

Research Article

Studies of Interactions of Aqueous Glycine/L-Proline with Triethylene Glycol Monobutyl Ether (TEGMBE) System at 313.15 K and at Various Concentrations

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Abstract

The thermo physical parameters viz. density (ρ), viscosity (η), and ultrasonic velocity (u) have been measured for aqueous amino acid and glycol ether system at 0.1 to 1 mole fractions and at 313.15 K. Physical parameters viz. acoustical impedance (z), adiabatic compressibility (β), relaxation time (τ), Rao's constant (R), Wada's constant (W), free volume (V_f), molar volume (V_m), intermolecular free length (L_f), relaxation strength (r), surface tension (σ), apparent molar volume (ϕ_v), classical absorption coefficient (α/f^2)Cl, internal pressure (π_i), excess volume (V^E) by using following standard relation have been obtained from experimental data which show intermolecular interaction. Thus it is clear from the above measured and calculated thermodynamic parameters that there is a weak association between present systems showing hydrophobic nature.

Keywords: Acoustical impedance, Adiabatic compressibility, Relaxation time, Intermolecular free length.

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Introduction

The thermo physical parameters are very easy tool for understanding and correlation of result. These results predict direct correlation of physical parameters of liquid system. The study of acoustic velocity is found to be useful in measuring no. of physicochemical parameters [1-4]. From a long time researcher interested in studies of solubility and stability of complex molecules like proteins but because of complex nature of molecules, simple molecules are more favourable[5]. Hence the physical properties of amino acids in aqueous solution have been studied to understand solute solvent interaction and their role in the stability of proteins [6]. The random coil, unfolded, forms of denatured proteins these studies in the form of thermodynamic stability of protein [7-8]. To study volumetric and compressibility parameter of amino acids in aqueous salt system shows molecular interactions [9-22]. The amino acid like l-proline shows solute solvent interactions [23]. The data of density of l-serine, l-alanine and glycine in aqueous glucose solutions discussed by Li et al [24]. The data of the ultrasonic velocity of glycine, DL-alanine, diglycine and triglycine in aqueous solution of glucose discussed by Banipal et al [25]. To study of the molecular interactions of ions and proteins are useful in the separation and purification processes and to understand the physiological systems [26-30]. In proteins the amino acids are building blocks compounds. Their studies provide important information about nature of larger bio-molecules. The proteins as amino acids play an important role in metabolism and neurochemical mechanisms such as, reflex action, pain transmission, hormones mechanism [31-32]. They have many applications in pharmaceutical industries and also used as food additives. To study the effect of temperature and concentration of salt on the thermodynamic properties of amino acids have been proved by researcher to useful in elucidating the various interactions [33-41]. The thermo physical parameter shows the molecular interactions of

aqueous glycine. This research useful to understand the characteristics of biological molecules [42]. The electrolyte in aqueous solution has been studied under thermo dynamical property [43-44].

Experimental

Source and Purity of Sample

All the chemicals are analytical reagent (AR) and spectroscopic reagent (SR) grades from E-Merck, Germany, AVRA chemicals India. The purities of the above chemicals were checked by density determination at 313.15 K.

Method

The liquid mixtures of different known compositions were prepared in stoppard volumetric flasks. The density, viscosity and ultrasonic velocity values were measured as a function of composition of the liquid mixture of amino acid with glycol ether at 313.15 K. The density was determined using a Bi-capillary pycnometer. The weight of the sample measured using electronic digital balance with an accuracy of ± 0.1 mg (Model: Shimadzu AX-200). An Ubbelohde viscometer (20ml) was to use for the viscosity measurement and efflux time determined with digital clock ± 0.01 s. An ultrasonic interferometer having the frequency of 3 MHz (Mittal Enterprises, New Delhi, Model: F-05) with an overall accuracy of $\pm 0.1\%$ was used for velocity measurement. An electronically digital operating constant temperature bath (RAAGA Industries) was used to circulate water through the double walled measuring cell made up of steel containing the experimental solution at the desired temperature with an accuracy of ± 0.01 K [45].

