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Acoustical studies on binary mixture of ascorbic acid (Vitamin C) in two different salts (NaCl and $MgCl_2$) using ultrasonic technique

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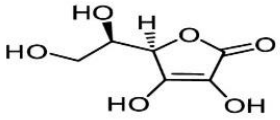
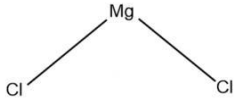
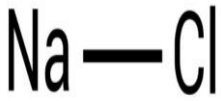
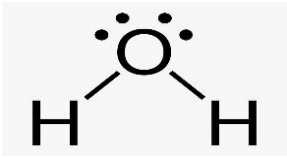
Abstract
The ultrasonic analysis of Ascorbic Acid at with salts solution of $MgCl_2$ and NaCl having a molality of 0.2M and 0.5 M at various temperature (283.15-298.15K) and concentration. From this analysis we determined the ultrasonic velocity with help of digital ultrasonic interferometer machine and density is measured by using of specific gravity density bottle. This observed velocity and density help to calculation of parameter like adiabatic compressibility, change in adiabatic compressibility, relative change in adiabatic compressibility, acoustic impedance, specific heat ratio, non- linear parameter, isothermal compressibility, isobaric thermal expansion coefficient, molecular radius, internal pressure, thermal conductivity, surface tension, Rao's constant, apparent molal volume, solubility parameter. This all parameters which are gives the information about strong intermolecular interactions, structure, behaviour of solution under various temperature and concentration. This approach is helpful in medical field for the treatment of various types of diseases.

Keywords: Ultrasonic velocity, density, ascorbic acid, salts solution, molecular interaction

Introduction
We know that the ultrasonic study is very important technique which can be taken under the study in all scientific field like physics, chemical, agriculture, medical and engineering [1]. Investigation of various types of properties like acoustical, thermodynamical, physicochemical and other is carried out under the ultrasonic technique, which largely beneficial to society. The ultrasonic wave are also be emitted through the solid, polymer and liquid solution [2]. The ultrasonic method is applicable in different activities like material testing, cracks in metals, sonar for underwater communication, and lithotripsy for kidney stone break [3]. By using ultrasonic method we determined ultrasonic velocity and other parameters of compound mixture under the different temperatures and concentration which express the all the behaviour of compound mixture and structural information of it [4]. As we know that vitamin C is also called as ascorbic acid and it is very important essential in human body. The ascorbic acid s provided a healthy development of brain and also physical development [5]. The ascorbic acid is aquatic in nature of all other compound and it will be found in various organic materials in nature. The ascorbic acid is applicable in various industries like medical, cosmetic, foods and other [6]. The ascorbic acid is majorly affected in human because of the deficiency of ascorbic acid in human beings they cause the disease like cardiovascular disease, high blood pressure, broken blood vessels, scurvy disease etc. [7] As deficiency of ascorbic acid impact on body as a disease of scurvy so, to fulfil this deficiency the ascorbic acid can be supplemented in human body through injection. But the injection can be containing a media of glucose or salt solution. So, by applying a combination of solution containing ascorbic acid and salt solution (NaCl and $MgCl_2$) then we can prevent quickly the scurvy disease and it helps in the formation of medicine for those treatment of diseases is too expensive which provides economy benefits to patients.
When we take an analysis of the some of the two-compound mixture like ascorbic acid (Vitamin C) with salt solution (NaCl and $MgCl_2$) at various temperature and concentration under the ultrasonic technique it gives the various information about the compound mixture. It helps to measures the ultrasonic velocity, density, adiabatic compressibility, change in adiabatic compressibility, relative change in adiabatic compressibility, acoustic impedance,

specific heat ratio, non- linear parameter, isothermal compressibility, isobaric thermal expansion coefficient, molecular radius, internal pressure, thermal conductivity, surface tension, Rao's constant, apparent molal volume, solubility parameter this all parameters gives the information about molecular interactions, structure, complex formation in the compound mixture under different temperatures and concentration [8].

Materials and Methods: All chemicals compound is AR grade with 99% purity of mass fraction, purchased from Himedia Lab Private Limited, Mumbai and this chemical compound are listed below:

1.Ascorbic acid - Molecular weight: 176.12 (g/mol) CAS.No:50-81-7  Molecular formula: $C_6H_8O_6$ Structure:	2. Magnesium chloride - Molecular weight: 203.30 (g/ mole). CAS. No: 7786-30-3 Molecular formula: $MgCl_2$  Structure:
3. Sodium chloride - Molecular weight: 58.44 (g/mol) CAS. No: 7647-14-5  Molecular formula: NaCl Structure:	4. Water - Molecular weight: 18 (g/mol) CAS. No: --- Molecular formula: H_2O Structure: 

Methods

1. This research was takes place at four various temperature (283.15- 298.15K) and it is carried out with the help of digital water bath with accurately.
2. Ultrasonic velocity was determined with help of digital ultrasonic interferometer operating at constant value of frequency 2MHz at having accuracy of 0.1%, which is provided by Vi Microsystems Private Limited from Chennai.
3. The 10 ml specific gravity density bottle is help to determine densities of the solution which consists of solute and solvent with accuracy of 10^{-2} Kg/m^3.
4. The weight measurement of the compound is taken with help of digital electronic balance machine detector.
5. In this analysis we have a constant value of temperature will be maintained by using digital water bath with accuracy of ±1 K.

Defining Relations

From the observed data of velocity and density the following parameters will have to be calculated:

Adiabatic Compressibility (β):

Adiabatic compressibility is defined as ratio of change in volume to the pressure.

$$\beta = \frac{1}{\rho \times U^2} \text{ -------- } (m^2N^{-1})$$

Where, U = Velocity of sound.
ρ = Density of solution.

Change in Adiabatic Compressibility (Δβ):

$$\Delta\beta = \beta - \beta_0 \text{ -------- } (m^2N^{-1})$$

Where, β = Adiabatic compressibility of solvent.
β_0 = Adiabatic compressibility of solute.

Relative Change in Adiabatic Compressibility =Δβ/β
Where, β = Adiabatic compressibility of solvent.
Δβ = Change in adiabatic compressibility.

Acoustic Impedance (Z):

It is depending on velocity of solution and density of solution.

$$Z = U\rho \text{ ------- } (Kg\text{- } m^2s^{-1})$$

Where, U = Velocity of sound.
ρ = Density of solution.

Specific Heat Ratio (γ):

It is defined as specific heat of solution at cons. pressure to the specific heat at cons. volume.

$$\gamma = \frac{17.1}{T^{\frac{4}{9}} \times \rho^{1/3}} \text{--------- } (K^{4/9})^{-1}(kg^{1/3}m^{-1})^{-1}$$

Where, T = Temperature.
ρ =Density of solution.

Non-linearity Parameter (B/A):

It is helpful to knowing the information about structural behaviour and interaction in solution mixture.

$$(B/A)_1 = 2 + \left[\frac{0.98 \times 10^4}{U}\right] \text{ ------ } (m^{-1}s) \text{ ----------known as Hartmann-Balizer constant.}$$

$$(B/A)_2 = -0.5 + \left[\frac{1.2 \times 10^4}{U}\right] \text{------ } (m^{-1}s) \text{ ----------known as Ballou's constant.}$$

Where, U = Velocity of sound.

Isothermal Compressibility (K_T):

It provides an information about the interaction of the solution mixture.

$$K_T = \frac{1.33 \times 10^{-8}}{(6.4 \times 10^{-4} U^{3/2} \rho)^{3/2}} \text{ ------- } (m^2N^{-1}) \text{ -------- known as Mc. Gowan's relation.}$$

Where, U = Velocity of sound.
ρ = Density of solution.

Isobaric Thermal Expansion Coefficient (α):

It is depended on the temperature, velocity, &density and understand structural changes in solution mixture.

$$\alpha = \frac{75.6\times10^{-8}}{T^{\frac{3}{10}}\times U^{\frac{1}{2}}\times\rho^{1/4}}$$ ------- (K^{-1})

Where, U = Velocity of sound.
ρ = Density of solution.
T = Temperature.

