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Acoustic, volumetric and visco metric studies of DL-alanine in aqueous galactose solution in the presence of sodium chloride at 298, 308 and 318 K

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ABSTRACT

Volumetric, viscometric and acoustic studies of DL-alanine in aqueous galactose solution in the presence of sodium chloride from 0.1035m -1.0345 m carried out at 298, 308 and 318 K temperature. Density (ρ), viscosity (η) and sound speed (u) have been measured by using precalibrated bicapillary pycnometer, Ostwald's viscometer and single frequency ultrasonic interferometer (2MHz frequency) respectively. The constancy of temperature was maintained by using refrigerated water bath using water circulating medium having an accuracy of $\pm 0.1^\circ\text{C}$. The experimental data was further used to compute various thermodynamic and acoustic parameters viz. apparent molal volume (ϕ_v), adiabatic compressibility (β), apparent molal compressibility (ϕ_k), relative association (R_A), intermolecular free length (L_f), acoustic impedance (Z), free volume (V_f), internal pressure (π_i), Rao's constant (R_M), Wada's constant (W), relaxation time (τ), hydration number (n_H), Gibbs free energy (ΔG), absorption coefficient (α/f^2) of the solution. Positive values of coefficient (B) suggest the structure making tendency.

Keywords: Acoustic, DL-alanine, viscometric

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INTRODUCTION

Ultrasonic measurement technique [1-3] is useful to study the nature and strength of intermolecular interactions in the mixed solvent. Present work provides the useful information regarding interaction of DL-alanine in aqueous galactose solution in the presence of sodium chloride. These interactions are useful to understand various biochemical reactions occurring in living organism. Sodium chloride salt has the significant role in the human body in various biological processes mainly in osmosis and blood pressure control. DL-alanine plays an important role in the glucose-alanine cycle between tissues and liver. Galactose is the key component of various dairy and bakery products, gum and sugar beets. When sound waves travel in different medium change in the wavelength of sound speed takes place due to the elastic properties and induced particles vibrations. Further the wavelength of sound wave is small and hence it exhibits some unique phenomena in addition to the properties of sound waves. The density and sound speed measure of certain dielectric liquids can be used to compute acoustical parameters like adiabatic compressibility, free length, acoustic impedance, Rao's constant, Wada's constant, hydration number which throw light on the exact nature of molecular interactions among the components of solution. A wide range of multi-component systems of organic solvents, aqueous, co-aqueous, biological molecules[4] and effect of salts can be studied by this technique to understand the nature of the system. Some other properties like apparent molar volume, Jones-Dole coefficient (A) and Falkenhagen coefficient (B) also provide significant information regarding solute-solute, solute-solvent interactions and structure making/breaking tendency of solute molecules in solvent.

MATERIALS AND METHODS

Experimental

Galactose and DL-alanine were obtained from Himedia Chemicals Ltd, India, NaCl from sd fine chemicals Ltd. (India). They were of purity greater than 99 percent and AR grade. The doubly distilled water was used to make the solution of galactose. The concentration of aqueous galactose was 0.01M and 0.2M of sodium chloride. The solutions were prepared on the basis of molarity (M) and then converted into molality using the expression,
$$C = \frac{dm}{1000} \frac{1000}{1000 + mM_2}$$

where, C is the molarity, d is density of the solution of galactose, m is molality and M_2 is the molecular weight of galactose.

The density measurement has been done from precalibrated bicapillary pycnometer[5, 6] having accuracy in the order of $\pm 0.06\%$. The viscosity of the solution was measured by using pre calibrated Ostwald's viscometer[7-9] with accuracy of $\pm 0.067\%$. The viscosity measurements are based on the measurement of flow time of the solutions taken for investigation. All the instruments and apparatus were calibrated with standard liquids benzene, hexane, cyclohexane, DMF and doubled distilled water before taking measurements. Sound speeds measurements were carried out using single frequency ultrasonic interferometer[10] (Model F-

81) at 2 MHz frequency having an accuracy within the order of $\pm 0.056\%$. The constancy of temperature is maintained by the thermostatically controlled water bath having PT-100 sensor with circulating water around the cell having an accuracy of $\pm 0.1^\circ\text{C}$. The weightings were done from Denver balance with accuracy of 0.1 mg.