Theory and Calculation

The present measured values of density (ρ), ultrasonic velocity (u) and viscosity (η). We were calculated the physical parameters viz. acoustical impedance (z), adiabatic compressibility (β), relaxation time (τ), Rao's constant (R), Wada's constant (W), free volume (V_f), molar volume (V_m), intermolecular free length (L_f), relaxation strength (r), surface tension (σ), apparent molar volume (ϕ_v), classical absorption coefficient ($(\alpha/f^2)Cl$), internal pressure (π_i), excess volume (V^E) by using following standard relation[45].

$$1) z = \rho u$$

$$2) \beta = 1/u^2 \rho$$

$$3) \tau = 4/3 \eta \beta$$

$$4) R = u^{1/3} v$$

$$5) W = \beta^{1/7} v$$

$$6) V_f = M_{\text{eff}} u / K \eta$$

($K=4.28 \times 10^9$ is a temperature independent constant) (M_{eff} —effective molecular wt. of solution. $M_{\text{eff}} = x_1 M_1 + x_2 M_2 + x_3 M_3$. Where $x_1, x_2, x_3, M_1, M_2, M_3$) are mole fractions and molar masses of the pure components 1, 2 and 3.)

$$7) V_m = M_{\text{eff}} / \rho$$

$$8) L_f = K_j \beta^{1/2}$$

($K_j = 6.0816 \times 10^4$) (K_j is Jacobson's constant which is temperature dependent constant but independent of the nature of the liquid.)

$$9) r = 1 - (U/U_\infty)^2 \quad \text{where, } U_\infty = 1.6 \times 10^5$$

$$10) \sigma = \rho u^{3/2} \times 6.4 \times 10^{-4}$$

$$11) \phi_v = \frac{M}{\rho} + \frac{(\rho - \rho_0) 1000}{m \rho \rho_0}$$

$$12) (\alpha/f^2)Cl = \frac{8\pi^2 \eta}{3\rho u^2} \quad (\pi = 8.3142)$$

$$13) \pi_i = bRT \left(\frac{K\eta}{u} \right)^{1/2} \left(\frac{\rho^{2/3}}{M^{7/6}} \right)$$

(Where, b stands for cubic packing which is assumed to be 2 for liquids, R -gas constant $8.3143 \text{ JK}^{-1} \text{ mol}^{-1}$, K -dimensionless constant independent of temperature and nature of liquids and its value is 4.28×10^9 , T is absolute temperature, M is effective molecular wt., K -Boltzmann's constant, h -Plank's constant.)

$$14) V^E = ((x_1M_1+x_2M_2+x_3M_3)/\rho) - (x_1M_1/\rho_1) - (x_2M_2/\rho_2) - (x_3M_3/\rho_3)$$

(Where $x_1, x_2, x_3, M_1, M_2, M_3, \rho_1, \rho_2, \rho_3$ are mole fractions, molar masses and densities of pure components 1,2 and 3 respectively.)

Table 1 Aqueous Glycine and Triethylene glycol monobutyl ether (TEGMBE) system at 313.15 K

x_1	x_2	x_3	x	ρ kgm^{-3}	η $(\times 10^{-3})$ Nsm^{-2}	u ms^{-1}	z $(\times 10^6)$ $\text{kg m}^{-2}\text{s}^{-1}$	β $(\times 10^{-10})$ $\text{N}^{-1} \text{m}^2$
0.9823	0.0177	00000	00000	990.5	0.8896	1475.1	1.4610	4.6398
0.9730	0.0175	0.0094	0.1006	988.0	0.8818	1468.4	1.4508	4.6941
0.9615	0.0173	0.0212	0.2032	983.3	0.8658	1456.0	1.4317	4.7972
0.9478	0.0171	0.0351	0.3004	981.0	0.8481	1450.6	1.4230	4.8444
0.9280	0.0167	0.0553	0.4102	978.1	0.8356	1431.2	1.3999	4.9913
0.9051	0.0163	0.0786	0.5009	975.4	0.8234	1428.0	1.3929	5.0276
0.8710	0.0157	0.1134	0.6024	973.0	0.8117	1405.3	1.3674	5.2041
0.8210	0.0148	0.1642	0.7060	971.2	0.7992	1398.1	1.3578	5.2676
0.7335	0.0132	0.2533	0.8055	967.6	0.7935	1389.7	1.3447	5.3513
0.5570	0.0100	0.4330	0.9090	966.1	0.7804	1373.2	1.3266	5.4892
		1.0000	1.0002	963.4	0.7710	1366.5	1.3165	5.5587

Where, mole fraction of water (x_1), mole fraction of glycine (x_2), mole fraction of triethylene glycol monobutyl ether (x_3), mole fraction of aqueous glycine with triethylene glycol monobutyl ether system (x), density (ρ), viscosity (η), ultrasonic velocity (u), acoustical impedance (z), adiabatic compressibility (β).