Molecular Radius (R_m):

It has properties of which depend on size of the molecule.

$$R_m = \{\frac{3b}{16\pi N_A}\}^{1/3}$$ ------ (m)

Where, b = Vander-Waal Constant.
Π =Constant = 3.14
N_A = Avogadro's Number = 6. 023×10^{23} mol^{-1}.
Internal Pressure (π_i)
It is giving an important information about Structure and interaction of solution and it depends on temperature.

$$\pi_i = \frac{\alpha T}{K_T}$$ ------(Nm^{-2})

Where, K_T = Isothermal compressibility.
α = Isobaric Thermal Expansion coefficient.
T= Temperature.
Thermal Conductivity(k):
Ability of generate heat from one side to another is called thermal conductivity.

$$K = \{3.0 \times (\frac{\rho N_A}{M})^{2/3} K_B U$$ ----- ($Wm^{-1}K^{-1}$)

Where, ρ = Density of solution.
N_A= Avogadro's Number = 6. 023×$10^{23}$$mol^{-1}$.
M = Molar mass of solution.
K_b = Boltzmann Constant.
Surface Tension (σ):
Surface tension is minimizing surface area of the solution

$$\sigma = (6.3 \times 10^{-4})\rho U^{3/2}$$ ------ (Nm^{-1})

Where, U = Velocity of sound.
ρ = Density of solution.
Rao's Constant (R):
It is indicating that presence of molecular interactions in the solution.

$R = (V_m U^{1/3})$ ------- (m^3mole^{-1}) (ms^{-1})$^{1/3}$

Where, U = Velocity of sound.
V_m = Molar volume.
Apparent Molar Volume (φ_V):

It is a ratio of volume of solution to the mole of solute.

$$V\varphi = \frac{1000}{m\rho_0}(\rho_0 - \rho) + \frac{M}{\rho_0}$$ ------ (m^3mole^{-1})

Where, ρ = Density of solution.
ρ_0 = Density of solvent.
M = Molality of the solution.
m = Molecular weight of solute.
Solubility Parameter (δ):= $\sqrt{\pi_i}$ ------ (Nm^{-2})$^{1/2}$

It depends on the internal pressure of solution and gives information about solution. Where, π_i=Internal Pressure.

Result and Discussion

The investigation of ascorbic acid with water at various temperatures (283.15-298.15K) with addition of salts (NaCl and $MgCl_2$) under the ultrasonic technique is observed. From fig. (1) it clearly observed that ultrasonic velocity is rises along with the temperature and concentration. This result express that there is strong intermolecular force is present in the ascorbic acid and salts solution which is because of the ascorbic acid molecule having hydrogen bonding with water and salts solution. Due to this there is an association carried out in the ions of solute-solvent solution. The observed trend of the solution mixture is as: H_2O<NaCl<$MgCl_2$ [1].

The measurement of density of the mixture of ascorbic acid and salts solution is graphically and expressed in fig. (2). From the graph it is clearly observed that value of density is rises along with the rise in concentration but the value of density is falling as rising of temperature. It indicates that there is presence of strong association in the solution mixture of solute-solvent. It is due to the solidity of ions in the structure of solute-solvent solution [2].

From this analysis, the values of adiabatic compressibility are falling along with rising concentration of the solution mixture which is express in fig. (3), which is because the presence of strong solidity in hydrogen bonding of molecules in solute-solvent solution. From fig. (3) it is clear that the falling of adiabatic compressibility with rising concentration is indicates that strong intermolecular forces are present which gives powerful association is carried out in the solution mixture. The observed trend of the solution mixture is as: MgCl2<NaCl<H_2O [3]. The measurement of values of change in adiabatic compressibility is taken from the calculation. From fig. (4) analysis, is shows that negative values of 'Δβ' are arises and its values rises along with rising concentration of the solution, which gives the help to increase bulk modulus of the system and it is because of the presence of solute-solvent forces and hydrogen bonding is takes place in the solution [9].

The measurement of values of relative change in adiabatic compressibility is taken from the calculation. From fig. (5) analysis, is shows that negative values of 'Δβ/β' are arises and its values is rises along with the concentration of the solution, which is express that presence of solute-solvent forces in the solution and gives rise to the value of bulk modulus of system due to the hydrogen bonding carried out in the solution [10].

