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Different Physical properties of Few Amino Acids for a Range of Different Temperatures in Aqueous Sodium Acetate Solution.

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Abstract--The physical properties of two basic amino acids namely L-arginine and L-lysine have been studied. The main focus of the work is to study the ultrasonic velocity of those amino acids and also the viscosity and density in aqueous sodium acetate solution at 300K, 305K, 310K, 315K and 320K. With the use of these experimental values, different parameters like adiabatic compressibility, apparent molal volume, apparent molal compressibility, limiting apparent molal volume, limiting apparent molal compressibility, and their constants, transfer volume, transfer adiabatic compressibility, and viscosity B-coefficient of Jones-Dole equation have been calculated. All these different parameters are thoroughly investigated to look for any possible molecular interaction.

Keywords-- L-arginine, L-lysine, sodium acetate, ultrasonic velocity

1 INTRODUCTION

For last two decades, scientists are extremely interested to understand the structures of protein by the means of volumetric and ultrasonic measurements which is important for not only to the chemical physicist or pure chemist but also to the applied biologist. But direct study of the structures of protein is tough due to the intricate molecular composition. Therefore, it is better to take the simple molecules for example amino acids which are usually regarded as the basic units of protein [1], [2]. Researchers are interested to study the volumetric as well as the thermodynamics properties of aqueous amino acids [3],[4]

Proteins are formed by amino acids with an amino (-NH2) group and a carboxylic (-COOH) functional group. The construction is quite difficult as –NH2 is a base and –COOH is an acidic group [5]. Amino acids are mainly two type, amino acid with non-polar substituent or hydrophobic (water hating) and polar substituent or hydrophilic (water loving) [6]. It is therefore of great interest to investigate the physio-chemical characteristics of the non-electrolyte such as sodium acetate with amino acids so that the character of molecular relations among the organic solute with solvent can be studied [7], [8].

In this paper the physical properties of two basic amino acids namely L-arginine and L-lysine have been studied in three different temperatures as 300K, 305K, 310K, 315K and 320K

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focusing mainly on the ultrasonic velocity of these amino acids.

2 MATERIALS AND METHODS

The spectroscopic regents and analytical grade L-lysine and L-arginine reagent procured from E-Merck, Germany and Sd Fine chemicals, India with a least assay of 99.9 has been used for the paper. The liquid was first distilled and then degassed to make the solvent. The required amount of sodium acetate and water were taken at a concentration range of 0.2 - 0.4 mol/dm3 following which the amino acids, L-lysine and L-arginine, were dissolved in the solutions. The reagents for the experiments were measured using a digital electronic balance having a precision of ± 1×10-4g (Shimadzu Ax - 200).

A specific gravity bottle has been used to determine the concentration using the relative measurement method with an accuracy of ± 0.01 kg m-3. The viscosity has been calculated with the help of an Ostwald's viscometer (10ml). The ultrasonic velocity was determined with the help of an ultrasonic interferometer of 3 MHz frequency and with 0.1% precision. A constant digital electronic temperature bath with an accuracy ± 0.1 K has been used for experiment.

2.1 THEORY AND CALCULATIONS

Adiabatic compressibility,

$$\beta = \frac{1}{U^2 \rho} \quad \text{...............} (1),$$

Where, U= ultrasonic velocity, ρ=density.

The apparent molal compressibility is given by the formula,

$$\phi_k = \frac{1000}{m\rho_o}(\rho_o\beta - \rho\beta_o) + \frac{\beta_o M_w}{\rho_o} \quad \text{.............} (2)$$

Where the symbols β, ϕ v, ϕ k,, ϕ °v, ϕ °k, m and Mw corresponds to the value of adiabatic compressibility, apparent molal volume, apparent molal compressibility, limiting apparent molal volume, limiting apparent molal compressibility, the molal concentration and the molecular weight of the solute respectively. φk is the function of M as obtained by "Gucker [1933] [9]" from Debye "Huckel theory [10]" as,

$$\phi_k = \phi_k^o + s_k M^{\frac{1}{2}} \quad \text{.......................} (3)$$

Where, the limiting apparent molal compressibility is denoted by φok and a constant is denoted by Sk. The apparent molal volume φv is given by,

$$\phi_v = \frac{1000}{m\rho_o}(\rho_o - \rho) + \frac{M}{\rho_o} \quad \text{...................} (4)$$

From Masson's empirical relation it can be taken as [11],

$$\phi_v = \phi_v^o + S_v M^{\frac{1}{2}} \quad \text{......................}(5)$$

Where, the limiting apparent molal volume is denoted as φov and a constant is denoted as Sv. The entire viscosity data can be analyzed using Jones-Dole semi empirical equation [12],

$$\frac{\eta}{\eta_o} = 1 + Am^{\frac{1}{2}} + Bm \quad \text{..........................} (6)$$

Where A and B are the coefficients of viscosity, η and ηo is the viscosity of the solution the solvent respectively.

