CHAPTER IV

STUDY OF SOLUTE-SOLVENT INTERACTION OF SOME BIO-ACTIVE SOLUTES PREVAILING IN AQUEOUS ASCORBIC ACID SOLUTION

4.1. INTRODUCTION

Amino acids are molecules containing an amine group, a carboxylic acid group and a side-chain that varies between different amino acids. The key elements of an amino acid are carbon, hydrogen, oxygen, and nitrogen. They are particularly important in biochemistry, where the term usually refers to *alpha-amino acids.* Amino acids are critical to life, and have many functions in metabolism. One particularly important function is to serve as the building blocks of proteins, which are linear chains of amino acids. Due to their central role in biochemistry, amino acids are important in nutrition and are commonly used in nutrition supplements, fertilizers, food technology and industry.

Importantly ascorbic acid (vitamin C) is also able to regenerate other antioxidants as vitamin E. Vitamin C is required for the synthesis of collagen, the intercellular "cement" which gives the structure of muscles, vascular tissues, bones, and tendon. Vitamin C with Zn is also important for the healing of wounds. It is also needed for the metabolism of bile acids which may have implications for blood cholesterol levels and gallstones. Ascorbic acid and its sodium, potassium, and calcium salts are commonly used as antioxidants food additives.Vitamin C plays an important role for the synthesis of several important peptide hormones, neurotransmitters and creatinine. It also enhances the eye's ability and delay the progression of advanced age related muscular degeneration [1].

The volumetric, viscometric and interferometric behavior of solutes has been proven to be very useful in elucidating the various interactions occurring in solutions. Studies on the effect of concentration (molality), the apparent molar volumes of solutes have been extensively used to obtain information on ion-ion, ion-solvent, and solvent-solvent interactions [2-6].

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In view of the above and in continuation of our studies, we have undertaken a systematic study on the density, viscosity, refractive index and ultrasonic speed of some amino acids in aqueous ascorbic acid solutions at 298.15 K and we have attempted to report the limiting apparent molar volume (ϕ_V^0), experimental slopes (S_V^*), and viscosity *B*-coefficients, molar refraction (*R*) and limiting apparent molar adiabatic compressibility (ϕ_K^0) for the cited amino acids in ascorbic acid.

4.2. EXPERIMENTAL METHODS

4.2.1. *Source and purity of samples*

Ascorbic acid was purchased from Sd. Fine chemicals Limited, and used as delivered. Its mass purity as supplied is 98%. The amino acids L-Glycine (S.D. Fine Chemicals, >99%), L-Alanine (S.D. Fine Chemicals, >98.5%), and L-Valine (Loba Chemie, India, >99%) were used for the present study and were used as such without further purification. Ascorbic acid was recrystallized twice from aqueous ethanol solution and dried under vacuum at T = 348 K for 6 h. Thereafter, it was stored over P_2O_5 in a desiccator before used [7]. Triply distilled water with a specific conductance $<10^{-6}$ S cm^{-1} was used for the preparation of different aqueous ascorbic acid solutions. The physical properties of different mass fraction of aqueous ascorbic acid mixture are listed in Table 1.

4.2.2. *Apparatus and Procedure*

The Density (ρ) was measured by means of vibrating-tube Anton Paar Density-Meter (DMA 4500M) with a precision of 0.00005 $g.cm^{-3}$. It was calibrated by double-distilled water and dry air [8]. The temperature was automatically kept constant within ± 0.01 K.

The viscosity (η) was measured by means of suspended Ubbelohde type viscometer, calibrated at 298.15 K with doubly distilled water and purified methanol. A thoroughly cleaned and perfectly dried viscometer filled with experimental solution was placed

vertically in a glass-walled thermostat (Bose Panda Instruments Pvt. Ltd.) maintained to 0.01 K. After attainment of thermal equilibrium, efflux times of flow were recorded with a stop watch. The flow times were accurate to ±0.1s. The mixtures were prepared by mixing known volume of solutions in airtight-stopper bottles and each solution thus prepared was distributed into three recipients to perform all the measurements in triplicate, with the aim of determining possible dispersion of the results obtained. Adequate precautions were taken to minimize evaporation loses during the actual measurements. Mass measurements were done on a Mettler AG-285 electronic balance with a precision of ±0.01 mg. The precision of density measurements was ± 3.10^{-4} g·cm^{-3}.