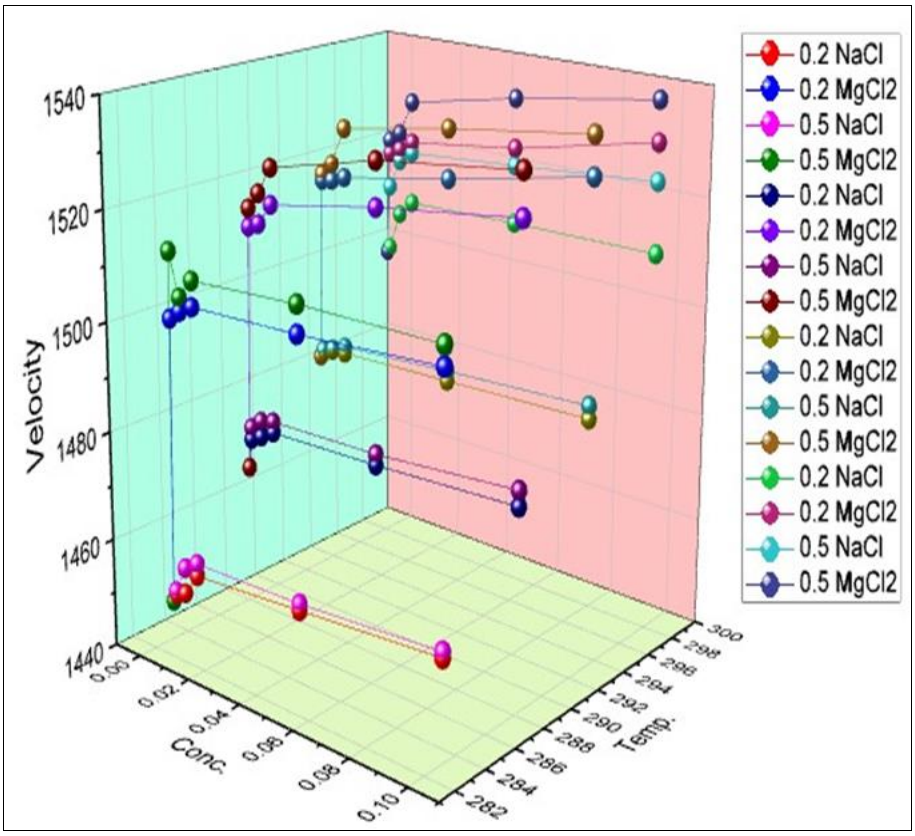


Fig 1: Velocity v/s Concentration at different Temperature

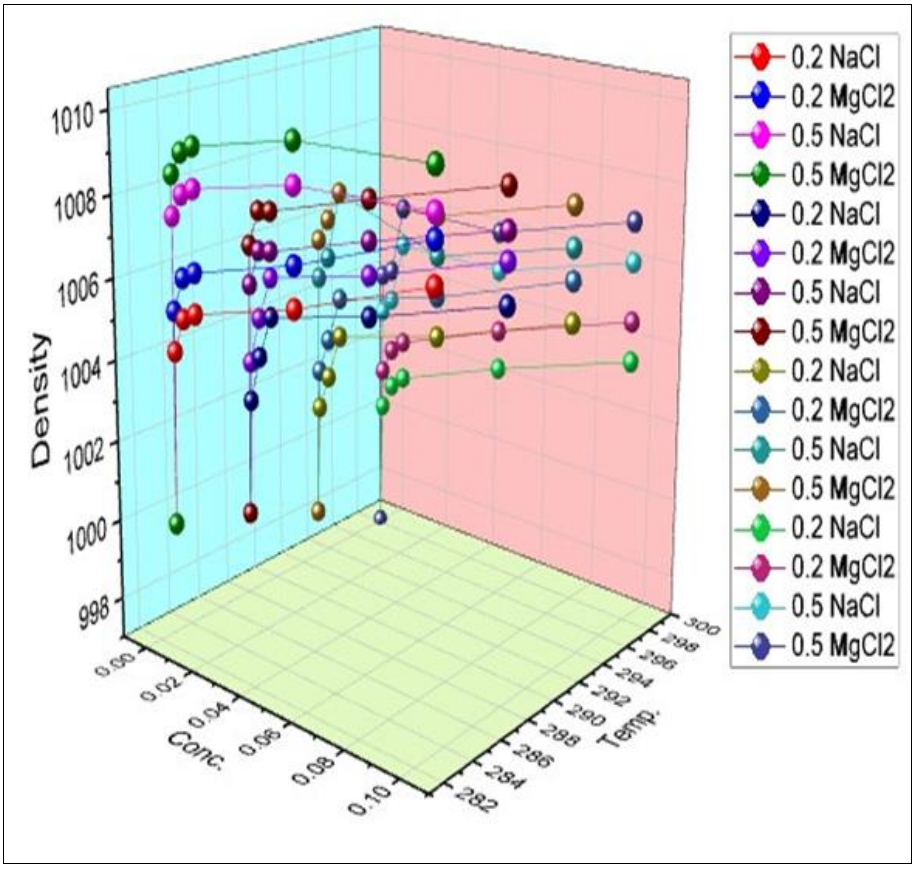


Fig 2: Density v/s Concentration at different Temperature

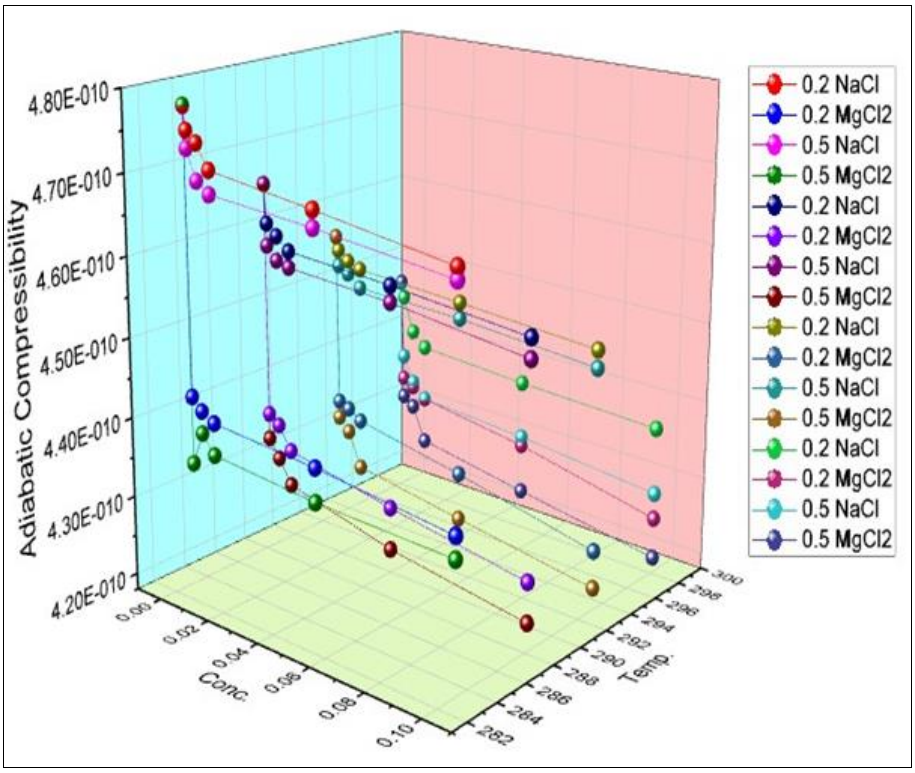


Fig 3: Adiabatic Compressibility v/s Concentration at different Tempearture

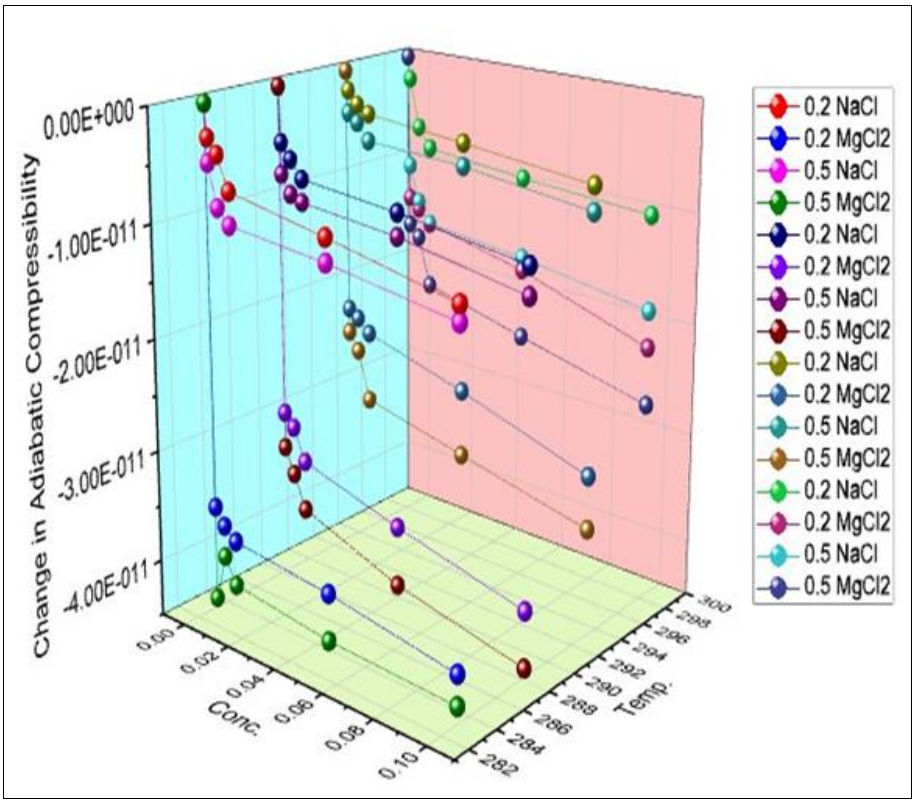


Fig 4: Change in Adiabatic Compressibility v/s Concentration at different Tempearture

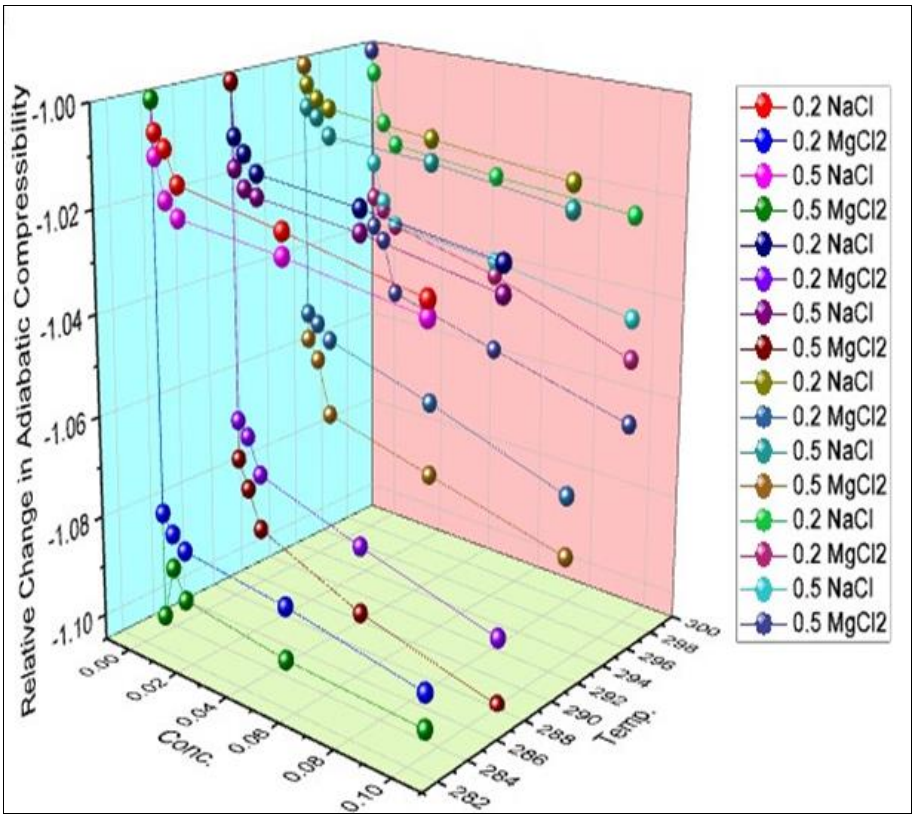


Fig 5: Relative Change in Adiabatic Compressibility v/s Concentration at different temperature