The above mentioned quantities have been obtained and the results are produced in the following tables for five different temperatures 300K, 305K, 310K, 315K and 320K.

3 RESULT AND DISCUSSION

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The values of density, viscosity and ultrasonic velocity for L-arginine and L-lysine have been listed in Table 1 and Table 2 respectively for three different temperatures. The values of adiabatic compressibility (β), apparent molal volume (ϕ v), apparent molal compressibility (ϕ k), limiting apparent molal volume (ϕ °v), limiting apparent molal compressibility (ϕ °k), and their constants (Sk, Sv), are given in Table 3 to 6.

TABLE 1: Density (ρ), viscosity (η) and ultrasonic velocity (U) for L-arginine with the temperature varying 300K, 305K, 310K, 315K and 320K for all the three columns.

Molality m (mol.kg-1)	Density ρ/(kg.m-3)					Viscosity η/(10-3 Nm-2)					Ultrasonic velocity U/(10-10m.s-1)				
	Temperature(K)					Temperature(K)					Temperature(K)				
	300	305	310	315	320	300	305	310	315	320	300	305	310	315	320
0.00	1018.55	1015.10	1009.20	1005.15	1002.0	1.0800	0.885	0.7670	0.669	0.5900	1536.1	1539.3	1541.0	1543.5	1546.0
0.02	1020.1	1017.20	1010.5	1007.0	1003.5	1.0820	0.895	0.7700	0.685	0.6100	1537.0	1540.1	1541.9	1544.3	1547.0
0.04	1021.99	1018.90	1011.90	1008.55	1004.80	1.0830	0.915	0.7850	0.708	0.6230	1537.9	1540.8	1542.5	1545.0	1547.8
0.06	1023.1	1020.08	1013.00	1009.15	1006.00	1.0850	0.935	0.7980	0.719	0.6330	1538.5	1541.9	1543.2	1546.1	1548.3
0.08	1024.99	1022.50	1014.5	1010.90	1007.30	1.0860	0.954	0.8100	0.723	0.6450	1539.1	1543.0	1544.0	1547.3	1549.1
0.10	1025.1	1023.20	1016.20	1012	1008.60	1.0880	0.971	0.8220	0.740	0.6500	1540.0	1544.1	1545.0	1548.1	1550.0

It has been observed (Table 1) that the density increased with the increased molality of L-arginine amino acid for all the five temperatures (300K, 305K, 310K, 315K and 320K). A similar observation was also observed for the viscosity as well as the ultrasonic speed of the L-arginine amino acid in which both the parameters were found to increase with the increased molal concentration of L-arginine for all the five temperatures (300K, 305K, 310K, 315K and 320K). The increase in the density and the viscosity of the amino acid for a certain concentration were observed to decline with the increased temperature. However, the ultrasonic velocity was found to increase with the increased temperature.

TABLE 2: Density (ρ), viscosity (η) and ultrasonic velocity (U) for L- lysine with the temperature varying 300K, 305K, 310K, 315K and 320K for all the three columns.

Molality m (mol.kg-1)	Density ρ/(kg.m-3)					Viscosity η/(10-3 Nm-2)					Ultrasonic velocity U/(10-10m.s-1)				
	Temperature(K)					Temperature(K)					Temperature(K)				
	300	305	310	315	320	300	305	310	315	320	300	305	310	315	320
0.00	1018.55	1015.10	1009.20	1005.15	1002.0	1.0800	0.885	0.7670	0.669	0.5900	1536.1	1539.3	1541.0	1543.5	1546.0
0.02	1020.1	1017.20	1010.5	1007.0	1003.5	1.0820	0.895	0.7700	0.685	0.6100	1537.0	1540.1	1541.9	1544.3	1547.0
0.04	1021.99	1018.90	1011.90	1008.55	1004.80	1.0830	0.915	0.7850	0.708	0.6230	1537.9	1540.8	1542.5	1545.0	1547.8
0.06	1023.1	1020.08	1013.00	1009.15	1006.00	1.0850	0.935	0.7980	0.719	0.6330	1538.5	1541.9	1543.2	1546.1	1548.3
0.08	1024.99	1022.50	1014.5	1010.90	1007.30	1.0860	0.954	0.8100	0.723	0.6450	1539.1	1543.0	1544.0	1547.3	1549.1
0.10	1025.1	1023.20	1016.20	1012	1008.60	1.0880	0.971	0.8220	0.740	0.6500	1540.0	1544.1	1545.0	1548.1	1550.0