Table-1 (continued...)

τ $(\times 10^{-13})$ s	$R(\times 10^3)$ $\text{ms}^{-1} \text{mol}^{-1}$	W $\text{m}^3 \text{mol}^{-1}$	V_f $\text{m}^3 \text{mol}^{-1}$	V_m $\text{cm}^3 \text{mol}^{-1}$	L_f A°	r 0.999915003	σ $(\times 10^4)$ Nm^{-1}
5.5035	1.0595	4.3197	0.00685	0.0940	1.3100	0.999915003	3.5353

5.5190	3.4025	13.9170	0.03975	0.3030	1.3176	0.999915773	3.5024
5.5379	3.3929	13.9602	0.04034	0.3044	1.3320	0.999917190	3.4417
5.4780	3.3887	13.9797	0.04138	0.3051	1.3386	0.999917803	3.4145
5.5610	3.3735	14.0395	0.04146	0.3061	1.3587	0.999919987	3.3364
5.5196	3.3710	14.0541	0.04225	0.3069	1.3636	0.999920344	3.3160
5.6323	3.3530	14.1235	0.04214	0.3077	1.3874	0.999922857	3.2293
5.6132	3.3473	14.1480	0.04280	0.3082	1.3958	0.999923645	3.1986
5.6617	3.3406	14.1799	0.04287	0.3094	1.4069	0.99992456	3.1580
5.7117	3.3273	14.2315	0.04317	0.3099	1.4249	0.999926341	3.0972
5.7144	3.3219	14.2571	0.04364	0.3107	1.4339	0.999927058	3.0659

Relaxation time (τ), Rao's constant (R), Wada's constant (W), free volume (V_f), molar volume (V_m), intermolecular free length (L_f), relaxation strength (r), surface tension (σ).

Table-1 (continued)...

ϕ_v	$(\alpha/f_2)Cl$ ($\times 10^{-11}$)	π_i ($\times 10^4$) Nm^{-2}	$\eta \cdot 1/\sqrt{C}$	\sqrt{C}	V^E
0.0743	1.08524	13.2696	0000000000	0000000000	-18.99094653
0.3934	1.08831	5.9992	-3.150053137	0.317175031	-20.74697666
0.2774	1.09204	5.9509	-2.21647059	0.450777107	-22.95828479
0.2480	1.08022	5.8915	-1.822978532	0.548087584	-25.56310313
0.2312	1.09659	5.8758	-1.560052177	0.640468578	-29.34229126
0.2225	1.08843	5.8285	-1.411779069	0.707742891	-33.7049603
0.2169	1.11064	5.8239	-1.287374369	0.776144316	-40.2225586
0.2139	1.10687	5.7866	-1.189187738	0.840238062	-49.73098732
0.2097	1.11644	5.7691	-1.113326325	0.897496518	-66.41005982
0.2087	1.12630	5.7496	-1.048042761	0.953414915	-100.0506821
0.2068	1.12683	5.7181	-0.999129092	1.000099995	-

Apparent molar volume (ϕ_v), classical absorption coefficient $(\alpha/f_2)Cl$, internal pressure (π_i), Excess molar volume (V^E).

Table 2 Aqueous L-Proline and Triethylene glycol monobutyl ether (TEGMBE) system at 313.15 K