RESULTS AND DISCUSSION

Table 1 Experimental value of density (ρ), viscosity (η) and sound speed (u) of DL-alanine+ aqueous galactose solution in the presence of NaCl at 298, 308 and 318 K temperature.

C/ mol.kg ⁻¹	$\rho/\text{kg.m}^{-3}$			$u/\text{m.s}^{-1}$			$\eta/10^{-3}\text{N.m}^{-2}.\text{s}$		
	298 K	308 K	318 K	298 K	308 K	318 K	298 K	308 K	318 K
0	988.6	984.8	981.3	1501.6	1525.2	1534.0	0.9094	0.7439	0.6135
0.1035	999.4	995.2	988.2	1509.2	1530.0	1541.6	0.9483	0.7719	0.6345
0.2069	1004.2	999.1	991.9	1512.0	1533.2	1545.2	0.9763	0.7950	0.6535
0.3104	1008.6	1003.4	995.4	1514.8	1536.0	1550.2	1.0060	0.8186	0.6725
0.4138	1012.4	1007.2	998.7	1518.4	1539.6	1556.0	1.0351	0.8418	0.6914
0.5173	1016.2	1010.6	1002.0	1522.8	1543.2	1561.0	1.0626	0.8648	0.7103
0.6207	1019.3	1013.4	1005.0	1528.0	1548.4	1569.6	1.0912	0.8873	0.7290
0.7242	1022.1	1016.8	1007.9	1534.0	1553.6	1577.6	1.1197	0.9105	0.7478
0.8276	1024.1	1019.2	1010.6	1541.6	1558.0	1586.0	1.1445	0.9327	0.7663
0.9311	1026.3	1021.8	1012.8	1549.2	1564.0	1593.4	1.1733	0.9552	0.7846
1.0345	1028.4	1023.8	1014.9	1556.8	1570.0	1602.0	1.2012	0.9772	0.8057

The experimental values of density (ρ), sound speed and viscosity (η) are summarised in table-1. The density and speed of sound for DL-alanine in aqueous galactose + NaCl system increase may be due to the cohesive forces and thus molecular association is responsible for the observed values. When amino acids are dissolved in water it tends to exist as zwitter ions. The hydration behaviour of amino acids depends upon the various factors like covalent bonding, ionic bonding, H-bond, Vander Waal's forces and Electrostatic forces. The water molecules remains attached from zwitter ions [11, 12] which create a greater cohesion in the atmosphere. Cohesive forces increase with rise in concentration of amino acid. These forces play an important role to understand volume changes in mixed solvent system. Viscosity of the solution increase with rise in concentration of DL-alanine may be due to the solute-solvent interaction. The viscosity decrease with rise in temperature may be due to the increase in movement of molecules and ions presents in the solutions.

The apparent molar volume of DL-alanine in aqueous galactose solution in the presence of sodium chloride systems as a function of concentration at 298, 308 and 318K has been determined using following equation:

$$\phi_v = \frac{1000(\rho_o - \rho)}{C\rho\rho_o} + \frac{M}{\rho_o} \dots\dots\dots(1)$$

where ρ and ρ_o are the density of solution and solvent respectively, C is the concentration and M is molar mass of solute. The plots of ϕ_v and $C^{1/2}$ are linear with the Masson's equation.

$$\phi_v = \phi_v^0 + S_v \sqrt{C} \quad \dots\dots\dots(2)$$

where limiting partial molar volume ϕ_v^0 was obtained from the intercepts of linear plot of ϕ_v vs. \sqrt{C} using the least square method and S_v is the experimental slope.