Table 2 shows the change in the density, viscosity and the ultrasonic velocity of the solution with the altered molality of L-lysine amino acid. It can be seen that the density increased with the increased

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molality of the amino acid for all the five temperatures 300K, 305K, 310K, 315K and 320K). A similar observation was also observed where the viscosity and the ultrasonic speed were found to increase with the increased molal concentration of the L-arginine amino acid for all the five temperatures (300K, 305K, 310K, 315K and 320K). The density and the viscosity of the L-lysine amino acid for a certain concentration have been seen to decrease with the increased temperature. In contrast the ultrasonic velocity was found to increase with the increased temperature.

The increased density with the increased concentration may be due to the enhanced solvent-solvent and solvent-solute dealings which may also influence the viscosity of the solution. This increased density and viscosity may act to keep up the integration of the solution due to the increased amount of solute which may result in shrinkage in the volume of the solution. With the raise in the concentration of solute (in this case amino acids) may lead to the formation of increased hydrogen bonding among the solute-solvent which may affect the overall characteristic of the solution. Thus the formation of the hydrogen bond can be linked with the variation in the density and viscosity of the solution. The density and the viscosity of the amino acids have been found to be the functions of temperature and both the factors were found to be decreased with the increased temperature. The molecular relations and bonding among the solute-solute and solute-solvent tends to get feeble with the raise in the temperature of the system that ultimately leads to increased molecular activities.

The increase in the ultrasonic velocity of the solution may be due to the boost in the consistency due to the ionic hydration. As a consequence of the dissolving of the amino acid in the solution, the cohesion of the solution increases due to the attraction of water molecules by the strong electrostatic forces which tends to increase with the boost in concentration of the amino acid. This increased association may also be explained as a consequence of water enhancement because of bigger electrostriction due to the occurrence of sodium acetate. The zwitterionic of the amino acid causes the electrostriction that escorts to the decline in the volume of the solvent. The ultrasonic velocity of the amino acids was seen to be temperature dependant where the ultrasonic velocity was found to amplify with the boost in the temperature. Similar type of previous findings were also reported by Thirumana et al., and D' Souza et al., who reported that with the amplified concentration of the amino acid in the solution, the density, viscosity and the ultrasonic velocity of the solution increased [13] , [14].

TABLE 3: Values of adiabatic compressibility (β), apparent molal compressibility (φk) and apparent molal volume (φv) of L-arginine with the temperature varying 300K, 305K, 310K, 315K and 320K.

Molality m (mol.kg-1)	compressibility β /(x 10-10 m2 N-1)					molal compressibility -φk/(x 10-7 m2 N-1)					apparent molar volume -φv/(x 10-3 m3 mol-1)				
	Temperature(K)					Temperature(K)					Temperature(K)				
	300	305	310	315	320	300	305	310	315	320	300	305	310	315	320
0.00	4.1082	4.1099	4.1156	4.1195	4.1220	3.6135	3.6325	3.6545	3.6755	3.6844	29.1841	29.3102	29.4101	29.6103	29.8321
0.02	4.1053	4.1089	4.1042	4.1185	4.1210	3.6115	3.6310	3.6500	3.6730	3.6800	29.1842	29.3103	29.4102	29.6104	29.8322
0.04	4.0900	4.1081	4.1036	4.1175	4.1190	3.6000	3.6290	3.6485	3.6510	3.6750	29.1843	29.3104	29.4103	29.6105	29.8323
0.06	4.0800	4.1075	4.1026	4.1165	4.1180	3.5985	3.6275	3.6445	3.6493	3.6760	29.1844	29.3105	29.4104	29.6106	29.8324
0.08	4.0720	4.1066	4.1017	4.1155	4.1970	3.5935	3.6260	3.6400	4.6479	3.6700	29.1845	29.3106	29.4105	29.6107	29.8325
0.10	4.0600	4.1054	4.1005	4.1145	4.1960	3.5900	3.6245	3.6375	3.6463	3.6680	29.1846	29.3107	29.4106	29.6108	29.8326