x_1	x_2	x_3	x	ρ kgm^{-3}	η $(\times 10^{-3})$ Nsm^{-2}	u ms^{-1}	z $(\times 10^6)$ $\text{kg m}^{-2}\text{s}^{-1}$	β $(\times 10^{-10})$ $\text{N}^{-1} \text{m}^2$
0.9884	0.0116	-	0.0000	1021.0	0.8914	1553.2	1.5858	4.0599
0.9790	0.0115	0.0095	0.1007	1016.1	0.8778	1539.4	1.5642	4.1530
0.9672	0.0114	0.0215	0.2049	1010.6	0.8596	1527.1	1.5433	4.2431
0.9532	0.0112	0.0356	0.3004	1000.0	0.8539	1506.0	1.5060	4.4091
0.9344	0.0110	0.0546	0.4035	994.5	0.8407	1485.3	1.4771	4.5579
0.9100	0.0107	0.0793	0.5048	989.1	0.8305	1451.5	1.4357	4.7987
0.8770	0.0103	0.1127	0.6014	985.0	0.8235	1437.0	1.4154	4.9164
0.8222	0.0097	0.1681	0.7068	976.3	0.8146	1425.1	1.3913	5.0434
0.7384	0.0087	0.2530	0.8010	971.5	0.7991	1403.3	1.3633	5.2270
0.5559	0.0065	0.4375	0.9055	969.1	0.7880	1387.2	1.3443	5.3623
-	-	1.0000	1.0021	967.4	0.7772	1364.1	1.3196	5.5552

Where, mole fraction of water (x_1), mole fraction of l-proline (x_2), mole fraction of triethylene glycol monobutyl ether (x_3), mole fraction of aqueous l-proline with triethylene glycol monobutyl ether system (x), density (ρ), viscosity (η), ultrasonic velocity (u), acoustical impedance (z), adiabatic compressibility (β).

Table-2 (continued)...

$\tau (\times 10^{-13})$ s	$R (\times 10^3)$ $\text{ms}^{-1} \text{mol}^{-1}$	W $\text{m}^3 \text{mol}^{-1}$	V_f $\text{m}^3 \text{mol}^{-1}$	V_m $\text{cm}^3 \text{mol}^{-1}$	L_f A°	r	$\sigma (\times 10^4)$ Nm^{-1}
4.8254	1.5418	6.0623	0.01262	0.1304	1.2254	0.999905764	3.9374
4.8607	3.9190	15.5057	0.05186	0.3340	1.2394	0.999907432	3.8664
4.8632	3.9085	15.5533	0.05288	0.3358	1.2527	0.999908905	3.7995
5.0199	3.8904	15.6388	0.05231	0.3394	1.2770	0.999911405	3.6820
5.1091	3.8725	15.7131	0.05244	0.3413	1.2984	0.999913824	3.5865
5.3138	3.8429	15.8291	0.05160	0.3432	1.3322	0.999917701	3.4459
5.3982	3.8301	15.8840	0.05148	0.3446	1.3485	0.999919337	3.3804
5.4778	3.8195	15.9420	0.05167	0.3476	1.3658	0.999920668	3.3090

5.5692	3.7999	16.0236	0.05197	0.3494	1.3904	0.999923076	3.2174
5.6340	3.7853	16.0822	0.05216	0.3502	1.4083	0.999924831	3.1544
5.7567	3.7642	16.1636	0.05193	0.3508	1.4334	0.999927314	3.0705

Relaxation time (τ), Rao's constant (R), Wada's constant (W), free volume (V_f), molar volume (V_m), intermolecular free length (L_f), relaxation strength (r), surface tension (σ).

Table-2 (continued)...

ϕ_v	$(\alpha/f_2)Cl$ ($\times 10^{-11}$)	π_i ($\times 10^4$) Nm^{-2}	$\eta - 1/\sqrt{C}$	\sqrt{C}	V^E
0.1414	0.9515	8.6996	0000000000	0000000000	-19.10797469
0.7078	0.9585	4.7290	-3.148501276	0.317332633	-20.8862978
0.4260	0.9590	4.6816	-2.207270407	0.452658812	-23.13695751
0.3227	0.9899	4.6657	-1.82296795	0.548087584	-25.76946814
0.2804	1.0074	4.6445	-1.572942929	0.635216499	-29.32615486
0.2560	1.0478	4.6528	-1.406304918	0.710492787	-33.94598859
0.2423	1.0645	4.6436	-1.288429023	0.775499839	-40.19365877
0.2264	1.0802	4.6103	-1.188496232	0.840713982	-50.56262504
0.2194	1.0982	4.5865	-1.116443009	0.894986033	-66.44714336
0.2163	1.1110	4.5733	-1.050058304	0.951577637	-100.9565967
0.2145	1.1352	4.5748	-0.998175266	1.001049449

Apparent molar volume (ϕ_v), classical absorption coefficient $(\alpha/f_2)Cl$, internal pressure (π_i), Excess molar volume (V^E).