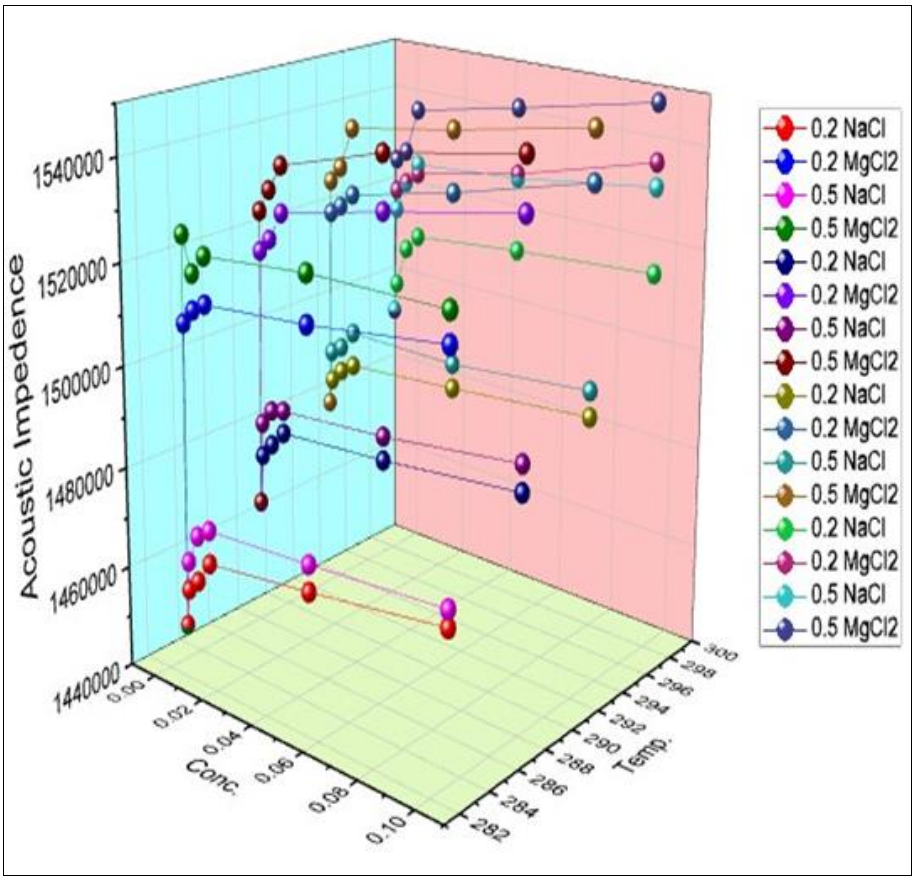


Fig 6: Acoustic Impedance v/s Concentration at different temperature

The data of acoustic impedance for ascorbic acid at various concentration in salt solution of $MgCl_2$ and NaCl were examined by using the ultrasonic velocity and density of medium. From the data and fig. (6) it is clear that with the rise in the concentration and temperature of solute and solvent the acoustic impedance is rises. This rise in concentration indicates that greater association in between solute-solvent through the hydrogen bonding. The observed trend of the solution mixture is as: H_2O<NaCl<$MgCl_2$. [11].

The specific heat ratio data of ascorbic acid with salts solution at various concentration and temperature is graphically express by fig. (7). From this analysis, it is clearly seeing that

specific heat ratio is falling with rising concentration and temperature which is because of the presence of solidity of hydrogen bonding in the structure of solution [12].