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Table 3 describes the changes in the adiabatic compressibility, molal compressibility and the apparent molal volume with the raise in the molal concentration of the L-arginine amino acid. The adiabatic compressibility for the L-arginine amino acid was seen to be decreased with the amplified concentration of the L-arginine amino acid for all the five temperatures (300K, 305K, 310K, 315K and 320K). The molal compressibility of the L-arginine amino acid was observed to be negative. The molal compressibility of the L-arginine amino acid has been seen to increase with the increased molal concentration of the L-lysine amino acid for all the five temperatures (300K, 305K, 310K, 315K and 320K). The apparent molal volume has been also observed to be negative for L-arginine amino acid which tends to reduce with the increase in the L-arginine concentration of for all the five temperatures (300K, 305K, 310K, 315K and 320K). The molal compressibility and the apparent molar volume for L-arginine amino acid were found to amplify with the boost in the temperature for a specific concentration. The compressibility for L-arginine at a precise concentration has been found to be more or less similar with the raise in the temperature of the system.

TABLE 4: Values of adiabatic compressibility (β), apparent molar compressibility (φk) and apparent molal volume (φv) of L- lysine with the temperature varying 300K, 305K, 310K, 315K and 320K.

Molality m (mol.kg-1)	compressibility β /(x 10-10 m2 N-1)					molal compressibility -φk/(x 10-7 m2 N-1)					apparent molar volume -φv/(x 10-3 m3 mol-1)				
	Temperature(K)					Temperature(K)					Temperature(K)				
	300	305	310	315	320	300	305	310	315	320	300	305	310	315	320
0.00	4.1192	4.1598	4.1878	4.1955	4.2210	4.6203	4.6430	4.6634	4.6694	4.6789	43.9752	44.1120	44.5112	44.8963	45.1531
0.02	4.0953	4.1476	4.1822	4.1900	4.2000	4.6100	4.623	4.6200	4.6394	4.6700	43.9753	44.1121	44.5113	44.8964	45.1532
0.04	4.0500	4.1048	4.1256	4.099	4.1700	4.5900	4.601	4.600	4.6100	4.6660	43.9753	44.1122	44.5114	44.8965	45.1533
0.06	4.0200	4.0915	4.1000	4.0000	4.1000	4.5185	4.589	4.5445	4.5891	4.6460	43.9754	44.1123	44.5114	44.8966	45.1534
0.08	3.8920	3.9056	3.9560	3.9780	4.9820	4.495	4.569	4.5135	4.5655	4.6200	43.9755	44.1124	44.5115	44.8967	45.1535
0.10	3.8600	3.8756	3.9000	3.9230	4.9450	4.4300	4.540	4.4075	4.5600	4.5880	43.9766	44.1125	44.5116	44.8968	45.1535

Table 4 describes the changes in the adiabatic compressibility, molal compressibility and the apparent molal volume with the amplification in the molal concentration of the L-lysine amino acid. The adiabatic compressibility for the L-lysine amino acid was seen to decrease with the amplified L-lysine concentration for all the five temperatures (300K, 305K, 310K, 315K and 320K). The molal compressibility of the L-lysine amino acid was observed to be negative. The molal compressibility of the L-lysine amino acid has been seen to enlarge with the boost in the molal concentration of the L-lysine amino acid for all the five temperatures (300K, 305K, 310K, 315K and 320K). The apparent molal volume was also found to be negative for L-lysine amino acid which tends to decrease with the increased L-lysine concentration for all the five temperatures (300K, 305K, 310K, 315K and 320K). The molal compressibility and the apparent molar volume for

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L-lysine amino acid were found to increase with the increased temperature for a specific concentration. The compressibility for L-lysine at a specific concentration was observed to be more or less similar with the increase in the temperature of the system.