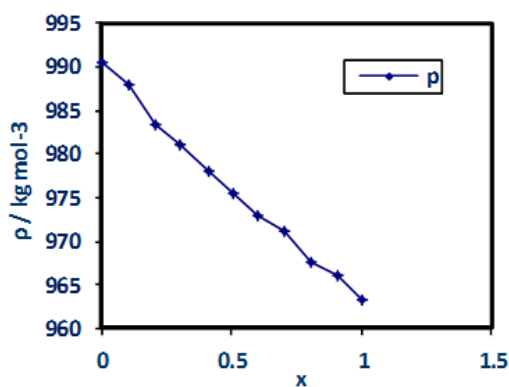


Figure 1 Mole fraction (x) Vs Density (ρ) at 313.15K aqueous glycine and TEGMBE

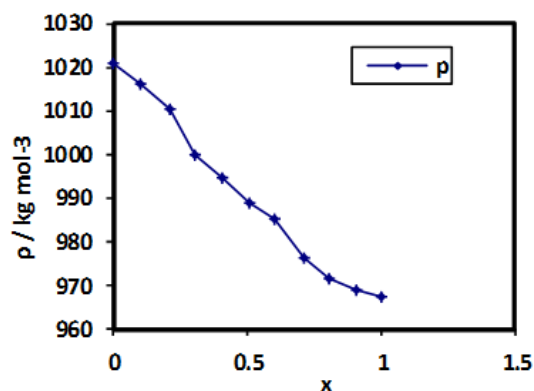


Figure 2 Mole fraction (x) Vs Density (ρ) at 313.15K aqueous l-proline and TEGMBE

The correlation of two systems as aqueous glycine with triethylene glycol monobutyl ether and aqueous l-proline with triethylene glycol monobutyl ether at 313.15K; studied by following graphical representations.

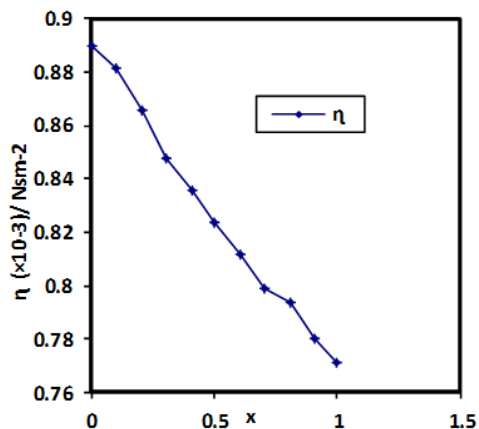


Figure 3 Mole fraction (x) Vs Viscosity (η) at 313.15K aqueous glycine and TEGMBE

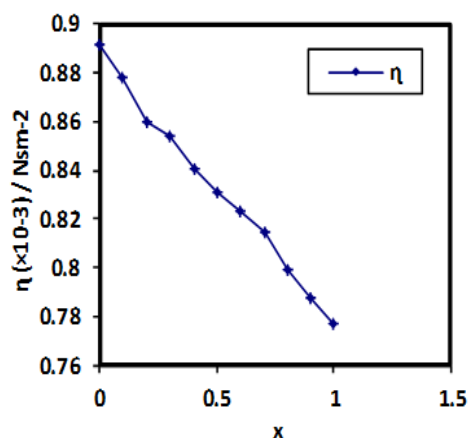


Figure 4 Mole fraction (x) Vs Viscosity (η) at 313.15K aqueous l-proline and TEGMBE

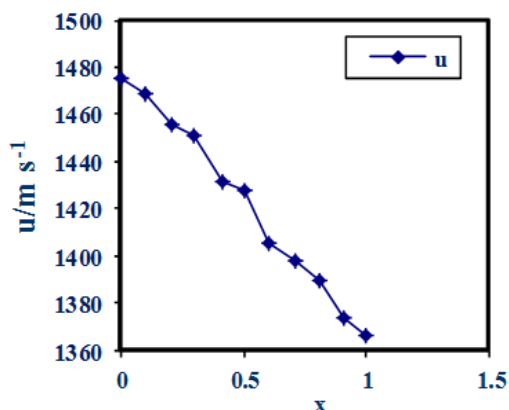


Figure 5 Mole fraction (x) Vs Ultrasonic velocity (u) at 313.15K aqueous glycine and TEGMBE