Table 2 Derived acoustic and volumetric parameters of DL-alanine+ aqueous galactose solution in the presence of NaCl at 298, 308 and 318 K temperatures

C /mol.kg ⁻¹	β /10 ⁻¹⁰ m ² N ⁻¹	ϕ_v /10 ⁻⁶ m ³ /mol	ϕ_k /10 ⁻¹¹ m ² N ⁻¹	Z /10 ⁶ Kg m ⁻² s ⁻¹	L _f /A ^o	τ /10 ⁻¹² s
298 K						
0	4.4861	-	-	1.4845	0.4355	0.5439
0.1035	4.3931	33.4764	-0.4312	1.5083	0.4310	0.5555
0.2069	4.3559	35.4823	-0.4635	1.5184	0.4292	0.5670
0.3104	4.3209	37.3969	-0.4745	1.5278	0.4274	0.5796
0.4138	4.2843	39.5968	-0.4795	1.5372	0.4256	0.5913
0.5173	4.2436	41.1141	-0.4880	1.5475	0.4236	0.6012
0.6207	4.2020	43.0736	-0.4917	1.5575	0.4215	0.6114
0.7242	4.1577	44.8914	-0.4956	1.5679	0.4193	0.6207
0.8276	4.1088	47.1131	-0.4999	1.5788	0.4168	0.6270
0.9311	4.0599	48.7244	-0.5039	1.5899	0.4143	0.6351
1.0345	4.0121	50.1281	-0.5058	1.6010	0.4119	0.6426
308 K						
0	4.3651	-	-	1.5020	0.4374	0.4330
0.1035	4.2925	34.7963	-0.312	1.5227	0.4338	0.4418
0.2069	4.2579	38.7091	-0.3583	1.5318	0.4320	0.4514
0.3104	4.2242	40.1794	-0.3868	1.5412	0.4303	0.4611
0.4138	4.1886	41.9266	-0.4048	1.5507	0.4285	0.4701
0.5173	4.1551	43.6922	-0.4120	1.5596	0.4268	0.4791
0.6207	4.1158	45.7240	-0.4210	1.5691	0.4248	0.4869
0.7242	4.0746	46.5962	-0.4323	1.5797	0.4226	0.4946
0.8276	4.0421	48.2676	-0.4290	1.5879	0.4209	0.5027
0.9311	4.0009	49.4237	-0.4342	1.5981	0.4188	0.5096
1.0345	3.9626	50.8703	-0.4343	1.6074	0.4168	0.5163
318 K						
0	4.3306	-	-	1.5053	0.4435	0.3542
0.1035	4.2581	46.5496	-0.3355	1.5234	0.4398	0.3602
0.2069	4.2224	48.0501	-0.3772	1.5327	0.4379	0.3679
0.3104	4.1805	49.2780	-0.4121	1.5431	0.4358	0.3749
0.4138	4.1357	50.3721	-0.438	1.5540	0.4334	0.3812
0.5173	4.0957	51.1010	-0.4493	1.5641	0.4313	0.3879
0.6207	4.0388	51.9852	-0.4762	1.5774	0.4283	0.3926
0.7242	3.9865	52.7482	-0.4915	1.5901	0.4255	0.3975
0.8276	3.9338	53.5303	-0.5029	1.6028	0.4227	0.4020
0.9311	3.8889	54.6097	-0.5035	1.6138	0.4203	0.4068
1.0345	3.8393	55.5719	-0.5073	1.6259	0.4176	0.4124

The positive values of apparent molal volume at different temperatures are given in table 2. The positive values of ϕ_v indicate greater solute-solvent interactions.

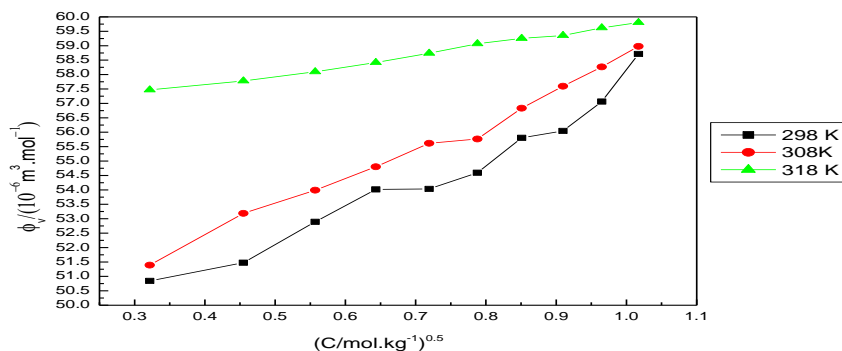


Figure 1 Variation of apparent molal volume (ϕ_v) with concentration ($C^{1/2}$) at 298, 308 and 318 K temperature

Figure 1 shows that ϕ_v values decrease with increase in concentration of solute due to the electrostriction effect.[13] Apparent molal volumes values increase with rise in concentration of DL-alanine. The positive values of ϕ_v^o indicate the presence of strong solute-solvent interactions. The negative values of S_v suggest a weaker solute-solute interactions.