Amino acids are seen to be present in dipolar form in neutral solutions having very strong interactions with close by water molecules. The enlarged electrostriction of the water molecules around the solutes may result in the decreased compressibility of the solutions. The adiabatic compressibility of the L-arginine amino acid was observed to be superior than that of the L-lysine amino acid which shows that L-arginine amino acid in sodium acetate solution has stronger molecular interaction in comparison to L-lysine. The maximum value for molal compressibility and apparent molar volume has been seen for L-arginine amino acid which shows that electrostriction and hyperphilic connections in the solution were superior in L-arginine which indicates a higher solute-solvent interaction in comparison to L-lysine. Temperature seems to be very important in changing the molal compressibility as well as molar volume of the amino acids which can be elucidated due to the boost in the molecular activities with amplified temperature which might eventually guide to the decrease in the molecular interaction of the among the solute-solvent.

TABLE 5: Values of limiting apparent molal compressibility (φok) and constant Sk with the temperature varying 300K, 305K, 310K, 315K and 320K.

Amino acids	limiting apparent molal compressibility φok /(x 10-8 m2 N-1)					constants Sk /(x 10-8 m-1 N-1 mol-1)				
	Temperature(K)					Temperature(K)				
	300	305	310	315	320	300	305	310	315	320
L-arginine	-3.590	-3.595	-3.601	-3.601	-3.615	6.00	5.93	5.82	5.73	5.69
L- lysine	-4.65	-4.67	-4.79	-4.86	-4.91	6.99	6.46	6.34	6.12	5.80

TABLE 5 describes the limiting apparent molal compressibility and the constants Sk for L-lysine and L-arginine amino acids in the sodium acetate solution. The limiting apparent molal compressibility of the L-arginine and the L-lysine amino acids was observed to reduce with the boost in the temperature of the system. Similarly the constants Sk for L-arginine and L-lysine amino acids was seen to decrease with the amplified temperature of the system.

The decrease in the limiting apparent molal compressibility and the constants of Sk for both the amino acids can be elucidated due to the presence of solute-solute interactions which might lead to increased electrostriction that may cause decreased compressibility of the solution. The molal compressibility for the amino acids was observed to be negative which represents hydrophilic solutes.

TABLE 6: Values of limiting apparent molal volume (φov), their constant Sv with the temperature varying 300K, 305K, 310K, 315K and 320K.

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Amino acids	limiting apparent molal volume φov /(x m3 mol-1)					constants Sv /(x m-1 N-1 mol-1)				
	Temperature(K)					Temperature(K)				
	300	305	310	315	320	300	305	310	315	320
L-arginine	-29.00	-29.13	-29.39	-29.45	-29.51	0.0396	0.0397	0.0399	0.0390	0.0386
L-lysine	-43.86	-43.96	-44.09	-43.22	-44.41	0.0736	0.0742	0.0755	0.0751	0.0748

Table 6 explains the limiting apparent molal volume and the constants Sv for L-arginine and L-lysine amino acids in the sodium acetate solution. The limiting apparent molal compressibility of the L-arginine and L-lysine amino acids has been observed to diminish with the amplified temperature of the system. The constants Sv for L-lysine and L-arginine amino acids has been seen to amplify for the increase in temperature from 300K through 310K but decreased with further increase in temperature from 315K to 320K.

The negative values of limiting apparent molal compressibility and limiting apparent molal volume specifies the occurrence of ionic as well as hydrophilic interactions in the system [15]. The negative limiting apparent molal volume value also indicates the electrostrictive salvation of ions [16]. The decline in the limiting apparent molal volume has been found to be due to the interruption of the side chain hydration as a consequence of the charged end due to the amplified temperature. It may also be attributed as a result of the hydrophilicity and/or polar nature of the amino acid side chain due to amplified temperature. The increased value of constant of Sv indicates that with the boost in temperature the solute-solute interaction amplified. Comparable type of molecular interactions among the solutes has also been observed by Banipal et al., 2007 [17]. In a study by Ali et al., related types of communications were observed for certain amino acids in occurrence of salts in aqueous medium[18].

4 CONCLUSION

From the magnitudes of compressibility, molal compressibility and apparent molar volume of the two amino acids under investigation, it can be concluded that the L-arginine in aqueous sodium acetate solution has stronger ionic interaction among solutes in comparison to L-lysine. The raise in temperature is also found to reduce the molal compressibility, apparent molar volume, limiting apparent molal compressibility and volume of both the amino acids due to the decrease in the ionic interactions among the solutes as a consequence of increased temperature. Lastly, the ultrasonic velocities of amino acids are observed to amplify with the increased temperature and concentration of the amino acids in the solutions.

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