Viscosity of the solution is evaluated using the following equation [9].

$$\eta = \left(Kt - \frac{L}{t} \right) \rho \qquad (1)$$

where K and L are the viscometer constants, t is the efflux time of flow in seconds and ρ is the density of the experimental liquid. The uncertainty in viscosity measurements is within ± 0.003 mPa·s.

Refractive index was measured with the help of a Digital Refractometer Mettler Toledo. The light source was LED, λ=589.3 nm. The refractometer was calibrated twice using distilled water and calibration was checked after every few measurements. The uncertainty of refractive index measurement was ± 0.0002 units.

The ultrasonic velocities, u (ms^{-1}) were measured using an ultrasonic interferometer (Model M-83) from Mittal enterprises. The interferometer working at 2 MHz is based on the same principle as was used by Freyer et al. [10] and Kiyoharo et al. [11,12]. The obtained velocities were corrected for diffraction errors as given by Subrahmayan et al. [13]. The maximum uncertainty in the velocity is ±0.5 m s^{-1}. The temperature was controlled within ±0.01 K using a Lauda thermostat for velocity measurements.

The solutions studied here were prepared by mass and the conversion of molarity into molality was accomplished [4] using experimental density values. The experimental values of densities (ρ), viscosities (η), refractive indices (n_D) and

ultrasonic speeds (u) of solutions are reported in Table 2 and the derived parameters are reported in Table 3 and Table 4.

4.3. RESULTS AND DISCUSSIONS

4.3.1. *Density calculation*

Apparent molar volumes (ϕ_V) were determined from the solution densities using the following equation [14].

$$\phi_V = M/\rho - 1000(\rho - \rho_o)/m\rho\rho_o \qquad (2)$$

where M is the molar mass of the solute, m is the molality of the solution ρ_0 and ρ are the densities of the mixture and the solution respectively. The limiting apparent molar volume ϕ_V^0 was calculated using a least-square treatment to the plots of ϕ_V versus $\sqrt{m}$ using the Masson equation [15].

$$\phi_V = \phi_V^0 + S_V^* \sqrt{m} \qquad (3)$$

where ϕ_V^0 is the limiting apparent molar volume at infinite dilution and S_V^* is the experimental slope. The plots of ϕ_V against square root of molal concentration ($\sqrt{m}$) were found to be linear with slopes. Values of ϕ_V^0 and S_V^* are reported in Table 4.

A perusal of Table 4 shows that ϕ_V^0 values for amino acids are positive and increases with the increase in the mass fractions of ascorbic acid in the mixture. This indicates the presence of strong solute-solvent interactions and these interactions are further strengthened with an increase in the mass fractions of ascorbic acid in the mixture.

L-Glycine < L-Alanine < L-Valine

This shows that with increases in the number of carbon atoms in the studied amino acids, the solute-solvent interaction also increases, similar results will be found for amino acid in methanoic acid (Formic acid) [16].

Ascorbic acid behaves as a vinylogous carboxylic acid wherein the double bond transmits electron pairs between the hydroxyl group and the carbonyl [17]. There are two resonating structures for the deprotonated form, differing in the position of double bond. The deprotonated form is an enolate which is usually strongly basic. Ascorbic acid

also converts into two unstable diketone tautomers by proton transfer, although it is the most stable in the enol form. The proton of the enol is lost, and re-acquired by electrons from the double bond to produce a diketone [18]. There are two possible forms: 1,2-diketone and 1,3-diketone(IIa and IIb). The molecule exists in equilibrium with two ketone tautomers, which are less stable than the enol form. In solutions, these forms of ascorbic acid rapidly interconvert **Scheme 1.**

It is known that the amino acids remain in zwitter ionic form in solid and in liquid. There are two acidic proton in ascorbic acid designated as H_α and H_β. On dissociation of any of this proton ascorbate ion will be formed. The stability of the conjugate base (respective ascorbate ion) will determine the acidity of the respective proton, **Scheme 2.**

Ascorbic acid (I) on dissociation of H_α proton gives its conjugate base structure 'X'. On the other hand enol form of ascorbic acid (I) on dissociation of H_β proton gives its conjugate base 'Y'. As structure 'Y' has one more equally contributing resonating structure 'Z', where as structure 'X' does not have any resonating structure. Therefore, the stability of conjugate base generated on removal of H_β proton is more than that of conjugate base generated on removal of H_α proton. Thus β proton of ascorbic acid is more acidic than the α proton as each dissociation is more facile. Therefore, the negatively charged oxygen atom in the carboxylic group of amino acids probably interacts with the most acidic hydrogen (β hydrogen) of enol form of ascorbic acid rendering higher solute-solvent interaction in comparison with solute-solute interaction as evident from ϕ_V^0 values. The order of solute-solvent interaction mentioned in Table 4 may be due to the reason, as the higher amino acids contain more alkyl groups (electron releasing group, +I effect), the caboxylate oxygen becomes more and more electron denser rendering to stronger interaction, i.e. stronger solute-solvent interaction.