Adiabatic compressibility (β) is given by the relation,

$$\beta = \frac{1}{u^2 \rho} \tag{3}$$

Apparent Molal Compressibility (ϕ_k) has been calculated using the relation as:

$$\phi_k = \frac{1000(\rho_o \beta - \rho \beta_o)}{C \rho \rho_o} + \frac{\beta_o M}{\rho_o} \tag{4}$$

where β , β_o , ρ and ρ_o are the adiabatic compressibility and density of solution and solvent respectively. M is the molar mass of solutes.

$$\phi_k = \phi_k^o + S_k \sqrt{C} \tag{5}$$

ϕ_k is the linear function of concentration and gives values of partial molar compressibility ϕ_k^o and experimental slope S_k .

The values of adiabatic compressibility (β) decrease with concentration due to the influence of the electrostatic field of the ions on the surrounding water molecules and the total internal pressure increases and solution becomes harder to compress. As the temperature increases system becomes less compressible [14, 15].

The derived acoustic parameters like apparent molal volume (Φ_v), apparent molal compressibility (Φ_k), acoustic impedance (Z), intermolecular free length (L_f), and acoustical relaxation time (τ) are given in Table-2.

Specific Acoustic Impedance (Z) is the product of density (ρ) and sound speed (u) and can be estimated as:

$$Z = u\rho \dots\dots\dots(6)$$

Acoustic impedance is the complex ratio of effective sound pressure at a point to the effective particle velocity at that point. Acoustic impedance increase with increasing concentration of solute and temperature indicates that molecular interactions are associative in the nature.[16]

Intermolecular free length (L_f) is obtained using the equation:

$$L_f = K_T \sqrt{\beta} \dots\dots\dots(7)$$

where K_T is Jacobson and it is temperature dependence constant and is given by $(K=93.875+0.375T)\times 10^{-8}$

The intermolecular free length decreases with increase in the solute concentration suggest that there is a significant interaction between solute and solvent molecules, suggesting a structure promoting behaviour on the addition of solute. These results are also supported by the viscosity data. As the temperature increases it leads to the less ordered structure and more spacing between the molecules due to increase in the thermal energy of the system[17], which causes increase in volume expansion and hence, increase in intermolecular free length.

Acoustic relaxation time (τ) is calculated using the following relation:

$$\tau = \left(\frac{4\eta}{3\rho u^2} \right) \dots\dots\dots(8)$$

Acoustical relaxation time indicates the presence of interactions by addition of amino acid.

Table 3 Derived acoustic parameters of DL-alanine+ aqueous galactose solution in the presence of NaCl at 298, 308 and 318 K temperatures

C/ mol.kg ⁻¹	V _f /10 ⁻⁸ m ³ mol ⁻¹	π / 10 ⁹ Nm ⁻²	n _H	(α/f^2)/ 10 ⁻¹⁵	ΔG / 10 ⁻²¹ J.mol ⁻¹	R _M / 10 ⁻⁴ m ⁵ N ⁻¹	W/ 10 ⁻⁴ m ⁴ S ⁻¹
298 K							
0	2.6894	2.0140	-	7.1561	5.0034	2.6950	5.0951
0.1035	2.5640	2.0542	3.3942	7.271	5.0897	2.6840	5.0809
0.2069	2.4799	2.0768	3.6602	7.4086	5.1745	2.6862	5.0883
0.3104	2.3956	2.1000	3.7682	7.5581	5.2642	2.6896	5.0973
0.4138	2.3204	2.1208	3.8718	7.6932	5.3468	2.6949	5.1096
0.5173	2.2574	2.1387	4.0151	7.7994	5.4151	2.7006	5.1224
0.6207	2.1961	2.1558	4.1376	7.9043	5.4841	2.7086	5.1390
0.7242	2.1408	2.1712	4.2672	7.9936	5.5464	2.7178	5.1575
0.8276	2.102	2.1804	4.4273	8.0347	5.5878	2.7299	5.1808
0.9311	2.0545	2.1933	4.5584	8.0992	5.6409	2.7415	5.2032
1.0345	2.0123	2.2046	4.6557	8.1539	5.6887	2.7533	5.2259
308 K							

