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ANALYSIS OF L-HISTIDINE AND ELECTROLYTE SALT SOLUTIONS USING ULTRASONIC TECHNOLOGY TO DETERMINE HOW THEY INTERACT TO MAINTAIN BLOOD PRESSURE

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ABSTRACT:

It is incredibly helpful to be able to predict different kinds of intermolecular interaction as well as the degree of the link between the solute and solvent utilizing thermo-acoustical and volumetric data. The human body is full of nutrients, both in the form of salts and amino acids. And how they interact determines how well these nutrients may be absorbed. It is discovered that one of the essential nutrients for preserving blood pressure is the amino acid L-histidine. L-Histidine amino acid administration may therefore be a treatment for regulating blood pressure. Numerous thermos-acoustical and volumetric characteristics of the L-histidine+H_2O and L-histidine+H_2O+NaCl/$MgCl_2$ systems at 283 and 293K temperatures with various concentrations (0.02-0.2M) have been investigated in this research. These volumetric and thermoacoustic properties' concentration-dependent fluctuation strongly suggests that molecular associations exist in all systems. The amino acid L-Histidine orders of magnitude greater molecular interaction at higher concentrations in all three solvents, but it exhibits maximum possible molecular interaction with $MgCl_2$ solvents. This suggests that L-Histidine molecules bind to magnesium molecules more readily than they do with water or sodium molecules.

Keywords :- Density, electrolyte salts, l-histidine, thermo-acoustical properties, ultrasonic velocity.

INTRODUCTION :

Currently, one of the best methods for determining the precise molecular interactions (ion-ion, ion-solvent, and solvent-solvent) in liquid mixtures is ultrasonic analysis. The objective of thermo-acoustical and volumetric research is to analyze the structure and molecular interaction using data from compounds and their interactions with other solutes and solvents that have been gathered and computed [1-4]. Numerous studies have examined the thermo-acoustical properties of amino acids using ultrasound [5–12].

Amino acids, which are the building blocks of protein, have both basic and acidic properties. Organic compounds known as amino acids have both amino and carboxylic acid functional groups. There are hundreds of different amino acids in nature, but the -amino acid, which is the building block of protein, is by far the most important. Only 22 essential and non-essential - amino acids are found in the genetic code. The body needs histidine, an important amino acid, heavily; when it is lacking, blood pressure levels fall. In order to maintain a healthy body and the proper blood pressure level, we must maintain histidine levels in the human body. But a biological study has found that some electrolyte salt constituents, such as Na and Mg, are highly good at controlling hypertension in the human body. Therefore, it can be concluded from this circumstance that the interaction between an amino acid and a certain salt combination is crucial for the human body to absorb this amino acid for quick repair of the deficiency.

In order to get around this problem, an effort has been made in this study to present a picture of the molecular interactions that took place in the solutions and may be able to assist in the selection of a suitable salt for keeping blood pressure at a healthy level in conditions of ambient temperature. As a result, the goal of the

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current research is to investigate the molecular interactions between L-histidine, water, and salts utilizing electrolytic (NaCl and $MgCl_2$) methods [13].

MATERIALS AND PROCEDURES :

Materials:

Without additional raffination, the chemicals specified below were purchased from Himedia Pvt. Ltd. in Mumbai and used in the current study. They are all compounds of the AR grade with a purity mass fraction of 99.8%.

Apparatus and Method:

Apparatus

- Digital ultrasonic velocity interferometer.
- A bottle with a specific gravity of 10 ml.
- Automatically controlled water bath.
- A machine that weighs objects electronically.
- Cell made of quartz.

Method

With an overall accuracy of 0.0001m/s, the ultrasonic velocity at a frequency of 2 MHz was measured using a digital ultrasonic velocity interferometer. The quartz crystal's ultrasonic wave is excited by a radio frequency oscillator. The density of the solution was carefully estimated using a 10 ml specific gravity density bottle and a highly accurate digital electronic weighing scale with an accuracy of 0.0001g and 2*10-2kg/m-3. An automated thermostatic water bath with a temperature precision of about 1K was used to keep the temperature of the test solutions consistent.

Clarifying relationships

The following volumetric and thermo-acoustical characteristics were estimated using the standard formula from the literature utilizing density and ultrasonic velocity measurements.