A plausible mechanism of interaction between ascorbic acid and different amino acids as evident from the experimental observation explained and discussed above is given in **Scheme 3.**

The S_V^* values of the amino acid solution given in Table 4 decreases with increases in the number of carbon atoms of the studied amino acids and with increases in the mass fraction of ascorbic acid in the solvent mixture rendering minimum solute-solute interaction in the higher analogs.

The magnitude of ϕ_V^0 (Figure 1) values is much greater than those of S_V^* for all studies amino acids as well as mass fraction of ascorbic acid in the mixture suggests that solute-solvent interactions dominate over solute-solute interactions.

4.3.2. *Viscosity calculation*

The viscosity data has been analyzed using Jones-Dole equation [19].

$$(\eta / \eta_0 - 1) / \ m^{1/2} = A + Bm^{1/2} \qquad (4)$$

where η_0 and η are the viscosities of the solvent and solution respectively. A and B are the viscosity co-efficient estimated by a least-squares method and are reported in Table 4. The values of the A co-efficient are found to decrease with the increase in the number of carbon atoms of amino acids (from L-Glycine to L-Valine) and with the increase in mass fraction of ascorbic acid in solvent mixture. The results indicate the presence of very weak solute-solute interactions. These results are in excellent agreement with those obtained from S_V^* values discuss earlier.

The effects of solute-solvent interactions on the solution viscosity can be inferred from the B-coefficient [20, 21]. The viscosity B-coefficient is a valuable tool to provide information concerning the solvation of the solutes and their effects on the structure of the solvent. From Table 4 and Figure 2 it is evident that the values of the B-coefficient are positive, thereby suggesting the presence of strong solute-solvent interactions, and strengthened with an increase the number of carbon atoms of amino acids and with the increase of mass fraction of ascorbic acid in the solvent mixture, are in agreement with the results obtained from ϕ_V^0 values discussed earlier.

4.3.3. *Refractive index calculation*

The molar refraction, R can be evaluated from the Lorentz-Lorenz relation [22].

$$R = \{(n_D^2-1)/(n_D^2+2)\}(M/\rho) \quad (5)$$

where R, n_D, M and ρ are the molar refraction, the refractive index, the molar mass and the density of solution respectively. The refractive index of a substance is defined as the ratio c_0/c, where c is the speed of light in the medium and c_0 the speed of light in vacuum. Stated more simply, the refractive index of a compound describes its ability to refract light as it moves from one medium to another and thus, the higher the refractive index of a compound, the more the light is refracted [23]. As stated by Deetlefs et al. [24]

The refractive index of a substance is higher when its molecules are more tightly packed or in general when the compound is denser and with the increase of mass fraction of ascorbic acid in solvent mixture refractive index value also increases. Hence a perusal of Tables 2 and 3 we found that the refractive index and the molar refraction values respectively are higher for L-Valine compare to other two amino acids, indicating the fact that the molecules are more tightly packed in the mixture. The interaction in the solution is basically solute-solvent interaction and a small amount of solute-solute interaction. This is also good agreement with the results obtained from density and viscosity parameters discussed above. The trend in the package of the studied amino acid in aqueous mixture of ascorbic acid is

L-Glycine < L-Alanine < L-Valine.

4.3.4. *Ultrasonic speed calculation*

The adiabatic compressibility (β) was evaluated from the following equation:

$$\beta = 1 / u^2\rho \quad (6)$$

where ρ is the density of solution and u is the speed of sound in the solution. The apparent molal adiabatic compressibility (ϕ_K) of the solutions was determined from the relation [16].

$$\phi_K = M\beta/\rho + 1000(\beta\,\rho_o - \beta_o\rho)\ /m\ \rho\ \rho_o \qquad (7)$$

where β_0, β are the adiabatic compressibility of the solvent and solution respectively and m is the molality of the solution. Limiting partial molal adiabatic compressibilities (ϕ_K^0) and experimental slopes (S_K^*) were obtained by fitting ϕ_K against the square root of molality of the electrolyte ($\sqrt{m}$) using the method of least squares.

$$\phi_K = \phi_K^0 + S_K^* . \sqrt{m} \qquad (8)$$

The values of β and ϕ_K are reported in Table 3. The values of ϕ_K^0 and S_K^* are presented in Table 4. Since the values of ϕ_K^0 and S_K^* are measures of solute-solvent and solute-solute interactions respectively, a perusal of Table 4 and Figure 3 shows that the ϕ_K^0 values are in good agreement with those drawn from the values of ϕ_V^0 discussed earlier.

