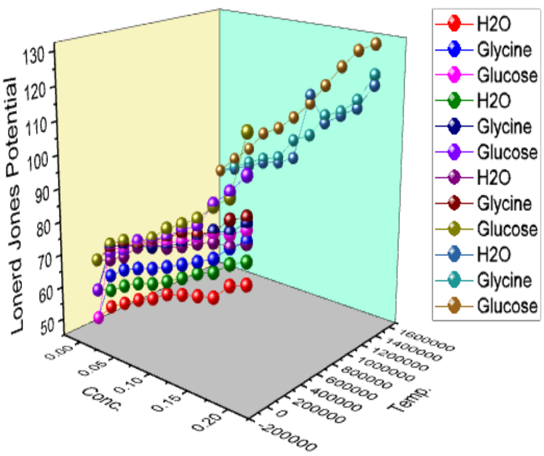


Fig. 15. Lenard-jones potential

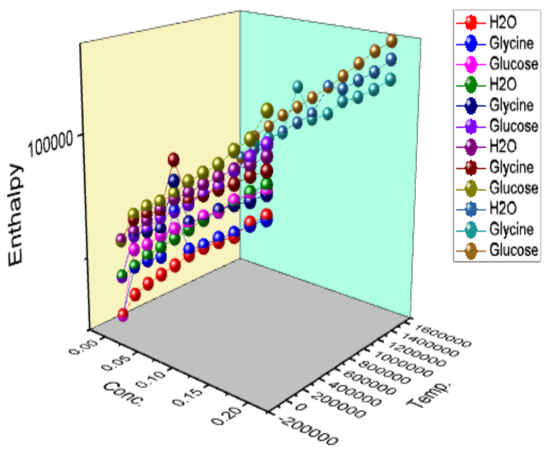


Fig. 16. Enthalpy

The Lenard-jones potential is expanding the potential energy of interaction between two molecules. The values of Lennard -Jones potential for Ascorbic Acid in various concentrations [0.02-0.2] from aqueous solutions of glycine and glucose and different temperatures [283K- 298K] from Fig 15. Show that the values Lennard-Jones potential decrease with an increase in concentration and temperature. Which results in molecular interaction among the constituent particles of solute-solvent and favours attractive force acts among the molecules of solute and solvent. [33]. These are considered to be very important thermodynamic parameters these parameters present information about how close the liquid molecule is. The variation of enthalpy with molal concentration is shown in Fig. 16. This indicates that the enthalpy of aqueous Ascorbic Acid decreases with increased concentration and temperature from this it achieves the intermolecular forces in the system [34].

5. CONCLUSION

In the present study, the volumetric and thermo-acoustic parameters for Vitamin C (Ascorbic Acid) in aqueous amino acid (Glycine) and Saccharide (Glucose) solution were used to explore the molecular interaction present in solution this experiment was carried out in various concentrations 0.02-0.2 Mol/kg and at various temperature 283 - 298K. This approach can help to understand the efficient interaction of Vitamin C with glucose and glycine. The increasing trend in ultrasonic velocity and density shows the attendance of powerful molecular interaction in solution at higher concentrations. The positive value of ultrasonic velocity showed the structure-making behavior of Vitamin C in solution. After consideration of the Research works it is found that based on thermo-acoustic parameters Among two solvent solutions strong intermolecular interactions are present in (Vitamin C + H_2O +glucose) than (Vitamin C + H_2O +glycine) and (Vitamin C + H_2O) which may due to the presence of H-bonding (carboxyl group) is glucose solution. Their combination shows stronger molecular interaction at higher concentrations and temperature.

According to the scenario, we may conclude that the mixture of Vitamin C And glucose is a sufficient quantity which repairs body cells in humans and provides fast recovery from disease (Sepsis) as compared to remaining two solvents. Through this approach a large amount of economical saving can be also done.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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