Adiabatic compressibility (β) – It may be calculated from the sound velocity and solution density data [14] using the Newton-Laplace equation.

$\beta = 1/[\rho^*U]^2$

Acoustic impedance (Z) – Equation created by connecting density and velocity to the specified acoustic impedance [15].

$Z = \rho U$

Relative association (R_A) – Use the ultrasonic velocity and density-dependent relationship below [16].

$RA = (\rho/\rho_0)(U_0/U)^{1/3}$

Relaxation strength (r) – The formula for calculating relaxation strength directly connects that to adiabatic compressibility [17].

$r = 1-(U/U_\infty)^2$

***Surface tension (σ)* –** The Flory hypothesis has been used to determine the surface tension of a composition utilizing the well-known Auerbach connection [18].

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

Specific heat ratio (γ) – Isothermal compressibility and adiabatic compressibility are connected simply by the equation [16].

$\gamma = 17.1/(T^{4/9}*\rho^{1/3})$

RESULT AND ANALYSIS :

The experimentally calculated value of density and ultrasonic velocity of distilled water at various temperatures is shown in the following table of data, which, when compared to the observed and published/literature data, shows a satisfactory agreement.

Ultrasonic velocity (U)

Ultrasonic velocity, which has structural connections, is a fundamental physical metric. The essential amino acid L-Histidine has an ultrasonic velocity that ranges from (0.02-0.2 mol/kg) of concentration. NaCl and $MgCl_2$ 0.1M solutions of the electrolyte salt solvents were tested at various temperatures in the current investigation (i.e., 283 and 293K). The obtained results demonstrating that ultrasonic velocity rises when temperature and concentration both rise are shown in Fig. 1 and Table 3. The ultrasonic velocity is influenced by the system's concentration and temperature. The association of the medium's constituent particles is

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observed to expand with increasing ultrasonic velocity, and this connection is caused by molecular interaction. [21,22].

Density (ρ)

Density is a crucial physicochemical property that depends on pressure and temperature. The density of a solute-solvent contact metric may also be explained by the concentration-dependent increase in density, which denotes an increase in solute-solvent interaction, whereas a reduction in density denotes a decrease in solute-solvent interaction. The rise in density with concentration is due to volume contraction caused by solute molecule presence. One interpretation of the results in Fig. 2 [23] is that the increasing density value in the ongoing study shows that the solvent is getting more organized as an outcome of the solute addition.

Adiabatic compressibility (β)

The hydrogen bonds between the different components dissolve as adiabatic compressibility rises with compressibility in the solution, which explains the physicochemical characteristics of liquids. It is shown that the amount of hydration compression that can occur around the solute molecule can be used to indicate the adiabatic compressibility of the solute in this case. As demonstrated in Fig. 3, the quantity of aqueous NaCl and MgCl2 as well as the molal concentration of the solute (amino acid) all tend to decrease with increasing adiabatic compressibility (solvent). The observed decrease in adiabatic compressibility in the solvent may be caused by the hydrogen bond being weaker in the solution [24].

Acoustic Impedance (Z)

The value of the acoustic impedance for the amino acid l-histidine of various weight fractions (0.02-0.2 mol/kg) in 0.1M of aqueous electrolyte salt solution of NaCl and MgCl2 was calculated and listed in Table 4. A decrease in the distance between molecules in mixes is shown by higher acoustic impedance values, which suggests that hydrogen bonding has successfully completed the solute-solvent interaction. The rise in ultrasonic velocity and decline in intermolecular free length, which have been observed, are therefore triggered by an increase in the potential energy of the interaction between the molecules. [25-27]

Relative association (R_A)

The relative link is a characteristic that aids in our understanding of the relationship. The relative relationship is influenced by two main elements.

1. Both the solute and the accompanying solvent molecule are dissolved.
2. An amino acid molecule is solvated.

According to Fig. 5, the relationship between RA and concentration shows that the parts of molecules have strong intermolecular ties and that the second factor has a greater impact than the first [26–28]. This leads to the increased relative association of l-histidine in both the electrolyte solutions and the water being seen in the following order: L-histidine with MgCl2, L-histidine plus NaCl, and L-histidine plus water.