4.4. CONCLUSION

The values of the limiting apparent molar volume (ϕ_V^0), viscosity *B*-coefficients and limiting partial isentropic compressibility (ϕ_K^0) indicate the presence of strong solute-solvent interactions which increases with the increase in the number of carbon atoms of the studied amino acids and with increase of mass fraction of ascorbic acid in the aqueous mixture. The refractive index and the molar refraction values suggest that L-Valine molecules are more tightly packed in the solution leading to higher solute-solvent interaction than the other studied amino acids.

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TABLES

Table 1. The values of density (ρ), viscosity (η), refractive index (n_D), and speed of sound (u) in different mass fraction of ascorbic acid at 298.15 K

Mass-fraction Ascorbic acid	ρ x 10^{-3} (kg m^{-3})	η (mPa s)	n_D	u (ms^{-1})
$w_1 = 0.01$	0.99785	0.823	1.3323	1500.8
$w_1 = 0.03$	0.99936	0.835	1.3330	1504.5
$w_1 = 0.05$	1.00074	0.847	1.3338	1509.4

Table 2. Experimental values of densities (ρ), viscosities (η), refractive Index (n_D), and ultrasonic Speed (u) of L-Glycine, L-Alanine and L-Valine in different mass fraction of ascorbic acid at 298.15 K

molality (mol kg^{-1})	P x 10^{-3} (kg m^{-3})	η (mPas)	n_D	u (m s^{-1})	molality (mol kg^{-1})	P x 10^{-3} (kg m^{-3})	η (mPas)	n_D	u (m s^{-1})
		w_1 = 0.01					w_1 = 0.03		
		L-Glycine					L-Glycine		
0.1001	0.99810	0.830	1.3324	1505.0	0.1001	0.99955	0.840	1.3335	1509.2
0.1584	0.99851	0.835	1.3328	1517.5	0.1583	0.99987	0.845	1.3339	1523.3
0.2004	0.99894	0.840	1.3331	1534.7	0.2003	1.00022	0.849	1.3342	1542.7
0.2351	0.99939	0.844	1.3334	1556.9	0.2349	1.00059	0.853	1.3345	1567.3
0.2653	0.99986	0.849	1.3337	1582.5	0.2651	1.00098	0.857	1.3348	1598.3
0.2924	1.00034	0.853	1.3340	1613.8	0.2923	1.00138	0.861	1.3351	1634.0
		L-Alanine					L-Alanine		
0.1001	0.99806	0.832	1.3326	1504.2	0.1001	0.99949	0.843	1.3336	1508.4
0.1584	0.99842	0.842	1.3330	1515.4	0.1583	0.99974	0.853	1.3340	1521.5
0.2005	0.99881	0.851	1.3333	1531.5	0.2004	1.00004	0.861	1.3343	1540.4
0.2352	0.99922	0.860	1.3336	1552.2	0.2351	1.00037	0.870	1.3346	1564.5
0.2654	0.99966	0.870	1.3339	1578.2	0.2653	1.00074	0.879	1.3349	1593.9
0.2926	1.00011	0.878	1.3342	1609.0	0.2925	1.00112	0.889	1.3352	1629.8
		L-Valine					L-Valine		
0.1002	0.99799	0.834	1.3328	1503.3	0.1001	0.99942	0.845	1.3337	1507.5
0.1585	0.99826	0.847	1.3333	1513.4	0.1584	0.99959	0.858	1.3343	1519.7