0	3.7207	1.8633	-	5.6082	4.3420	2.7195	5.1348
0.1035	3.5639	1.8971	2.5335	5.7042	4.4275	2.7076	5.1193
0.2069	3.4460	1.9171	2.9665	5.8158	4.5187	2.7125	5.1309
0.3104	3.3323	1.9377	3.2043	5.9298	4.6090	2.7161	5.1403
0.4138	3.2304	1.9564	3.4019	6.0326	4.6920	2.7214	5.1526
0.5173	3.1363	1.9737	3.5070	6.1333	4.7722	2.7276	5.1663
0.6207	3.0552	1.9883	3.6740	6.2126	4.8412	2.7364	5.1842
0.7242	2.9758	2.0038	3.8300	6.2896	4.9077	2.7435	5.1994
0.8276	2.9027	2.0172	3.8481	6.3740	4.9764	2.7528	5.2179
0.9311	2.8371	2.0297	3.9598	6.4365	5.0343	2.7624	5.2370
1.0345	2.7772	2.0404	4.0233	6.4968	5.0901	2.7735	5.2587
318 K							
0	5.0114	1.7379	-	4.5619	3.7422	2.7345	5.1590
0.1035	4.8367	1.7608	2.9982	4.6162	3.8159	2.7337	5.1615
0.2069	4.6781	1.7790	3.3532	4.7041	3.9088	2.7393	5.1743
0.3104	4.5372	1.7954	3.7228	4.7771	3.9906	2.7463	5.1893
0.4138	4.4098	1.8106	4.0287	4.8404	4.0647	2.7542	5.2059
0.5173	4.2865	1.8258	4.1615	4.9089	4.1405	2.7616	5.2214
0.6207	4.1869	1.8379	4.5225	4.9413	4.1935	2.7718	5.2417
0.7242	4.0911	1.8497	4.7415	4.9770	4.2474	2.7820	5.2617
0.8276	4.0032	1.8606	4.9203	5.0067	4.2968	2.7927	5.2827
0.9311	3.9193	1.8705	4.9794	5.0438	4.3497	2.8043	5.3050
1.0345	3.8239	1.8827	5.0770	5.0859	4.4097	2.8167	5.3288

Table-3 show the values of derived acoustic parameters free volume, internal pressure, hydration number, absorption coefficient, Gibb’s free energy, Rao’s constant and Wada’s constant.

Gibbs free energy is calculated from acoustic relaxation time (τ) following Eyring rate process theory:

$$\Delta G = RT \ln \left(\frac{kT\tau}{h} \right) \dots\dots\dots(9)$$

where R is the gas constant, k is the Boltzmann’s constant ($1.23 \times 10^{-23} \text{ J.K}^{-1}$), T is absolute temperature, h is Planck’s constant ($6.62 \times 10^{-34} \text{ J.s}$) and τ is the relaxation time.

The Gibb’s free energy reveals closer packing of the molecules due to the H-bonding of unlike molecules in the solutions. The Gibb’s free energy [ΔG] decreases with temperature rise suggest that less time is required for the cooperative process or the rearrangement of molecules in the solution decreases the energy that leads dissociation.