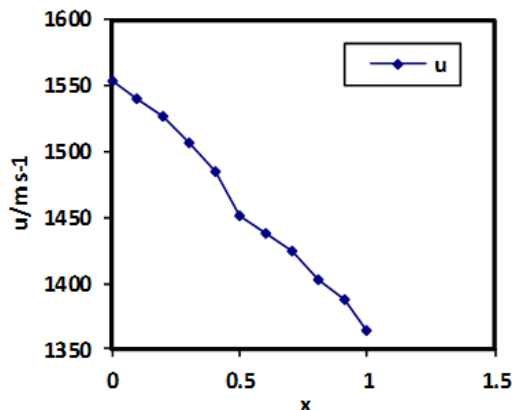


Figure 6 Mole fraction (x) Vs Ultrasonic velocity (u) at 313.15K aqueous l-proline and TEGMBE

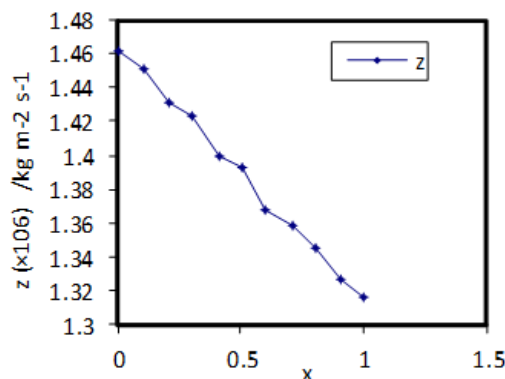


Figure 7 Mole fraction (x) Vs Acoustic impedance (z) at 313.15K aqueous glycine and TEGMBE

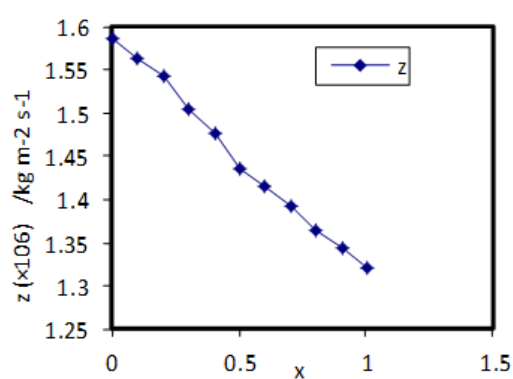


Figure 8 Mole fraction (x) Vs Acoustic impedance (z) at 313.15K aqueous l-proline and TEGMBE

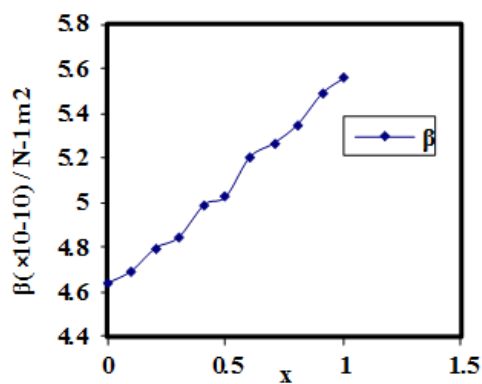


Figure 9 Mole fraction (x) Vs Adiabatic Compressibility(β) at 313.15K aqueous glycine and TEGMBE

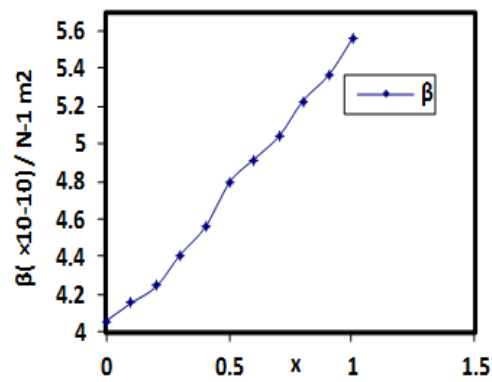


Figure 10 Mole fraction (x) Vs Adiabatic compressibility(β) at 313.15K aqueous l-proline and TEGMBE

