

# Acoustic Experiments on the Binary Mixture of Glycerine and Water at Various Temperatures, Concentrations, and Dielectric Constants

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## ABSTRACT

Using solvents and solvent mixtures as a medium for chemical processes is crucial. The ability of the medium to participate in intermolecular interactions like van der Waals, electrostatic attraction, and hydrogen bonding, as well as its polarity, frequently affect the reaction rate and even the reaction mechanism. Water and glycerol are examples of hydroxylic solvents with high dielectric constants. Even in their purest form, they are connected. Intramolecular hydrogen bonding may give rise to intermolecular hydrogen bonding during mixing. This causes the solvent mixture to behave in a non-ideal manner. This can be qualitatively appreciated by conducting ultrasonic research on mixtures of various compositions at various temperatures and dielectric constants.

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## INTRODUCTION

Water and glycerine are two substances that interact to generate intermolecular solid hydrogen bonds. Water molecules quickly destroy the network created by the intermolecular hydrogen bonds in glycerine. Consequently, it is reasonable to anticipate a significant departure from the behaviour of such a binary mixture. This is simply comprehended by evaluating the density, viscosity, and ultrasonic properties of different ratios of binary glycerine-water solutions. At various temperatures, the dielectric constant of various mixes is tested. This leads to a qualitative link between intermolecular interactions and acoustic properties. It is possible to comprehend how intermolecular interactions and other factors impact the dielectric constant.

Considering the dielectric constant of mixtures between water, ethanol, and glycerol, the effect of the dielectric constant upon the aggregation behaviour of biological molecules, like protein in solution, had already been examined. It is generally known that crystallisation and elution chromatography solvent selection is based on the dielectric constant of the solvent. It has been noted that protein aggregation occurs at high dielectric constant levels, demonstrating the impact of the solvent mixture's dielectric constant. Molecular aggregation, Association, and complexation have already been documented in the solution of binary and ternary mixtures.

With this in mind, research was done on the ultrasonic behaviour of binary mixes of glycerine and water with various dielectric constants at various temperatures and concentrations.

## Experimental

A pycnometer bulk with an  $8 \times 10^{-6} \text{ m}^3$  capacity and a graduated scale with  $5 \times 10^{-8} \text{ m}^3$  division was used to test the density. The stem markings were calibrated using triple-distilled water with known densities. A crystal variable path interferometer with a 2MHz frequency measures the ultrasonic velocities in binary mixtures and pure liquids. The measuring accuracy of densities was  $\pm 0.05\%$ , while ultrasonic velocity was discovered to be  $0.001 \text{ g/cc}$ . The liquid mixes' viscosity was determined using Ostwald's viscometer. In an electronically controlled thermostatic water bath, the temperature of the test liquids was maintained with an accuracy of  $\pm 0.02^\circ\text{C}$ .

The following relationship between the recorded density and ultrasonic velocity was used to compute  $K_s$ ,  $L_f$ ,  $R_A$ , and  $Z$ . Adiabatic compressibility is  $\beta = 1/U^2 \rho$  ( $10^{-10} \text{ m}^2/\text{N}$ ).

$$\text{Free length } L_f = K/U\rho^{1/2} (10^6 \text{ Kg m}^2/\text{s})$$

$$\text{Relative association } R_A = \rho/\rho_0 (U_0/U)^{1/3}$$

$$\text{Acoustic impedance } Z = \rho U$$

$K$  is a constant that changes with temperature.

$$K = (93.875 + 0.375 \times T) \times 10^{-8}$$

T is the absolute temperature, while  $\rho_0$ ,  $U_0$ , and U are the solvent and solution's densities and ultrasonic velocities. In tables and graphs, the values of  $\rho$ , U,  $\beta L_f$ ,  $R_A$ , and Z are depicted as functions of mole fraction.