Suryanarayana calculated the internal pressure from the free volume concept on the basis of statistical thermodynamics as,

$$\pi_i = bRT \left(\frac{K\eta}{u} \right)^{\frac{1}{2}} \frac{\rho^{\frac{2}{3}}}{M_{eff}^{\frac{7}{6}}} \dots\dots\dots(10)$$

Where b is the space packing factor generally 2 for liquids, R is the gas constant, T is absolute temperature and K is a constant equal to 4.28×10^9 , independent of temperature for all type of liquids. M_{eff} is the effective molecular weight. .

$$M_{eff} = \frac{\sum x_i M_i}{\sum x_i} \quad \text{Where } x_i \text{ and } M_i \text{ mole fraction and molar mass of it components.}$$

Internal pressure decreases with rise in temperature because of the thermal agitation of ions from each other due to increasing thermal energy, which reduces the possibility for interactions and reduces the cohesive forces and ultimately leads to a decrease in the internal pressure. [19]

Molar sound speed or Rao’s constant (R_M) can be calculated using the following relation:

$$R_M = \frac{M}{\rho} (u)^{\frac{1}{3}} \quad \dots\dots\dots (11)$$

Molar compressibility or Wada’s constant (W)

$$W = \frac{M_{eff}}{\rho} \beta^{-\frac{1}{7}} \quad \dots\dots\dots (12)$$

Rao’s constant or molar sound velocity shows increase with increase in concentration and temperature. The increasing trends of molar sound velocity and Wada’s constant or molar compressibility with concentration suggest the availability of more number of components in a given region thus leads to a close packing of the medium and thereby increase the interactions.[20, 21]

Free volume calculated from sound speed (u) and viscosity (η) of solutions using Suryanarayana relation,

$$V_f = \left(\frac{M_{eff} u}{K \eta} \right)^{\frac{3}{2}} \quad \dots\dots\dots (13)$$

Free volume is a free space in which the core molecules can move inside the solution due to the repulsion of neighbouring molecules. The decrease in free volume with rise in concentration and increase with temperature also confirm the ion-solvent interactions.[22]

Hydration number (n_H) was calculated by the following relation:

$$n_H = \frac{n_1}{n_2} \left(1 - \frac{\beta}{\beta_o} \right) \quad \dots\dots\dots(14)$$

where n_1 and n_2 are the number of moles of solvent and solute presenting the solution respectively, β and β_o are the adiabatic compressibility of the solution and solvent respectively.

The hydration number is the number of water molecules rigidly bound to the ions. The positive values of hydration number [23] reveal that there is a significant interactions between solute and solvent molecules due to which structural arrangement in the surrounding is affected. In the present study hydration number shows increase with concentration. It also suggest that hydration sphere of solute-solvent interaction is more intensive than solvent-solvent interactions. Water molecules are bonded more tightly in the presence of Na⁺ ions than pure water molecules, so net positive hydration enhances the structure of solution than pure water.

The NaCl works as structure maker in the solvent system.

Absorption coefficient (α/f^2) is calculated from the following equation:

$$\alpha = \frac{\omega^2 \tau}{2u} \quad \text{where } \omega = 2\pi f$$

$$\frac{\alpha}{f^2} = \frac{4\pi^2 \tau}{2u} \quad \dots\dots\dots(15)$$

where τ is acoustical relaxation time, f is frequency and u is speed of sound

The values of absorption coefficient decreases with rise in the temperature and increases with increase in the concentration also indicate that interaction decreases with temperature but increases with rise in concentration.[24]

The relative viscosity were measured at 298, 308 and 318 K and analysed by the Jones – Dole equation:

$$\frac{\eta}{\eta_o} = \eta_{rel} = 1 + A\sqrt{C} + BC \quad \dots\dots\dots(16)$$

where η and η_o are the viscosities of the solution and solvent respectively, A is Falkenhagen coefficient and B is Jones-Doles coefficient.

Table 4 Limiting apparent molal volume (ϕ_v^o), experimental slope (S_v), Jones-Dole coefficient (A), Falkenhagen coefficient (B), apparent molal compressibility (ϕ_k^o) and experimental slope (S_k) of DL-alanine in aqueous galactose solution in the presence of NaCl at 298, 308 and 318 K temperatures

Parameters	298 K	308 K	318 K
$\phi_v^o / (10^{-6} \text{ m}^3 \cdot \text{mol}^{-1})$	15.7613	20.2384	37.9809
$S_v / (10^{-6} \text{ m}^3 \text{ lt}^{1/2} \text{ mol}^{-3/2})$	30.5157	27.5517	15.5237
$\phi_k^o / (10^{-10} \text{ m}^2 \text{ N}^{-1})$	-0.3833	-0.2299	-0.1806
$S_k / (10^{-10} \text{ N}^{-1} \text{ m}^{-1} \text{ mol}^{-1})$	-0.1159	-0.1999	-0.3114
$A / (\text{dm}^{3/2} \text{ mol}^{-1/2})$	-0.1250	-0.1372	-0.1472
$B / (\text{dm}^3 \text{ mol}^{-1})$	0.3750	0.3806	0.3866