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0.2006	0.99857	0.861	1.3337	1528.9	0.2005	0.99982	0.872	1.3347	1537.8
0.2354	0.99892	0.874	1.3341	1548.7	0.2353	1.00010	0.885	1.3351	1561.5
0.2658	0.99929	0.887	1.3345	1573.6	0.2656	1.00042	0.898	1.3355	1590.4
0.2931	0.99969	0.901	1.3349	1603.5	0.2929	1.00076	0.913	1.3359	1625.3
		$w_1 = 0.05$							
		L-Glycine							
0.1000	1.00089	0.851	1.3346	1514.6					
0.1582	1.00115	0.855	1.3350	1530.3					
0.2002	1.00144	0.859	1.3354	1552.7					
0.2348	1.00176	0.863	1.3357	1581.3					
0.2650	1.00209	0.866	1.3360	1615.3					
0.2921	1.00244	0.870	1.3363	1657.4					
		L-Alanine							
0.1000	1.00078	0.854	1.3347	1513.8					
0.1582	1.00091	0.863	1.3351	1528.5					
0.2002	1.00109	0.872	1.3354	1549.4					
0.2349	1.00131	0.880	1.3357	1577.0					
0.2652	1.00157	0.889	1.3360	1610.4					
0.2924	1.00185	0.899	1.3363	1651.7					
		L-Valine							
0.1000	1.00072	0.856	1.3348	1512.8					
0.1583	1.00080	0.869	1.3354	1526.0					
0.2004	1.00096	0.882	1.3358	1545.8					
0.2351	1.00117	0.896	1.3362	1571.9					
0.2655	1.00145	0.909	1.3366	1603.8					
0.2928	1.00175	0.922	1.3370	1642.6					

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Table 3. Molality, apparent molar volume (ϕ_v), $(\eta/\eta_0-1)/m^{1/2}$, molar refraction (R), adiabatic compressibility (β) and apparent molal adiabatic compressibility (ϕ_K) of L-Glycine, L- Alanine, and L-Valine in ascorbic acid at 298.15 K

molality (mol kg^{-1})	ϕ_v x 10^6 (m^3 mol^{-1})	$(\eta/\eta_0-1)/m^{1/2}$ ($kg^{1/2}$ $mol^{-1/2}$)	R (cm^3 mol^{-1})	β x 10^{10} (Pa^{-1})	ϕ_K x 10^{10} (m^3 mol^{-1} Pa^{-1})
			w_1 = 0.01		
			L-Glycine		
0.10001	50.1779	0.082	15.4456	4.4234	-2.3674
0.15840	48.7749	0.094	15.4562	4.3490	-3.7936
0.20040	47.9230	0.103	15.4622	4.2502	-4.7626
0.23510	47.1714	0.111	15.4678	4.1280	-5.6308
0.26530	46.4556	0.118	15.4732	3.9937	-6.3018
0.29240	45.8745	0.124	15.4784	3.8384	-6.9824
			L-Alanine		
1.0010	68.2367	0.107	18.3410	4.4283	-1.7987
0.1584	66.4328	0.143	18.3544	4.3615	-3.2169
0.2005	65.2302	0.169	18.3622	4.2686	-4.2272
0.2352	64.3192	0.193	18.3697	4.1538	-5.0864
0.2654	63.3691	0.215	18.3766	4.0163	-5.9037
0.2926	62.6364	0.230	18.3833	3.8622	-6.6275
			L-Valine		

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0.1002	103.3723	0.132	24.1326	4.4339	-1.0809
0.1585	100.9671	0.185	24.1590	4.3737	-2.5738
0.2006	99.3636	0.229	24.1778	4.2841	-3.6863
0.2354	97.9060	0.263	24.1956	4.1738	-4.5725
0.2658	96.7867	0.293	24.2129	4.0413	-5.3977
0.2931	95.7087	0.324	24.2295	3.8904	-6.1489
			$w_1 = 0.03$		
			L-Glycine		
0.1001	56.1059	0.061	15.4696	4.3924	-2.5846
0.1583	54.7050	0.074	15.4814	4.3101	-4.1839
0.2003	53.6043	0.084	15.4886	4.2009	-5.2589
0.2349	52.7401	0.092	15.4955	4.0685	-6.1701
0.2651	51.9604	0.100	15.5021	3.9107	-7.0559
0.2923	51.3382	0.107	15.5085	3.7402	-7.7790
			L-Alanine		
0.1001	76.1387	0.094	18.3647	4.3973	-2.0036
0.1583	73.9373	0.132	18.3801	4.3208	-3.6683
0.2004	72.1362	0.157	18.3896	4.2142	-4.8442
0.2351	70.7717	0.180	18.3985	4.0840	-5.8090
0.2653	69.4201	0.200	18.4066	3.9333	-6.6564
0.2925	68.4279	0.220	18.4146	3.7605	-7.4649
			L-Valine		
0.1001	111.2212	0.121	24.1572	4.4029	-1.2925
0.1584	108.0191	0.177	24.1925	4.3317	-3.0819
0.2005	105.7177	0.218	24.2132	4.2294	-4.3159
0.2353	103.7619	0.254	24.2326	4.1008	-5.3575