## DISCUSSION

### Consistency VS. Density

A binary mixture's density is determined by its constituent parts' composition and liquid densities. Consequently, a linear graph is anticipated for the perfect solution. The density is a function of the glycerol-water mixture's chemical makeup within the concentration range under investigation. A graph almost like a straight line and shows increasing density at higher concentrations is produced. A straight-line part is seen between concentrations of 0.2-0.4%. A slight hump is seen above the concentration between 0.41 and 0.4%. The creation of intermolecular hydrogen bonds between the molecules of the solute and solvent can explain the increase in density. In the 1–2% concentration range, intramolecular hydrogen bonding breaks down and is replaced by increased intermolecular hydrogen bonding.

The energy of the molecules to increase in volume also increases as the temperature rises. In the end, this reduces density. In both situations, an ideal binary mixing produces a straight graph. Ideal behaviour is observed at low concentrations (0.5 to 1%). Similarly, a nearly straight-line graph is produced at a high temperature of 45°C. Higher concentration region exhibits departure at all temperatures.

### Viscosity VS. Concentration

The binary liquid mixture's viscosity depends on the component viscosities and how they are mixed. For an ideal binary mixture, this is true. The system does not produce a linear graph under study. The breakdown of the intermolecular contact between the pure liquid molecules is the basis for the deviation from ideal behaviour; the development of intermolecular hydrogen bonding between glycerol and water predominates over the breakage of bonds. Additionally, the intermolecular hydrogen bonding in glycerol has been replaced with intermolecular hydrogen bonding, which is the cause of the rise in viscosity. The amount of the molecule in the liquid state and the potency of the intermolecular interaction determines the viscosity. The composition's viscosity and the characteristics of the mixture's components establish the viscosity of the optimal mixture. The mixture's viscosity is anticipated to change rectilinearly as the concentration rises. The fluidity rises when the temperature rises due to the molecules' increased kinetic energy. As a result, it is discovered that viscosity decreases as temperature rises. Depending on how temperature and concentration affect the intermolecular interaction, deviations from optimal behaviour are to be expected. The deviation from the optimal behaviour is observed to be harmful at 35°, 40° & 45°C. At 30C, a positive deviation is seen. The variations range from 0.8~1.8%. Under 0.8%, intermolecular H-bonding mutually dissociates, increasing volume.

### Concentration versus Ultrasonic Velocity

The medium's density affects the ultrasonic velocity. Ultrasonic velocity will increase with density. Inverse relationships exist between linear free length, adiabatic compressibility, and ultrasonic velocity. No matter what influences them,  $L_f$  and  $\beta\beta$  will lessen the molecular forces that contribute to the U-value's magnitude.

The addition of glycerol from a concentration of 0.5% in water with molecular contact between glycerol and water occurring until a concentration of roughly 0.8% can be used to explain the initial fall in U-values by disrupting the intermolecular attraction that previously existed with water.

The reduction in U-value denotes the breakdown of glycerol's intramolecular hydrogen bonding. Between 0.7 and 1.5% concentrations, this occurs. When the U-value is at its highest, it is replaced by intermolecular hydrogen bonding between glycerol and water up to 1.75% concentration. Additionally, as glycerol concentration rises, some hydrogen connections between glycerol and water are further disrupted. Intermolecular interactions between glycerol molecules gradually take their place. In a denser medium, sound waves have been seen to move more quickly. The ultrasonic velocity increases with increasing medium density. U is therefore anticipated to grow along with an increase in concentration.

Similar to how warmth increases molecular kinetic energy, an increase in U with temperature is anticipated. Although optimal solutions are predicted to have straight lines, nonlinear graphs were found instead. U has been observed to rise from 0.4 to 1.6% before falling. At 1.6% concentration, a maximum U value is seen. Interestingly, maxima are seen for the binary mixture for the 1% concentration solution at all the other temperatures. The graph shows that peaks are almost 1% concentration at temperatures between 30°C and 40°C.