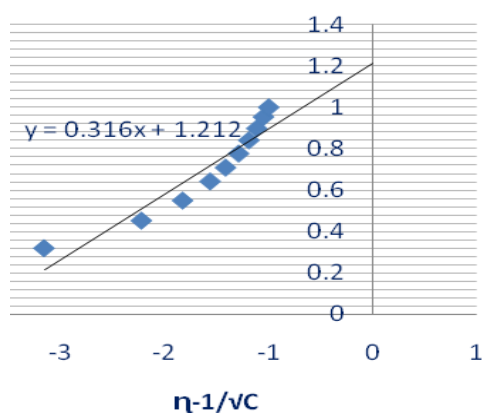


Figure 11 $\eta-1/\sqrt{vC}$ Vs \sqrt{vC} at 313.15K aqueous glycine and TEGMBE

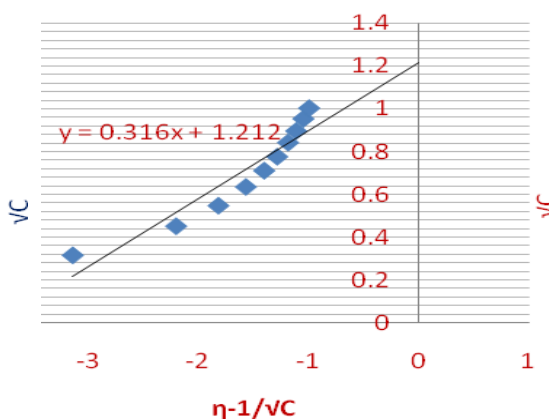


Figure 12 $\eta-1/\sqrt{vC}$ Vs \sqrt{vC} at 313.15K aqueous l-proline and TEGMBE

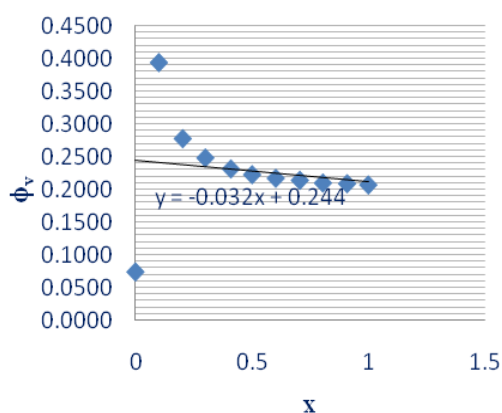


Figure 13 Apparent molar volume (ϕ_v) Vs Mole fraction (x) at 313.15K aqueous glycine and TEGMBE

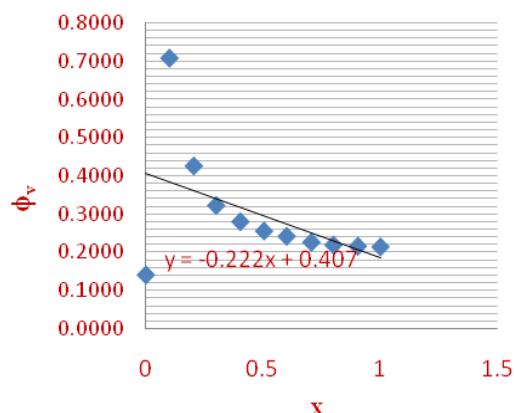


Figure 14 Apparent molar volume (ϕ_v) Vs Mole fraction (x) at 313.15K aqueous l-proline and TEGMBE

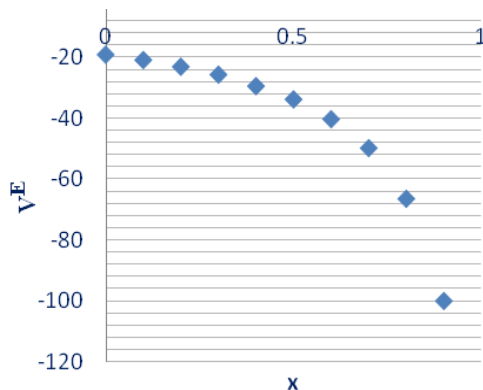


Figure 15 Excess molar volume (V^E) Vs Mole fraction (x) at 313.15K aqueous glycine and TEGMBE