Relaxation strength (r)

There is a clear connection between adiabatic compressibility and relaxation strength. The complete solution is determined by the factor 1-U/U^{∞}, where U is the ultrasonic speed and U^{∞} is a constant with a value of 1600 m/s. Clarifying the system's molecular relationships is an essential characteristic. The solute-solvent interaction in the system, as shown in Fig. 6, is confirmed if the value of relaxation strength falls with rising concentration and temperature after adding a solute to solvent. This would suggest a greater relationship between salts and amino acids [29,30].

Surface tension (σ)

The surface tension of liquids and liquid mixtures is a key factor in several industrial and biological operations. As a solute is added, a solution's surface tension rises; Figure 7

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illustrates the rising trends in surface tension. Surface tension is revealed to be generally greater as a result of h - bonding and dipole-dipole interactions [31].

Specific heat ratio (γ)

The amount of heat needed to raise a liquid's temperature by each degree is determined by the liquid's specific heat. Table 5 lists the specific heat ratios for a number of mass fractions (0.02-0.2M) of the amino acid (l-histidine) in water as well as in 0.1M aqueous solutions of NaCl and MgCl2 at different temperatures. Figure 8 clearly shows that the heat capacity constantly decreases as the solution concentration rises, supporting the occurrence of intermolecular interaction [16].

CONCLUSION :

Numerous volumetric and thermo-acoustical parameters were calculated by measuring the density and ultrasonic velocity of solutions of l-histidine in water and electrolyte salt solutions. The weight fraction, temperature, solute, solvent composition, and position all play crucial roles in determining the interaction that takes place in the liquid mixture, according to the aforementioned findings and observations. H-bonding is strong at higher concentrations, as can also be deduced from the various volumetric and thermo-acoustical properties. In all three solvents (water, sodium chloride, and magnesium chloride), the L-histidine amino acid interacted in the following order: ($C_6H_9N_3O_2$+$MgCl_2$+H_2O) > ($C_6H_9N_3O_2$+NaCl+H_2O) > ($C_6H_9N_3O_2$+H_2O)

The interaction between the solvent (NaCl, $MgCl_2$) and the amino acid (see above sequence of interactions) increases when salts are introduced to the water because of the greater hydrogen bonding. And it is evident from this that the amino acid interacts with Mg++ ions more so than Na+ ions. As a result, the whole scenario led to the conclusion that L-histidine interacts more quickly and affects blood pressure when supplied with a solvent containing Mg++ than one containing Na+.

Conflicts of interest:

The authors don't reveal any conflicts of interest in regard to the current study's endeavor.

Contribution of Author:

PRS performed all of the experimental work and conducted the data analysis. PRS and UPM conceptualized the study. PRS, UPM, and PLM constructed the theoretical and experimental models. The document was written by all contributors. The document was examined by PLM and UPM.

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Table 1: All about materials

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Sr. No.	Chemical Name	Solute/Solvent	Type of amino acid &salts	Molecular Formula	Molecular Weight (g/mol)	CAS Number
1	L-Histidine	Solute	Essential amino acid	$C_6H_9N_3O_2$	155.16	71-00-1
2	Water	Solvent 1	Universal solvent	H_2O	18.01528	----------
3	Sodium chloride	Solvent 2	Saline salt	NaCl	58.44	7647-15-5
4	Magnesium chloride	Solvent 3	Ionic salt	$MgCl_2$	203.30	7791-18-6

Table 2: Freshly distilled water at 283 and 293 K ultrasonic velocities and densities.

Temperature (T) K	Obtained data		Literature data	
	U. Velocity (U) m/s	Density (ρ) kg/m³	U. Velocity (U) m/s	Density (ρ) kg/m³
283	1447.427	999.70	1448.16[19]	999.891[19]
293	1481.496	998.200	1482.63[20]	998.202[20]

Table 3: Lists the measurements made for the L-histidine + water system's ultrasonic velocity and density at 283 and 293 K. The system also contains 0.1 M of an aqueous solution of NaCl and MgCl2.