Similarly, even at 30°C, a rapid increase in U is seen at about 1% concentration, and maxima are seen at about 1.5% concentration. The maxima depict an instance of intense interaction between dissimilar molecules. Another upward trend is seen around 1.5% concentration at 45°C. This might correspond to the creation of glycerol-water bonds due to the breakdown of intramolecular hydrogen bonds in trihydroxy compounds.

Density,  $U$ , and  $Z$  values are inversely correlated with concentration vs adiabatic compressibility, while  $L_f$  values correlate directly. The fact that the Concentration vs charts almost precisely mirror each other is quite intriguing. The disruption of intermolecular connection in water initially causes the to increase. All discrepancies can be accounted for by the glycerol/water interaction that replaces this and causes a reduction.

Ultrasonic velocity and adiabatic compressibility are inverse, although  $L_f$  and  $L_f$  have a straight relationship. It also has to do with the medium's density. Since the medium is typically denser, the value is lower. A lower value indicates strong intermolecular bonding, whereas a more significant value indicates weaker intermolecular force or repulsion.

Plots are obtained for temperatures between 35<sup>o</sup> and 45<sup>o</sup>C that are almost exact. Minima are attained at these temperatures practically at the same concentration of 1%. There is a falling trend from 0.4% to 1%, followed by an upward trend. For the combination at 30<sup>o</sup>C as well, there is a gradual drop in concentration starting at 0.4%, followed by a substantial drop from 1% and reaching a minimum of about 1.5%, and finally, there is a sharp rise in value. The rate of intermolecular bond formation is modest at low temperatures below 1% concentration. It is suggested that solid intermolecular forces will develop between glycerol and water. The creation of intermolecular solid bonds between unlike molecules increases as temperature rises due to the weakening of intermolecular bonds between like molecules.

The breakdown of intra-molecular H-bonds in the trihydroxy molecule glycerol causes the increase in value following the minimum. The process above ends at 45<sup>o</sup>C and is replaced by the creation of glycerol-water bonds, which exhibit a further decline in value as the concentration rises.

### Concentration Vs Accoustic Impedence

The  $Z$  is inversely proportional to  $L_f$ ,  $\beta$  and  $R_A$  and directly proportional to  $U$ . The graphs generated for  $Z$  vs  $C$ ,  $U$  vs  $C$ ,  $L_f$  vs, and  $\beta$  vs  $C$  make this fact quite evident.

The graph obtained for  $U$  matches the curve's prediction for  $Z$  vs Concentration exactly. The breakdown of the pre-existing intermolecular link accounts for the decrease in  $Z$  values, while the production of new bonds is responsible for the rise.

$Z = U\rho$ . This demonstrates that  $Z$  values rise when density or ultrasonic velocity increases. This becomes evident by contrasting the graphs for  $Z$  vs  $C$  and  $U$  vs Concentration. The inverse proportionality of  $Z$  is also evident when the former graph is compared to that of  $V$ s Concentration ( $\beta = 1/Z * \rho * U$ ). When it comes to  $Z$  change with temperature, the behaviour of the mixtures is virtually identical to that of  $U$  and inverse for that of  $\rho$ .  $\rho$  It has a more significant value at 30<sup>o</sup>C, while the  $Z$  and  $U$  values are shallow. The creation of intermolecular solid forces between dissimilar molecules explains an increase in  $Z$ , whereas a drop in  $Z$  points to the breakdown of glycerol's intramolecular H-bonds.

Maxima appears at 1% concentration between 35 and 45 degrees Celsius but between 1.5 and 2.0% between 30 degrees Celsius.

### Concentration versus Relative Association

Low glycerol concentrations result in a low relative Association. This occurs because the mutual intermolecular connections are broken when a solute is added.

Two things influence the relative Association.

(i) Soluting a solute breaks up solvent molecules, raising  $R_A$  levels.