Table-4 shows the values limiting apparent molal volume (ϕ_v^o), experimental slope (S_v), limiting apparent molal compressibility (ϕ_k^o), experimental slope (S_k), Jones-Dole coefficient (A) and Falkenhagen coefficient (B). Values of constant A and B calculated from the plot between $(\eta_r-1/C^{1/2})$ and $C^{1/2}$. The Jones-Dole coefficient [25] (A) values was observed negative which indicate that solute-solute interactions are relatively weak in this system. Falkenhagen coefficient-B is highly sensitive to the nature of solute-solvent interactions. It is found to be positive and increases with rise in temperature from 298 to 318 K that suggest structure making solute possess in definite solvent. [26]

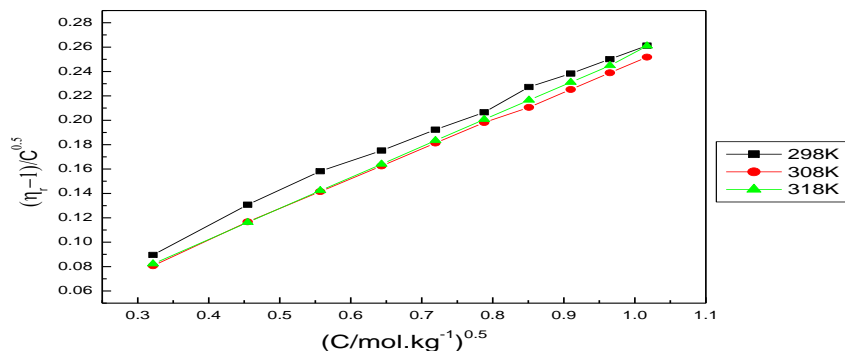


Figure 2 Variation of $(\eta_r-1)/C^{1/2}$ with concentration ($C^{1/2}$) of DL-alanine at 298, 308 and 318 K temperature

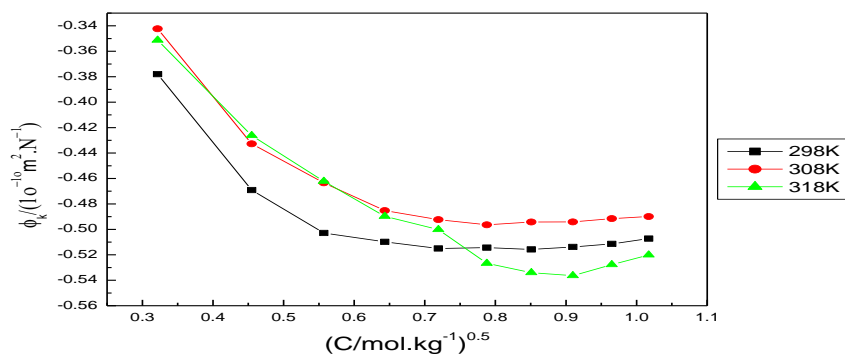


Figure 3 Variation of apparent molal compressibility (ϕ_k) with concentration ($C^{1/2}$) of DL-alanine at 298, 308 and 318 K temperature

Figure-3. Show that values of apparent molal compressibility (ϕ_k) decreases with increase in concentration. The limiting apparent molal compressibility ϕ_k^o is negative for 298K temperature but became positive as the temperature increase which show solute-solvent interactions increases with rise in temperature. The magnitude of compressibility depends upon electrostriction and throws a light on hydrophobic-hydrophilic interactions in solution. The negative values indicate hydrophobic interactions and loss of structural compressibility [27] due to increased population of H-bonded water molecules. The negative values of S_k indicates weak solute-solute interactions.



CONCLUSION

Solute-solvent interactions are dominating over the solute-solute interactions [28] over the whole concentration range and each temperature. Positive B-coefficient value indicates structure making effect.

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