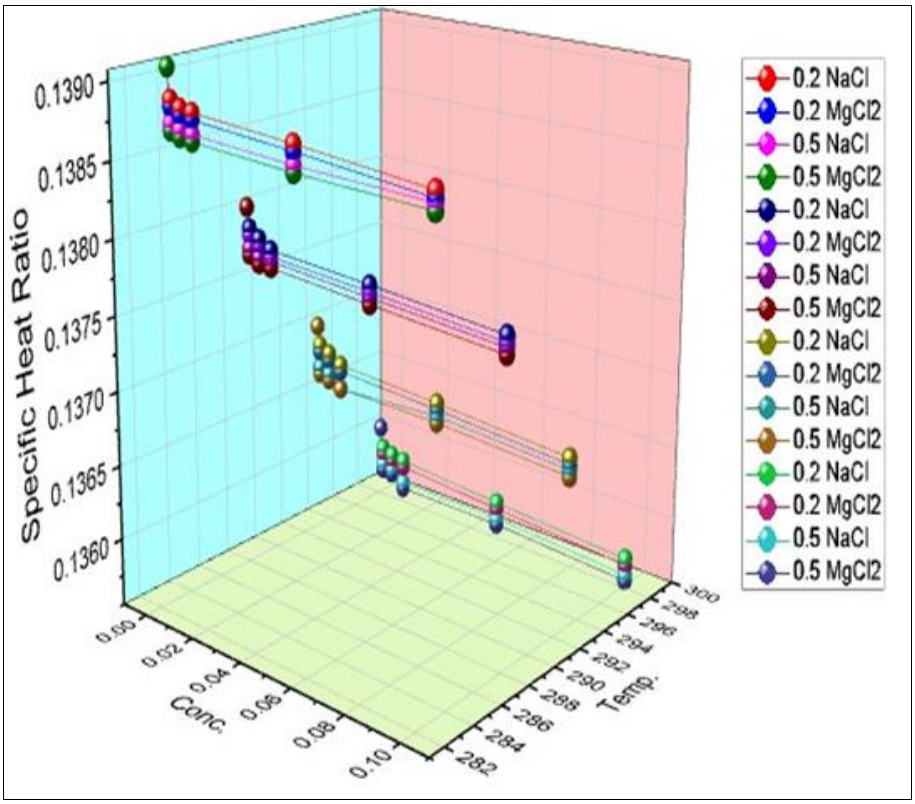


Fig 7: Specific Heat Ratio v/s Concentration at different temperature

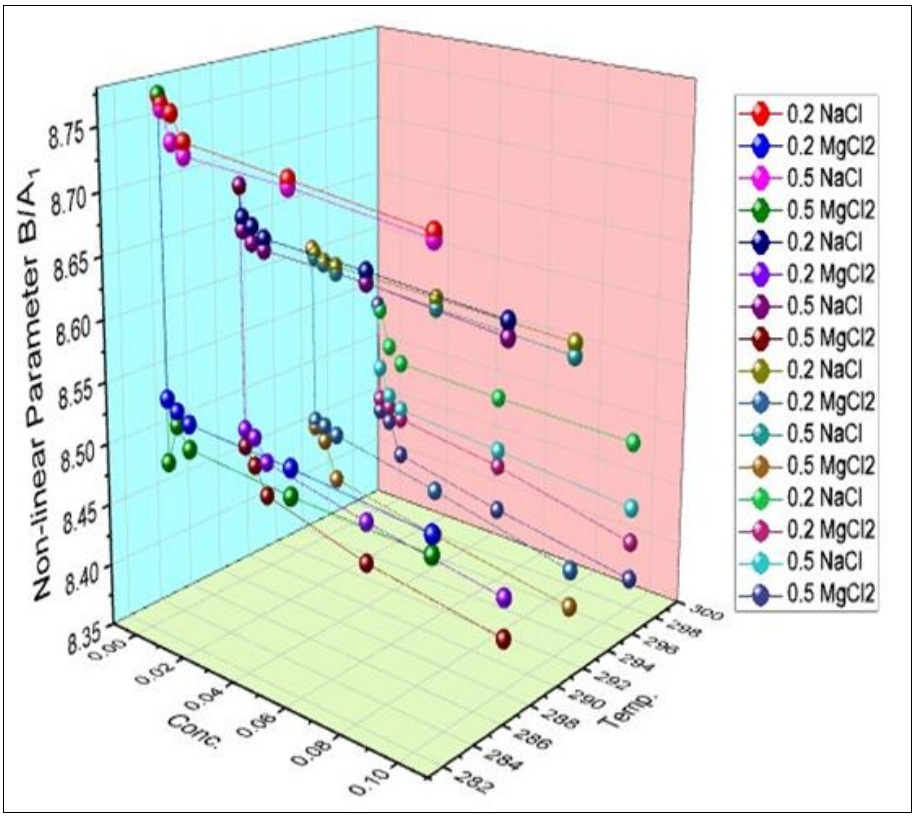


Fig 8: Non-Linearity Parameter (B/A1) v/s Concentration at different temperature

The non-linearity parameter (B/A) which is calculated from the formula given by Hartmann- Balizer and Ballou is related to the internal pressure, hardness and so on. The non-linearity parameter for all the medium as a function of concentration and temperature is graphically express in fig. (8) & (9). The falling modes of both measurements with the rising in concentration and temperature express the interaction between constituents of solute and solvent which are strong at higher concentration while mixing [13].

The isothermal compressibility is depending on the velocity,

density and surface tension of the solution. The calculated data of 'K_T' is graphically express in fig. (10) & (11). From this analysis, it is clear that as isothermal compressibility is falling along with rising concentration and temperature of the solution. This is due to the assembly of molecules in the solution mixture, which helps to the strong interaction in the solution [14].

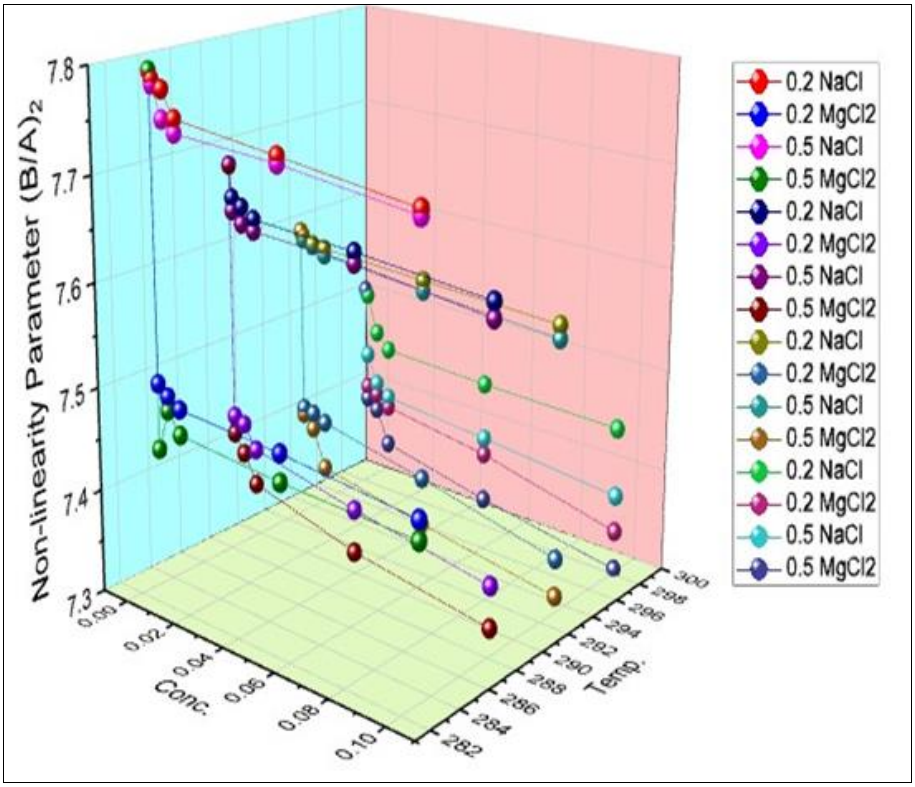


Fig 9: Non-Linearity Parameter (B/A_2) v/s Concentration at different temperature