Conc. (M) mol/kg	Ultrasonic Velocity(U) (m/sec)			Density(ρ) (kg/m³)		
	H_2O	NaCl	$MgCl_2$	H_2O	NaCl	$MgCl_2$
			283 K			
0.00	1447.427	1447.427	1447.427	0999.700	0999.700	0999.700
0.02	1459.633	1466.575	1472.658	1006.679	1028.847	1049.593
0.04	1463.483	1469.902	1473.435	1007.017	1029.787	1050.325
0.06	1469.619	1471.234	1477.326	1007.551	1030.135	1051.208
0.08	1471.174	1472.014	1479.942	1008.681	1031.704	1052.641
0.10	1472.729	1474.919	1480.452	1009.122	1032.974	1052.920
0.12	1474.288	1475.919	1480.952	1009.939	1033.109	1053.024
0.14	1475.811	1478.257	1485.120	1010.333	1034.936	1054.376
0.16	1480.337	1483.319	1487.789	1011.899	1035.377	1055.017
0.18	1482.850	1490.923	1494.720	1012.330	1035.817	1055.860
0.20	1485.860	1492.743	1495.270	1013.643	1036.261	1056.551
			293 K			
0.00	1481.496	1481.496	1481.496	0998.200	0998.200	0998.200
0.02	1488.577	1493.329	1500.606	1000.864	1022.204	1041.301
0.04	1490.158	1497.310	1503.014	1001.785	1023.348	1042.271
0.06	1492.536	1499.707	1506.428	1002.865	1024.031	1042.887
0.08	1495.716	1501.308	1508.658	1003.570	1025.080	1043.912
0.10	1498.108	1502.914	1507.849	1003.988	1025.847	1044.277
0.12	1500.507	1508.553	1510.277	1004.887	1026.405	1045.101
0.14	1502.363	1509.839	1511.890	1005.819	1027.170	1045.974
0.16	1506.131	1511.959	1517.712	1006.122	1027.867	1046.839
0.18	1506.938	1514.229	1519.237	1007.971	1028.459	1047.891
0.20	1510.980	1516.672	1523.339	1009.198	1029.325	1048.619

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Table 4: shows the calculated values for adiabatic compressibility, acoustic impedance, and relative association of the L-histidine + water system at 283 and 293 K with 0.1 M of aqueous NaCl/MgCl2 solution.

Conc. (M) mol/kg	Adiabatic Compressibility (β) (m^2N^{-1})			Acoustic Impedance (Z) ($kg\text{-}m^2s^{-1}$)			Relative Association (R_A) (----)		
	H_2O	NaCl	$MgCl_2$	H_2O	NaCl	$MgCl_2$	H_2O	NaCl	$MgCl_2$
	283K								
0.00	4.77E-10	4.77E-10	4.77E-10	1446993	1446993	1446993	1.00000	1.00000	1.00000
0.02	4.66E-10	4.52E-10	4.39E-10	1469381	1508882	1545692	1.00417	1.02466	1.04388
0.04	4.64E-10	4.49E-10	4.39E-10	1473752	1513686	1547585	1.00362	1.02482	1.04442
0.06	4.60E-10	4.48E-10	4.36E-10	1480717	1515570	1552977	1.00275	1.02486	1.04438
0.08	4.58E-10	4.47E-10	4.34E-10	1483945	1518682	1557848	1.00353	1.02623	1.04519
0.10	4.57E-10	4.45E-10	4.33E-10	1486163	1523554	1558798	1.00361	1.02682	1.04535
0.12	4.56E-10	4.44E-10	4.33E-10	1488941	1524785	1559478	1.00407	1.02673	1.04533
0.14	4.54E-10	4.42E-10	4.30E-10	1491060	1529902	1565875	1.00411	1.02800	1.04569
0.16	4.51E-10	4.39E-10	4.28E-10	1497951	1535795	1569642	1.00465	1.02727	1.04570
0.18	4.49E-10	4.34E-10	4.24E-10	1501133	1544323	1578215	1.00451	1.02595	1.04492
0.20	4.47E-10	4.33E-10	4.23E-10	1506132	1546871	1579830	1.00513	1.02597	1.04547
	293K								
0.00	4.56E-10	4.56E-10	4.56E-10	1478829	1478829	1478829	1.00000	1.00000	1.00000
0.02	4.51E-10	4.39E-10	4.26E-10	1489863	1526487	1562582	1.00108	1.02134	1.03873
0.04	4.50E-10	4.36E-10	4.25E-10	1492819	1532269	1566548	1.00164	1.02157	1.03914
0.06	4.48E-10	4.34E-10	4.23E-10	1496812	1535747	1571034	1.00219	1.02171	1.03897
0.08	4.45E-10	4.33E-10	4.21E-10	1501055	1538961	1574906	1.00218	1.02239	1.03948
0.10	4.44E-10	4.32E-10	4.21E-10	1504082	1541760	1574612	1.00207	1.02279	1.04003
0.12	4.42E-10	4.28E-10	4.19E-10	1507840	1548387	1578391	1.00243	1.02207	1.04029
0.14	4.40E-10	4.27E-10	4.18E-10	1511105	1550862	1581398	1.00295	1.02254	1.04079
0.16	4.38E-10	4.26E-10	4.15E-10	1515351	1554093	1588801	1.00241	1.02276	1.04032
0.18	4.37E-10	4.24E-10	4.13E-10	1518950	1557323	1591995	1.00407	1.02284	1.04101
0.20	4.34E-10	4.22E-10	4.11E-10	1524878	1561148	1597402	1.00440	1.02315	1.04080