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0.2656	102.0725	0.283	24.2511	3.9519	-6.2464
0.2929	100.7439	0.316	24.2691	3.7827	-7.0607
			$w_1 = 0.05$		
			L-Glycine		
0.1000	60.0256	0.043	15.4951	4.3553	-2.8085
0.1582	58.6266	0.057	15.5079	4.2653	-4.5722
0.2002	57.5274	0.067	15.5201	4.1419	-5.8505
0.2348	56.4827	0.077	15.5278	3.9922	-6.9133
0.2650	55.7430	0.084	15.5352	3.8246	-7.7756
0.2921	55.0293	0.092	15.5424	3.6315	-8.6352
			L-Alanine		
0.1000	85.0271	0.078	18.3959	4.3604	-2.1905
0.1582	82.2292	0.116	18.4135	4.2764	-4.0256
0.2002	80.2806	0.144	18.4251	4.1610	-5.2728
0.2349	78.6681	0.166	18.4360	4.0158	-6.3868
0.2652	77.1757	0.185	18.4462	3.8499	-7.3201
0.2924	75.9750	0.208	18.4559	3.6588	-8.2226
			L-Valine		
0.1000	119.0619	0.106	24.1980	4.3664	-1.4384
0.1583	114.6651	0.165	24.2354	4.2909	-3.3035
0.2004	111.5674	0.206	24.2577	4.1810	-4.6369
0.2351	109.2510	0.243	24.2788	4.0424	-5.7678
0.2655	106.9280	0.274	24.2982	3.8821	-6.7293
0.2928	105.1898	0.302	24.3171	3.6998	-7.6119

Table 4. Limiting apparent molar volumes (ϕ_V^0), experimental slopes (S_V^*), *A*, *B* coefficients, limiting partial adiabatic compressibility (ϕ_K^0), and experimental slope (S_K^*) of L-Glycine, L-Alanine, and L-Valine in aqueous ascorbic acid at 298.15 K

Salt	$\phi_V^0 \times 10^6$ ($m^3\ mol^{-1}$)	$S_V^* \times 10^6$ ($m^3\ mol^{-3/2}\ kg^{1/2}$)	*A* ($kg\ mol^{-1}$)	*B* ($kg^{1/2}\ mol^{-1/2}$)	$\phi_K^0 \times 10^{10}$ ($m^3\ mol^{-1}\ Pa^{-1}$)	$S_K^* \times 10^4$ ($m^3\ mol^{-3/2}\ Pa^{-1}\ kg^{1/2}$)
			$w_1 = 0.01$			
L-Glycine	52.366	-22.222	0.0592	0.2210	0.0143	-23.907
L-Alanine	71.083	-28.967	0.0411	0.6476	0.7418	-25.002
L-Valine	107.300	-39.660	0.0298	0.9952	1.5682	-26.222
			$w_1 = 0.03$			
L-Glycine	58.625	-25.019	0.0362	0.2407	0.1121	-26.943
L-Alanine	80.256	-40.514	0.0280	0.6506	0.8187	-28.251
L-Valine	116.680	-54.719	0.0182	1.0051	1.6724	-29.846
			$w_1 = 0.05$			
L-Glycine	62.716	-26.286	0.0161	0.2581	0.2131	-30.261
L-Alanine	89.716	-47.113	0.0114	0.6629	0.9370	-31.208
L-Valine	126.150	-72.078	0.0039	1.0161	1.7674	-32.021

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FIGURES

Figure 1. The plots of limiting apparent molar volumes (ϕ_V^0) for L-Glycine (—♦—), L-Alaline (—■—), L-Valine (—▲—) in different mass fractions (w_1) of ascorbic acid in aqueous mixture at 298.15 K