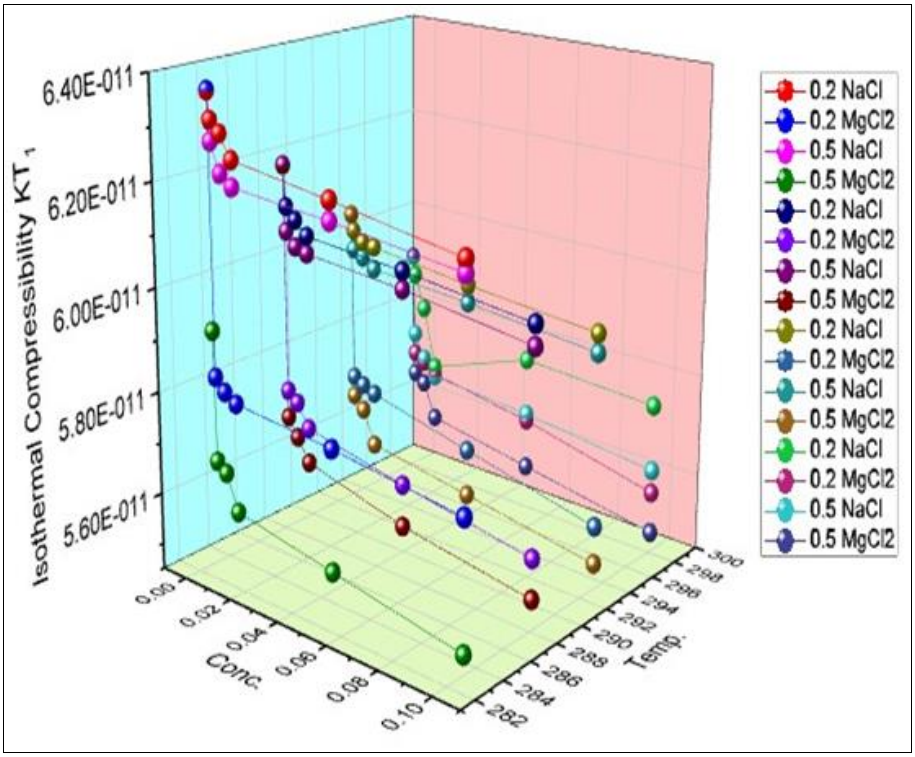


Fig 10: KT_1 v/s Concentration at different temperature

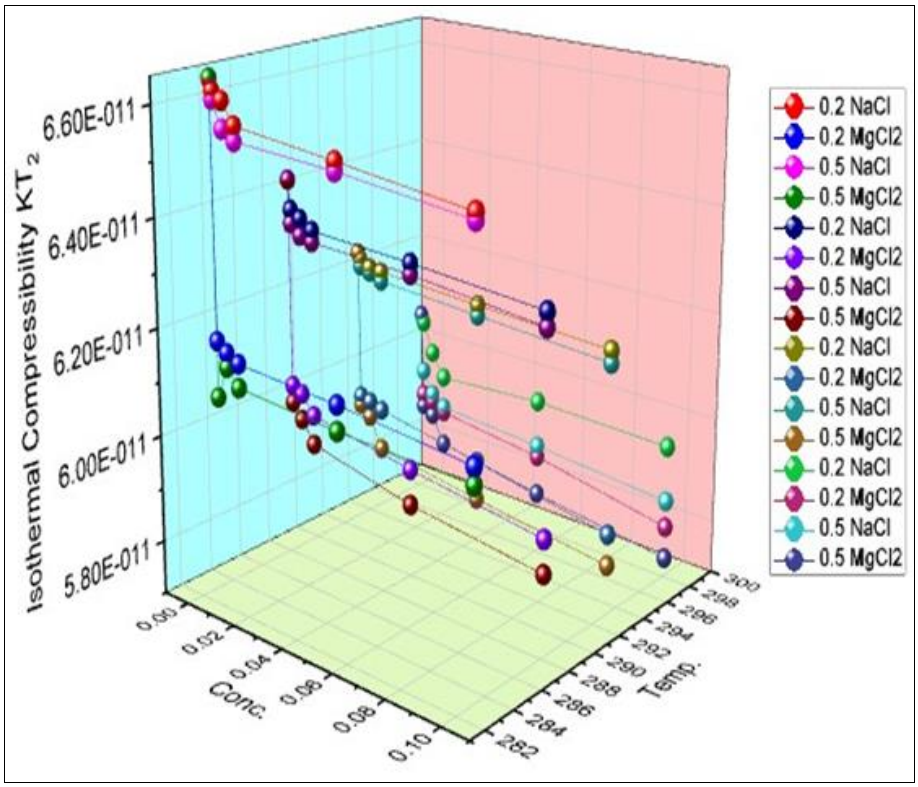


Fig 11: KT_2 v/s Concentration at different temperature

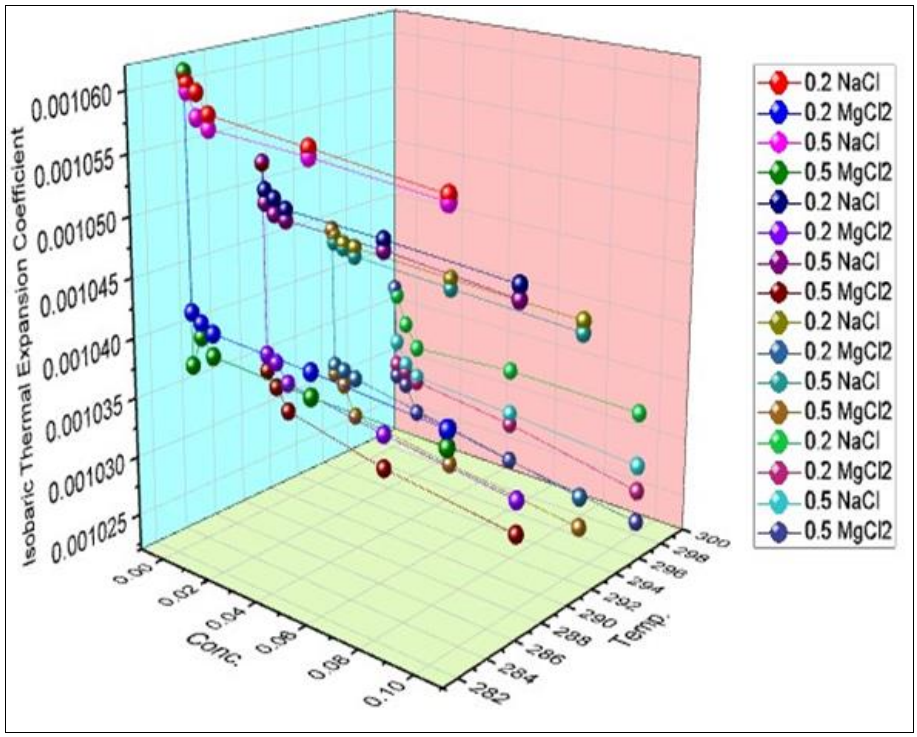


Fig 12: Isobaric Thermal Expansion Coefficient v/s Concentration at different temperature

From fig. (12) graphically signify the behaviour of ascorbic acid at various temperature. From the figure it is conclude that as the concentration of ascorbic acid rises the value of isobaric thermal expansion coefficient falling which revealed the falling in the fluidly of medium due to large interaction between the constituents of solute-solvent ions [15].

Molecular radius is the major listed parameter of moral liquid which reflects their structural characteristics. The measure data of molecular radius is graphically expressed from fig. (13). It is understood that a rise in molecular radius with concentration exhibits large association among the constituents which results and rise in intermolecular hydrogen bonding and dispersive forces between solute-solvent molecules [16].

As we know that internal pressure is depend on the 'K_T', 'α', and temperature and help of understand presence of interaction in the solution mixture. From this analysis, it is clearly seeing that internal pressure rises along with rising concentration and temperature of the solution as graphically express in fig. (14). This behaviour of solution expressed that rise of interaction and strong association of us takes place in the ions of the solute-solvent solution [17].