The  $R_A$  value increases by up to 0.5% in the low-concentration zone. This shows that the intermolecular hydrogen bonding in water is broken when more glycerol is added. Beyond that,  $R_A$  values drop because glycerol/water aggregate production reduces the concentration from 0.8% to 1% to as little as 0.8%. Since glycerol is a trihydric alcohol, there is likely an increase because intramolecular hydrogen bonds are destroyed and then created with water molecules. For the three hydroxyl groups, this occurs essentially sequentially. As glycerol concentration rises, glycerol/water/glycerol contact replaces water/glycerol/water molecular interaction. The molecules' relative Association ( $R_A$ ) declines with concentration, reaching a minimum at 1.0%, and then increases at temperatures between 35 and 45 degrees Celsius.  $R_A$  is closely related to the density of the solution at low-concentration regions. At 30<sup>o</sup>C, the trend is the exact opposite. The overall tendency, as demonstrated in the case of  $R_A$ , is the inverse of  $U$ . The interaction between water, glycerol, and water is responsible for the decrease in  $R_A$ .

In contrast, the interaction between glycerol, water, and glycerol is responsible for increased  $R_A$ . Higher temperatures cause  $R_A$  levels to decrease because the intermolecular interaction might be hampered by thermal energy. The maximum  $R_A$  value is observed for the solution with a 1.6 to 2.0% concentration at 35<sup>o</sup>C. Contrast this with a solution of 0.4 to 1.0% concentration at 30<sup>o</sup>C. As a result, the Association between similar molecules is encouraged in areas of low concentration. In contrast, the Association promotes more concentration solutions as the temperature rises.

### Concentration Versus Molecular Volume

Molar volume and density typically have an inverse relationship. On a graph, the molar volume suddenly rises in a low-concentration area. The graphs of density vs concentration and increase vs concentration show that the reduction in density does not offset the increase. This demonstrates unequivocally that mutual breakage of the intermolecular interactions between glycerol and water occurs first. The intermolecular interaction between glycerol and water replaces this. The relationship between molar volume and solution density is inverse. The graph of density vs temperature and temperature illustrates this. With an increase in concentration, the value first rises steadily. At all temperatures, it reaches maximum values at 1.0% concentration. Values outside the Concentration change uniformly across all temperatures—maximum at high temperatures. With concentration, values rise at a specific temperature. In every instance, the initial gain in value is comparatively higher. The value for the solution at 30°C rises with concentration, reaching a maximum of 0.176M solution before falling. Compared to the other temperatures, it has been observed that the behaviour of the binary mixture at 30°C is unusual.

### Molecular Association Versus Concentration

Similar to the curves produced for  $U$ ,  $Z$ , and  $R_A$  vs Concentration, the curves obtained for  $M_A$  vs Concentration also show a relationship with concentration. Pure liquids are linked liquids, as indicated by the initial high value of  $M_A$ . Intermolecular bonds are broken when one is added to another. This particular graph style resembles water and di- or trihydric alcohol.

### Molecular Association ( $M_A$ ) VS Mol Fraction

In contrast to molecules, molecular Association is the measure of Association between molecules. The  $M_A$  values will increase as the solute concentration rises. Similar to  $R_A$ , it is inversely proportionate in that connections between dissimilar molecules grow as those between like molecules contract. Dissociation of the solute or the solvents causes the molecules of the solute and the solvents to associate. As a result, associations between water and water and glycerol and glycerol give way to associations between water and glycerol and water or vice versa. In contrast to  $M_A$ , which rises as the temperature rises,  $R_A$  falls as the temperature rises. Following is an explanation for this.

The intermolecular interactions between glycerol and water molecules weaken as the temperature rises. As a result, dissimilar molecules begin to dissociate and create intermolecular hydrogen bonds. The binary mixture behaves similarly to the other qualities at 35° to 45°C. However, oppositely at 30°C. At all temperatures, the maximum molecular Association happens at a concentration of 1.0%. Except for 30°C, molecular association values rise as glycerol concentration rises. While at other temperatures, molecular association values initially rise and then fall as concentration increases in low-concentration regions between 35° and 45°C. Predominantly, molecules with opposite properties associate. There is less dissociation between similar compounds. In the high concentration range, dissociation between like molecules predominates concurrently with an increase in Association between unlike molecules.