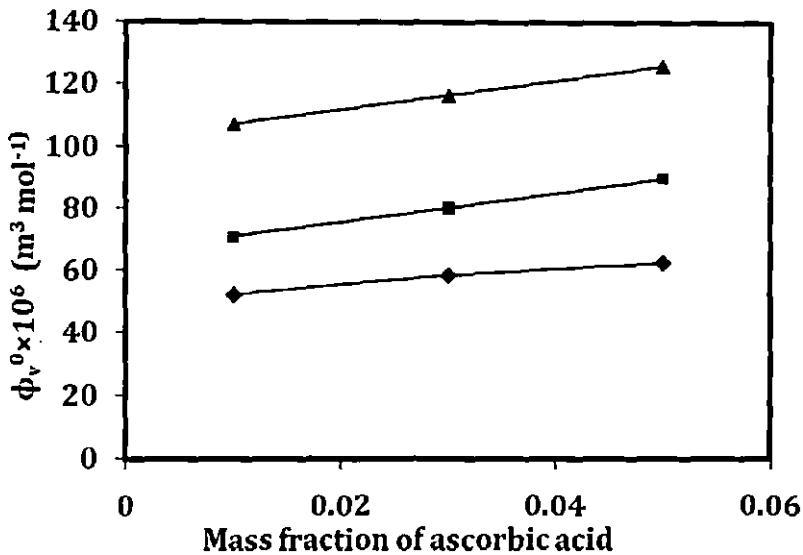


Figure 2. The plots of viscosity *B*-coefficient for L-Glycine (—♦—), L-Alaline (—■—), L-Valine (—▲—) in different mass fractions (w_1) of ascorbic acid in aqueous mixture at 298.15 K

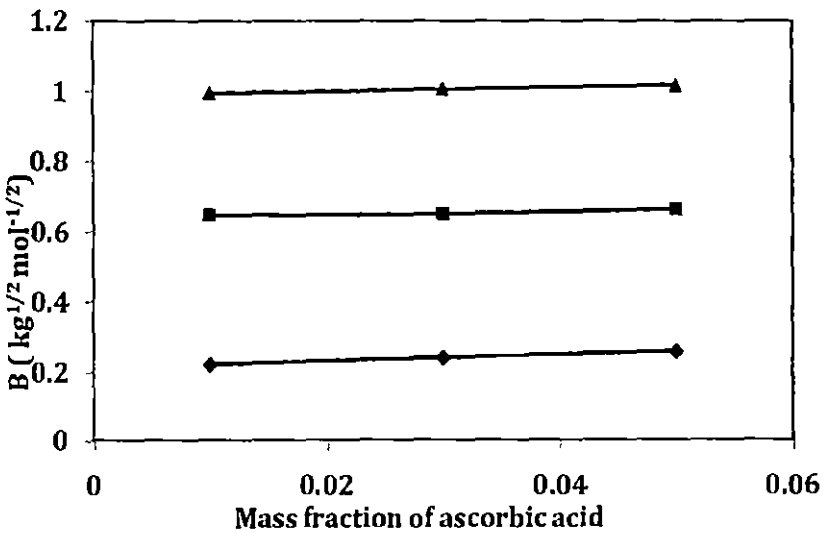
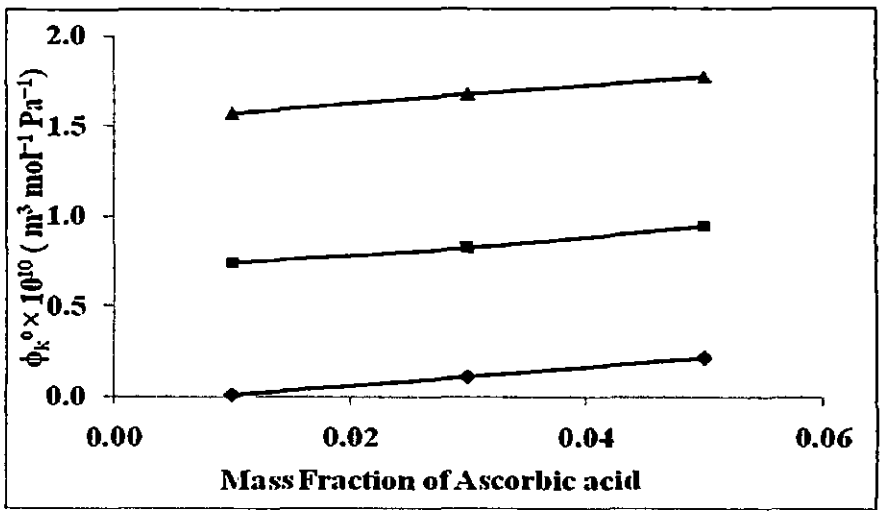
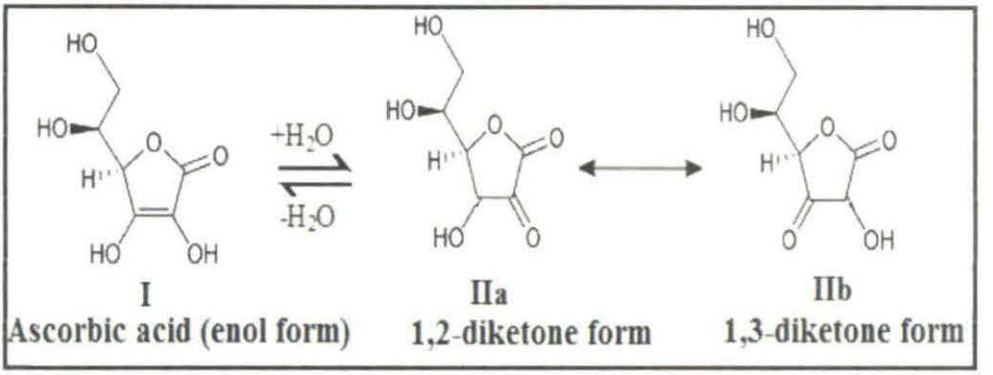