Table 5: shows the calculated values for the system's relaxation strength, surface tension, and specific heat ratio at 283 and 293 K. The system consists of L-histidine + water and 0.1 M of a NaCl / MgCl2 aqueous solution.

Conc. (M) mol/kg	Relaxation Strength (r) (----)			Surface Tension (σ) (Nm^{-1})			Specific Heat Ratio (γ) $(K^{4/9})^{-1}(kg^{1/3}m^{-1})^{-1}$		
	H_2O	NaCl	$MgCl_2$	H_2O	NaCl	$MgCl_2$	H_2O	NaCl	$MgCl_2$
	283K								
0.00	0.181623	0.181623	0.181623	34682.09	34682.09	34682.09	0.139109	0.139109	0.139109
0.02	0.167762	0.159827	0.152843	35366.89	36403.90	37369.26	0.138787	0.137783	0.136869
0.04	0.163366	0.156011	0.151949	35518.83	36561.21	37424.90	0.138772	0.137741	0.136838
0.06	0.156336	0.154481	0.147464	35761.43	36623.29	37604.83	0.138747	0.137726	0.136799
0.08	0.154550	0.153584	0.144442	35858.36	36708.22	37756.18	0.138695	0.137656	0.136737
0.10	0.152761	0.150240	0.143852	35930.92	36862.29	37785.71	0.138675	0.137599	0.136725
0.12	0.150967	0.149087	0.143274	36017.14	36904.58	37808.57	0.138638	0.137594	0.136721
0.14	0.149212	0.146389	0.138445	36087.02	37057.75	38017.06	0.138620	0.137512	0.136662
0.16	0.143985	0.140533	0.135345	36309.36	37264.13	38142.73	0.138548	0.137493	0.136634
0.18	0.141077	0.131699	0.127270	36417.36	37566.98	38440.28	0.138529	0.137473	0.136598
0.20	0.137586	0.129577	0.126628	36575.69	37651.91	38486.69	0.138469	0.137454	0.136568
	293K								
0.00	0.142644	0.142644	0.142644	35859.88	35859.88	35859.88	0.137048	0.137048	0.137048
0.02	0.134429	0.128894	0.120383	36213.67	37163.06	38134.38	0.136926	0.135966	0.135130
0.04	0.132590	0.124243	0.117558	36304.77	37353.52	38261.83	0.136884	0.135916	0.135088
0.06	0.129819	0.121437	0.113545	36430.93	37468.25	38414.96	0.136835	0.135885	0.135061
0.08	0.126107	0.119560	0.110918	36573.11	37566.70	38538.13	0.136803	0.135839	0.135017
0.10	0.123310	0.117676	0.111872	36676.15	37655.16	38520.60	0.136784	0.135805	0.135002
0.12	0.120500	0.111042	0.109009	36797.20	37887.88	38644.13	0.136743	0.135781	0.134966
0.14	0.118322	0.109526	0.107105	36899.69	37964.61	38738.42	0.136701	0.135747	0.134928
0.16	0.113894	0.107023	0.100215	37049.75	38070.41	38994.61	0.136687	0.135716	0.134891
0.18	0.112944	0.104340	0.098406	37147.67	38178.15	39092.64	0.136603	0.135690	0.134846
0.20	0.108179	0.101448	0.093531	37342.64	38302.79	39278.33	0.136548	0.135652	0.134815