### Concentration versus free length

Free length is directly proportional to while being inversely proportional to density,  $U$ , and  $Z$ . The initial rise in the  $L_f$  value suggests that glycerol/glycerol aggregation dissociates when glycerol is added to water. The interaction between glycerol and water comes next. The intramolecular hydrogen bonding in glycerol is broken, resulting in glycerol/water contact, according to an increase with  $L_f$  over 0.5% concentration and another at 1% concentration. Beyond the concentration, glycerol/water/glycerol interactions take the place of water/glycerol/water interactions by 1.5%.

Intermolecular free length  $L_f$  varies in the same way as the concentration and temperature of the binary mixture, while  $L_f$  &  $\square$  are inversely related to ultrasonic velocity & density. Since  $L_f$  is connected to the square root of  $U$ , &,  $L_f = K/(U\rho)^{1/2} = (\beta/\rho)^{1/2}$ . Therefore, the sharp positive and negative deviations are minor compared to those of  $U$ ,  $\beta$  &  $\rho$  because the observed deviation in  $L_f$  is correspondingly reduced. Anyhow, the fluctuation of  $L_f$  with Concentration & temperature makes the pattern expected along the lines of  $U$  pretty obvious. The behaviour at 30°C differs from that at 35°C, 40°C, and 45°C, as found in earlier examples; maxima arise at 1.0% for the latter.

### Molar Concentration $v/s\beta^E$ (Negative Function)

The void or empty space in the solvent structure is measured by adiabatic compressibility; the higher the former, the lower the  $\beta$ -value.

The initial drop in the  $\beta^E$  value shows that the additional glycerol molecules' intermolecular hydrogen bonds are broken in a highly diluted solution.  $\square^E$  continues to get closer to  $\beta^{id}$ . Due to the glycerol/water interaction, more glycerol addition worsens the non-ideal behaviour, resulting in  $\beta^{exp}$  less than  $\beta^{ideal}$ .

### Greater Function

The experimental value is more significant than the ideal value, as shown by the excess function's positive value. The experimental value could be better, as shown by the excess function's negative value. A low value for  $U^E$  denotes the presence of hydrogen bonds between two dissimilar molecules, in this case, water and glycerol. Positive readings for



$U^E$  indicate the breaking of hydrogen bonds between dissimilar molecules. Positive  $\beta^E$  &  $U^E$  values are produced via weak physical interaction, dispersion forces, and dipole-dipole interaction. With the presence of a solute, linked molecules break apart.  $U^E$  and  $\beta^E$  values rise as a result. Volume expansion happens when constituent molecules do not fit tightly into one another's structures. As a result, the values of  $E$  &  $U^E$  are positive. Liquid with positive  $\beta^E$  &  $U^E$  mixed in, of equal molecular size.

A drop or an increase in  $\beta$  &  $L_f$  values results from the creation of hydrogen bonds between dissimilar molecules and the mutual dissociation of component molecules. Few OH groups are available for the component in a multi-hydroxy alcohol with inter- and intramolecular hydrogen bonding, increasing  $\beta$  &  $L_f$ . In the analysis of the properties of the binary mixture, the following trend is seen in the variation of all excess functions with concentration and temperature.

The behaviour at 30°C differs from that at higher temperatures (the trend is in the opposite direction). Therefore, the maximum or minimum occurs at a concentration of about 1.0%.

#### **Efficacy vs. $L_f^E$ (negative function)**

Most negative values of  $L_f^E = L_f^{ideal} > L_f^{exp}$ , indicating a more significant intermolecular interaction.  $L_f^E = L_f^{exp} - L_f^{ideal}$ . This is deteriorating, which lowers  $L_f^E$  values. The  $L_f^E$  falls when  $L_f^{exp}$  gets closer to  $L_f^{ideal}$ . This demonstrates that dissociation between dissimilar molecules predominates over Association.