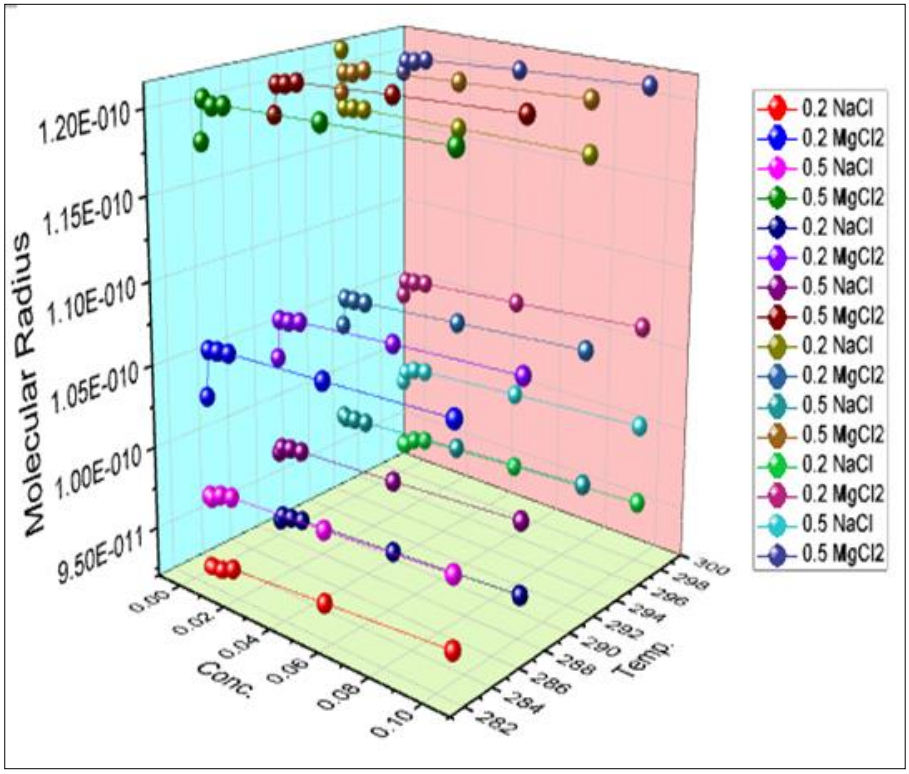


Fig13 Molecular Radius v/s Concentration at different temperature

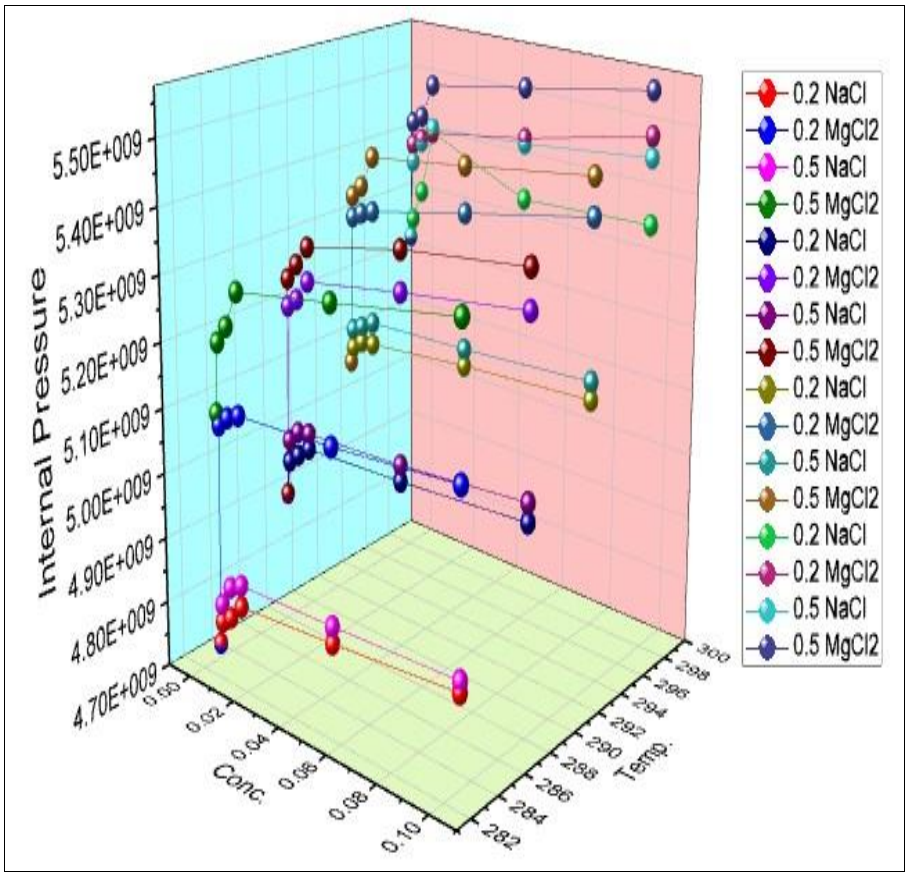


Fig 14: Internal Pressure v/s Concentration at different temperature

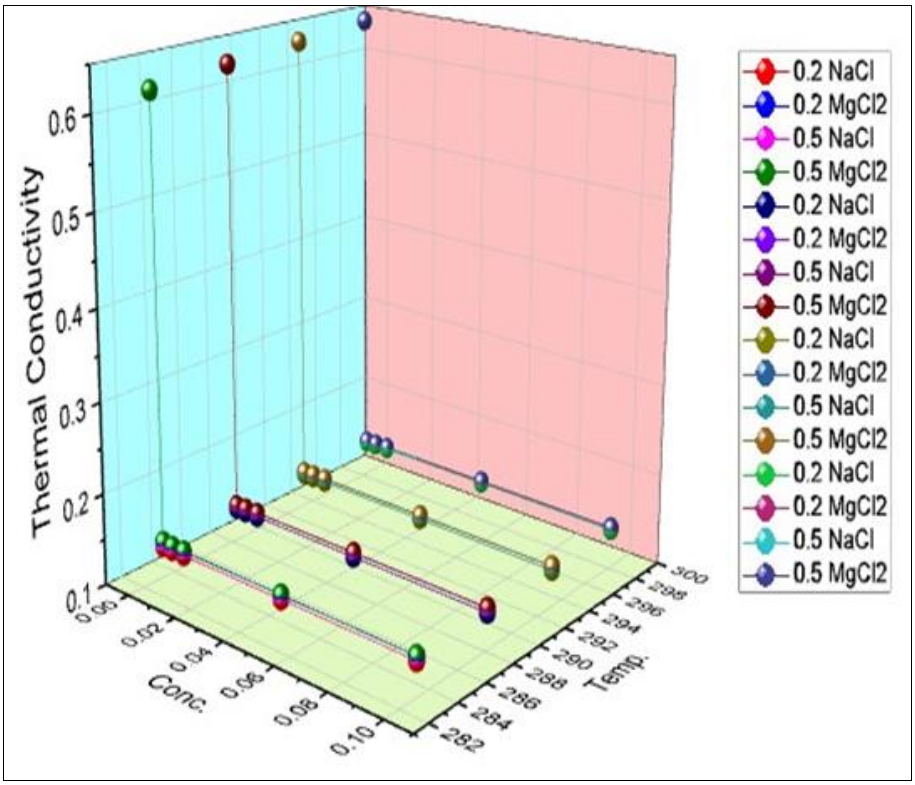


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Fig 15: Thermal Conductivity v/s Concentration at different temperature

In recent analysis, it clear that the thermal conductivity is moderately rises along with concentration and temperature of solution is graphically express in fig. (15). which is because of the energy transfer from the closed molecule of solution and it gives presence of strong intermolecular forces in the solution.

The surface tension is said to be reduction in surface area of the solution. It is depended on the velocity and density which helps in the calculation of data in this research it was graphically express in fig. (16). From this analysis, it was clear that surface tension rises along with concentration and temperature of solute and association is carried out which is because of the strong interaction forces is present in the solution [19].

The Rao's constant is also known as molal sound velocity of system. Form fig. (17) it is confirmed that the Rao's constant is rises along rising of concentration and temperature this rising mode of Rao's constant is expressed that there is a presence of solute-solvent interaction in medium which is because of more constituents is available in medium of the solution and hydrogen bonding is takes place in solution mixture [20].