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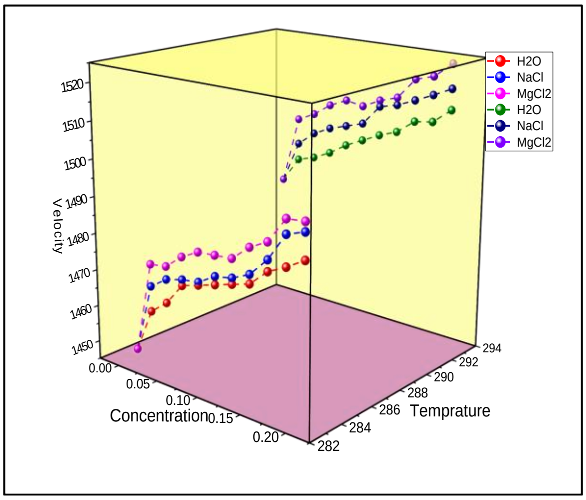

Figure 1 Concentration, Temperature-related changes in ultrasonic velocity

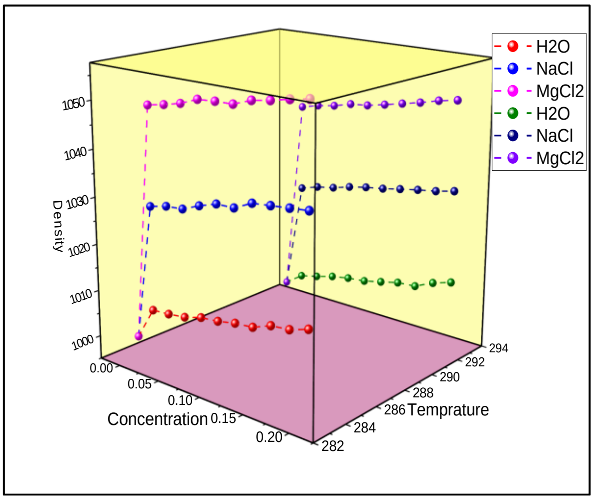

Figure. 2 Concentration, Temperature-related changes in density

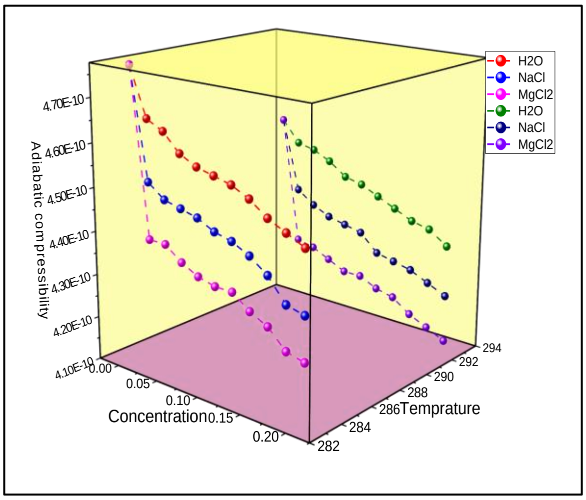

Figure 3 Concentration, Temperature-related changes in Adiabatic compressibility

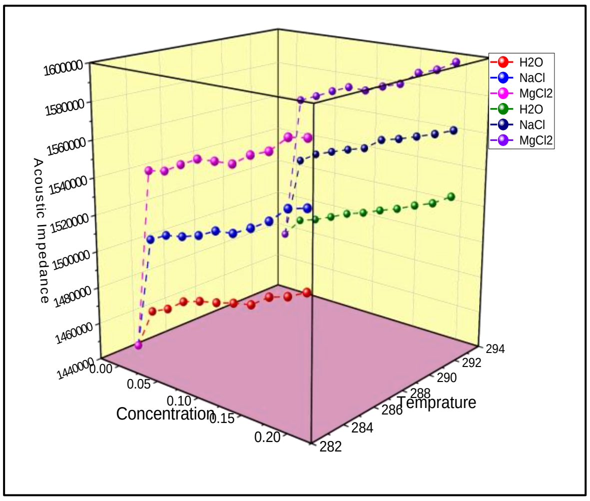

Figure 4 Concentration, Temperature-related changes in Acoustic Impedance

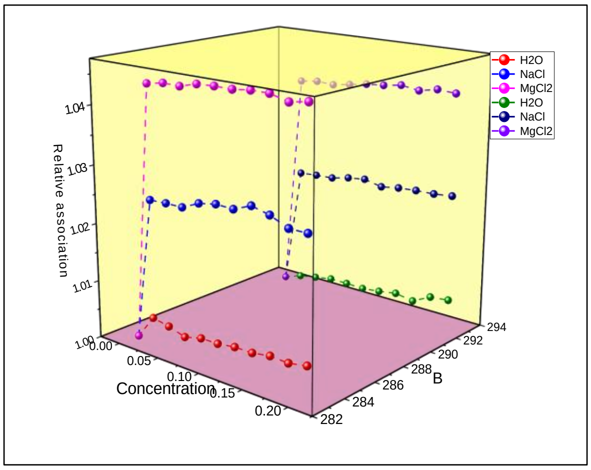