#### **Concentration Versus Dielectric Constant**

The DEC produces linear fluctuation with a concentration in the glycerol/water mixture's composition range. The DEC is decreased by increasing the glycerol concentration in the glycerol/water mixture.

#### **Density Vs. Dielectric Constant**

The experimental result often shows an increase in density and a decrease in the DEC of the binary mixture. Both 30<sup>0</sup>- and 45 degrees Celsius show almost rectilinear variation, whereas 35<sup>0</sup>- and 40 degrees Celsius produce curves with minima and maxima. Density increases when DEC decreases. This demonstrates that intermolecular interactions between similar molecules deteriorate at lower DEC. Intermolecular bonding between the dissimilar molecules comes next.

#### **Viscosity And Density Vs Dielectric Constant**

Glycerol concentrations in the water-glycerol combination ranged from 0.3 to 4.0 millimetres. Each mixture's density, viscosity, dielectric constant, and ultrasonic characteristics were determined at room temperature. A nearly rectilinear graph is produced by the plot of density and DEC with concentration, although there are tiny density-related variations.

The size of the molecules in liquids affects viscosity. Each glycerol and water molecule interacts with other molecules in the mixture, causing solvation and increasing the bulk. This impacts the liquid's viscosity. All of the ultrasonic parameters and extra functions demonstrate this. A crucial characteristic of the mixture is its dielectric constant. The analysis of how each property changes due to the mixtures' DEC reveals that the behaviour of liquid mixtures is eventually severely affected by DEC change. The relative connection between dielectric constant and highly polar molecules containing hydroxyl groups, such as water and alcohol, are characterised by relative Association. In contrast to molecules, relative Association refers to the Association between entities. This frequently refers to hydrogen bonds between the solute and solvent molecules.

The  $R_A$  values for the system under consideration between dissimilar molecules refer to glycerol/water association, as we have already seen from the study of all ultrasonic functions that mutual dissociation of component molecules occurs at insufficient concentrations, i.e., with further increase of concentration, intermolecular Association (glycerol/water) occurs. The concentration of glycerol decreases with increasing DEC of the combination. It can be noticed that  $R_A$  values are low with greater DEC values. The wavy pattern on the graph, which is not linear, represents the many stages of the Association between glycerol and water. The relative Association gauges the dissolution of solvent molecule aggregates by introducing solute. The relative Association is raised as a result. By adding glycerol,  $R_A$  rises from a low concentration to a maximum concentration between 1.0 and 1.5% before falling. The solvation of glycerol is responsible for the decline in  $R_A$ . For 30°C, the same tendency is seen. With the addition of glycerol at higher temperatures, there is initially a reduction in  $R_A$  values; a minimum is attained at 1.0% conc, and above this, there is an increase. This can be explained by assuming that the energy required to disintegrate solvent aggregates is at higher temperatures. As a result, the solute solvates at a concentration of 1.0%. Beyond this, intramolecular bonding in glycerol begins to break down, raising  $R_A$  levels. It has been found that the DEC values of the combination decrease as temperature increases. The glycerol/water system has a greater  $R_A$  when the DEC value is lower.

#### **Diffraction Versus Free Length**

The relationship between  $L_f$  and the mixture's dielectric constant reveals that the  $L_f$  values are lower for larger DEC values. Intermolecular interaction mutually dissociates at low concentrations and high DEC in the mixture. As a result,

$L_f$  has a higher value. Glycerol is a trihydric alcohol, thus. The graph shows that there are various forms of interactions with water.

#### Dielectric Constant Concerning Z, V, B and $R_A$

The V or Z vs Dielectric constant plots show that Z or U values considerably drop with an increase in concentration within the measurement range at a high dielectric constant value. This demonstrates that the molecules dissociate when glycerol is added. The mixture with a high DEC value exhibits the same effect at low concentrations. The mixture with low DEC exhibits the same behaviour as the region of high concentration.

This applies to every aspect of ultrasonics we have investigated, including adiabatic compressibility and relative Association.