Figure 3. The plots of limiting partial adiabatic compressibility (ϕ_K^0) for L-Glycine (—♦—), L-Alanine (—■—), L-Valine (—▲—) in different mass fractions (w_1) of ascorbic acid in aqueous mixture at 298.15 K

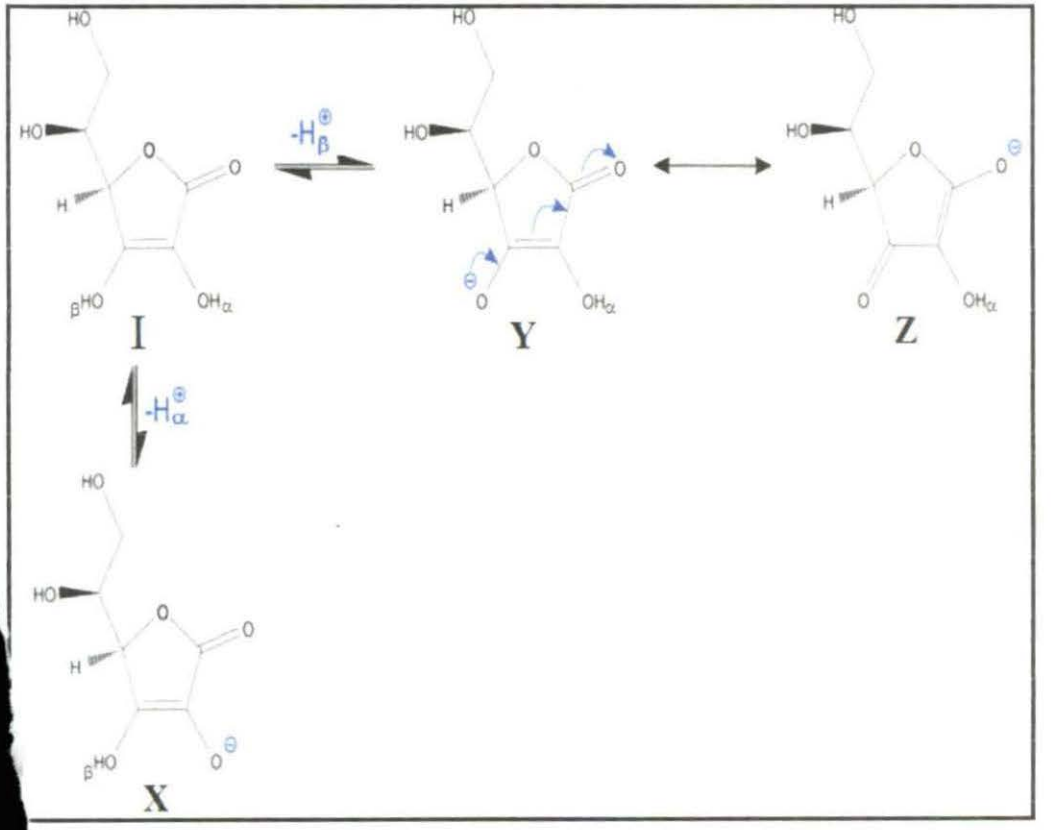


SCHEMES

Scheme 1. Keto-enol tautomerism of ascorbic acid.



Scheme 2. The stability of the conjugate base of ascorbate ion.



Scheme 3. Interaction between ascorbic acid and different amino acids.