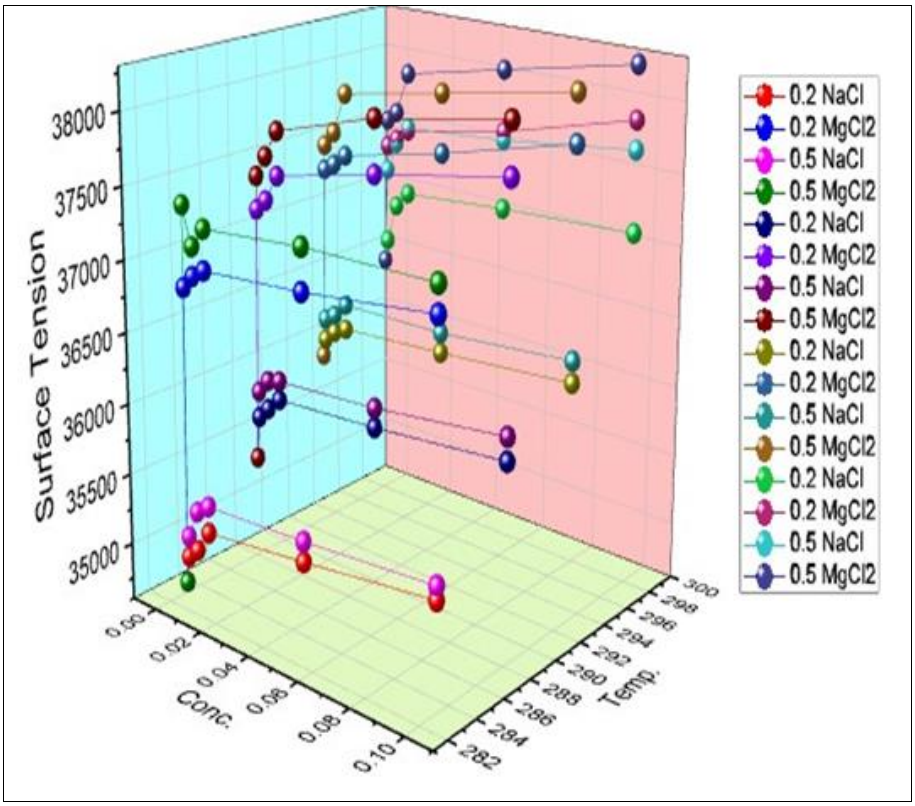

Fig 16: Surface Tension v/s Concentration at different temperature

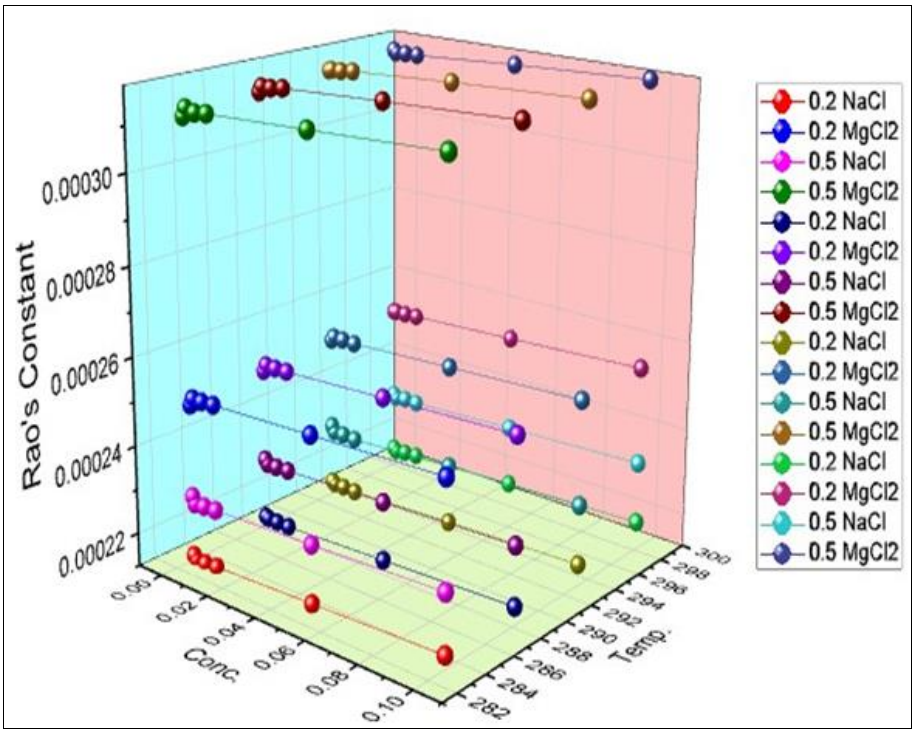

Fig 17: Rao's Constant v/s Concentration at different temperature

Apparent molal volume is known as volume of solution to the mole of solute. The calculated values of apparent molal volume are express in fig. (18). From the fig. (18) it is clear that, the negative values of 'Vφ' are arises and falling with rising concentration and temperature of the solution. Which is because of strong hydrogen bonding is takes place in the solution mixture and strong interaction forces are present in it [21]. The solubility parameter is depending on the internal pressure of the solution and calculation is taken with help internal pressure data is express in fig (19). From the fig. (19) it is clearly see that, the moderately rise of solubility parameter with the concentration and temperature of solution. It indicates that association is carried out in the system and system has high capacity to be a soluble [22].

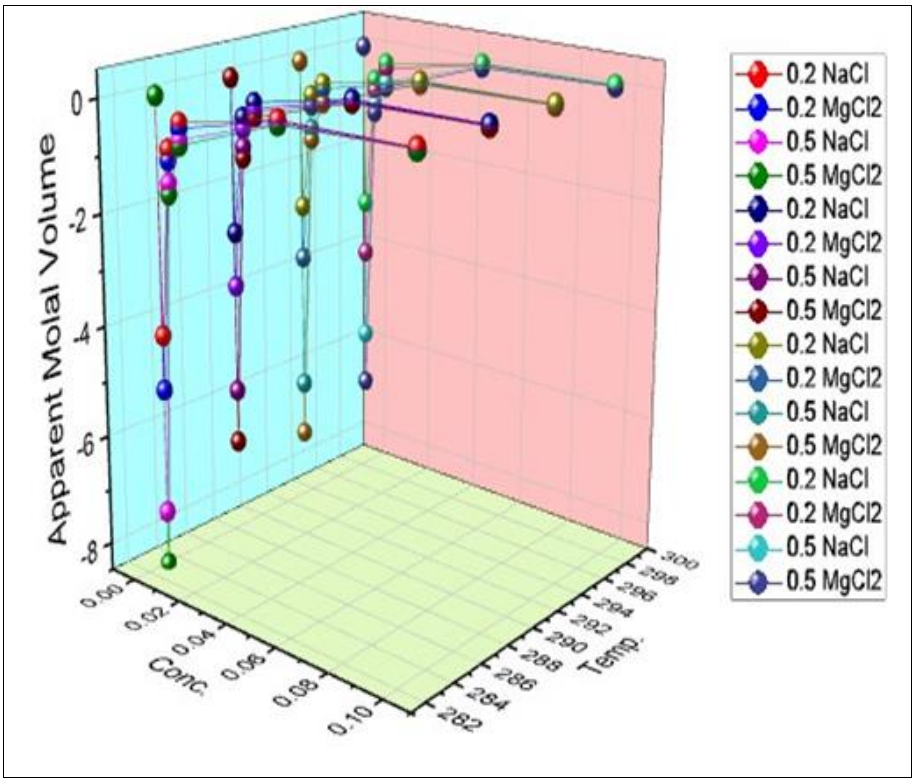

Fig 18: Apparent Molal Volume v/s Concentration at different temperature

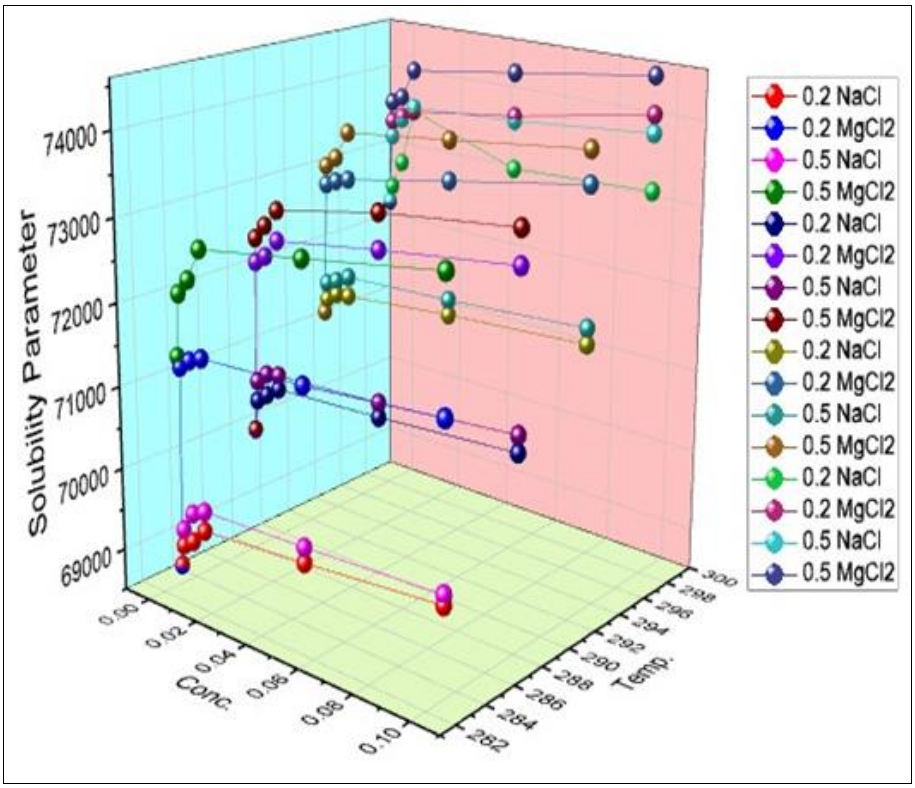

Fig 19: Solubility Parameter v/s Concentration at different temperature

Conclusion

Ultrasonic analysis of ascorbic acid with salts solution at various concentration along with various temperature (283.15–298.15K) we determine values of ultrasonic velocity and density. The calculated parameters give important information about structural and molecular interactions of ascorbic acid with salts (NaCl and $MgCl_2$) solution under the different temperature. The mixture of ascorbic acid with salts gives information about strong intermolecular forces and association in the solution which is because of strong hydrogen bonding and solubility present in the solution. From the observation of adiabatic compressibility is falling with concentration and molality of the solution indicates that system is soluble. The observed trend of the solution is as: $MgCl_2$<NaCl<H_2O.From this analysis, we can provide ascorbic acid with media of salts solution to the patient who are suffering from scurvy disease for fast recovery. Moreover, the ascorbic acid is applicable in food industry, cosmetics industry, medical and biological field.

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