Figure 5 Concentration, Temperature-related changes in Relative association

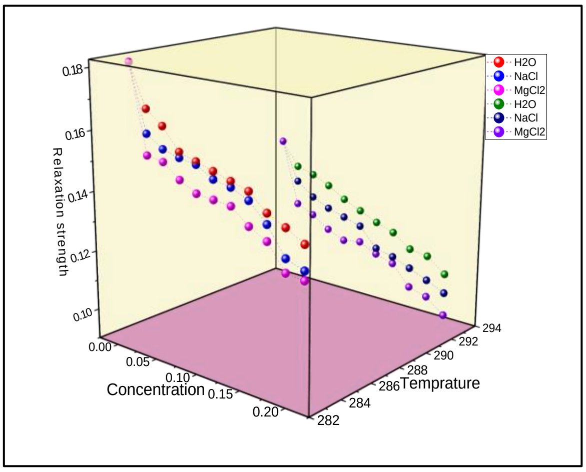

Figure 6 Concentration, Temperature-related changes in Relaxation strength

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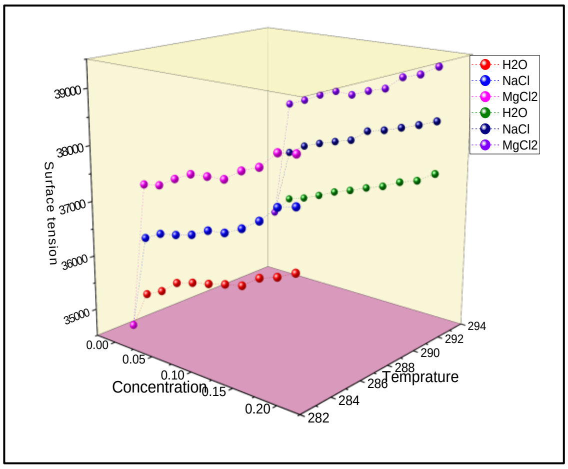

Figure 7 Concentration, Temperature-related changes in Surface tension

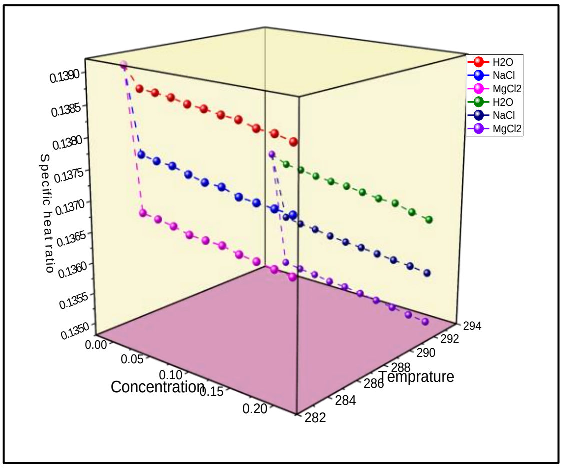

Figure 8 Concentration, Temperature-related changes in Specific heat ratio

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