#### Adiabatic Compressibility Vs Dielectric Constant

The binary mixture's DEC and have no direct link. A parabolic curve is produced at 30°C, and maxima are seen at DEC values of 76.10. For the other temperature at various DEC values, the maxima are visible. The combination becomes practically incompressible at the minimal value. This demonstrates how the intermolecular force diminishes. This instance exemplifies how solvents and solvent interaction form.

#### Acoustic Impedance against Dielectric Constant

The acoustic impedance and have an inverse relationship. This is evident from the graph's shape. The DEC vs and DEC vs Z plots are nearly identical. With DEC values, Z grows, but the growth is rapid. At 30°C, the maximum is reached at DEC values of 76.10, while maxima at higher temperatures happen at DEC values. Changes in temperature impact both DEC values and Z values. Maxima Z values show cluster water-glycerol water production. This cluster formation occurs for binary mixtures with low and high DEC values.

#### Diffraction Versus Free Length

The temperature affects how  $L_f$  changes with DEC. The  $L_f$  values grow as the mixture's DEC increases at 30°C. At higher temperatures, a wavy graph with maxima and minima is produced. The minima at temperatures of 35°, 40°, and 45°C are located around the concentration of 1.0% glycerin, and as the temperature rises, DEC values fall. High DEC equates to a low glycerol percentage in the binary combination of glycerol and water. In this case, intermolecular links between similar molecules break down, raising the  $L_f$  value.

### CONCLUSION

We created the glycerol and water binary systems with various compositions. For each mixture, density, viscosity, and ultrasonic velocity measurements were made at four different temperatures. In addition to  $L_f$ , Z,  $R_A$ , Vm, and  $M_A$ , other ultrasonic parameters were also determined using conventional equations. Additionally, as mentioned earlier, the excess function of the parameters was computed. These variables are displayed versus the mixture's dielectric constant, temperature, and concentration. The observed graphs regarding hydrogen bond formation and breakage, inter- and intramolecular forces, and other molecular forces were interpreted.

The binary system changes at a concentration of 1% glycerol, modifying all properties with concentration. At a concentration of 1%, either a maximum occurs for V, Z, Vm, and  $M_A$ , or a minimum occurs for  $L_f$ ,  $R_A$ , and ae. This is remarkably accurate for temperatures up to 3545 C. Different behaviour is seen at 30°C. At a concentration of 1.5%, several peaks or minima are seen at 30°C.

Based on the primary function of water glycerol (solvent/solute) interaction achieving a maximum or minimum value at 1% concentration, an increase in V, Z,  $M_A$  or decrease in  $L_f$ ,  $R_A$ , are described. Beyond the concentration, it is seen that V, Z, and  $M_A$  decrease while  $L_f$ ,  $R_A$ , and grow. The breakdown of intramolecular hydrogen bonding explains this; more hydroxyl groups are liberated in glycerol, a trihydroxy molecule. The creation of hydrogen bonds between the liberated OH groups of glycerol-water-glycerol accounts for the further increase in U and Z with increasing concentration.

It is generally known that DEC impacts the behaviour of mixes. Therefore, the higher the DEC, the higher the value of U, Z, or  $R_A$  is for the system under consideration, and the lower the DEC, the higher the value of  $L_f$  and  $M_A$  is preferred. It is discovered that the DEC of the binary mixture affects the way molecules aggregate.

The DEC of the combination lowers as the proportion of glycerol in the mixture rises. At all temperatures, density rises when the mixture's DEC lowers. The other properties do, however, vary rectilinearly with a change in DEC. Water has a relatively high DEC (80.37), but glycerol has a lower DEC (41.14).

Additionally, although both liquids are hydroxylic, glycerol, which has a low DEC, can interact with solids via hydrogen bonding rather than dipole-dipole interaction. This characteristic has precedence over DEC's effect. Contrary

to the DMF-water system or the DMSO-water system, it is evident that the intermolecular H-Bonding between the water and glycerol has a crucial influence in determining the property of the binary combination.

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