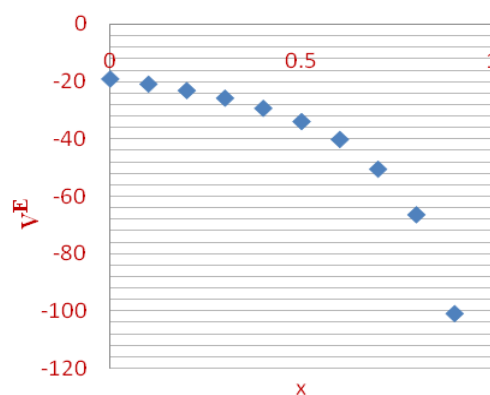


Figure 16 Excess molar volume (V^E) Vs Mole fraction (x) at 313.15K aqueous l-proline and TEGMBE

Results and Discussion

The First System (S1) aqueous glycine with triethylene glycol monobutyl ether (TEGMBE) and Second System (S2) aqueous l-proline with triethylene glycol monobutyl ether (TEGMBE). The physical properties correlated at 313.15K and various concentrations 0.1 to 1.0.

The Comparison of density, viscosity and ultrasonic velocity of triethylene glycol monobutyl ether (TEGMBE) of this research work with literature values at 298.15K tabulated as follows... The above table-3 clearly shows that literature values are close to present research work. These are satisfied results of the present first system (S1) aqueous glycine with triethylene glycol monobutyl ether (TEGMBE) and second system (S2) aqueous l-proline with triethylene glycol monobutyl ether (TEGMBE).

The concentration increases the number of molecules in the medium increases making the medium to be denser. The increase in the number of particles that increases the fractional resistance between the layers of medium and that leads to increase the coefficient of viscosity. The present system in which particle-particle frictional resistance leads intermolecular interaction. It shows increasing and decreasing trend of the measured parameters.

The present system shows the density decreases with concentration increases of TEGMBE it is shown by table no.1 and 2. It is clearly shown from graphical representation of figure no.1 and 2. The aqueous TEGMBE also showed same results Xin-Xue Li et al[46]. The decrease in density indicates the decrease in solute-solvent and solvent-solvent interactions which results structure-breaking of the solvent. It shows that solvent-solvent interactions bring about a bonding, probably hydrogen bonding between them. Thus, size of the resultant molecule increases and there will be decrease in density[51]. The variation trends of density with molar concentration suggest a solute-solvent interaction exist between water and amino acid[52]. In other words such variations in density may be interpreted to the structure of the solvent due to H-bonding[53-54]. The temperature increases density decreases as the interactions break by heat. The density is a parameter giving information about solvent-solvent and ion-solvent interactions[55].

The viscosity, ultrasonic velocity, acoustic impedance decreases as concentration of TEGMBE increases; this is shown by above table no.1 and 2. It is clear from figure no.3 and 4. As the increase in the number of particles that increases the fractional resistance between the layers of medium and that leads to increase the coefficient of viscosity. The viscosity is a physical property in understanding the structure as well as molecular interaction occurring in the aqueous system. The variations of physicochemical parameter related to aqueous system attributed to structural changes[54]. The present system in which particle-particle frictional resistance leads intermolecular interaction. The acoustic impedance shows that the specific interactions are of solute-solute and solute-solvent type. The increase in ultrasonic velocity in the aqueous solution of amino acid may be attributed to the strong cohesion brought by the ionic hydration while decrease in ultrasonic velocity (present research work) in the aqueous solution of amino acid may be attributed to the weak cohesion brought by the ionic hydration. The trends of acoustic velocity depend on the intermolecular free length on mixing[56]. The value of acoustic impedance (z) varies with solute concentration and

variation observed as regards the trends in ultrasonic velocity (u) with temperature[57]. The ultrasonic velocity decreases depending on the structural properties of solute[58]. The solute that decreases the ultrasonic velocity is of structure breaker[59-60] type. The solute occupies the interstitial space of water and tends to break the original ordered state of water due to its self-association. But with rise in temperature, there occurs a structural rearrangement as a result of hydration[61-63] leading to a comparatively more ordered state.

Table 3 Comparison of Present Research Work With Literature

Temp. (T/K)	Density (ρ / kgm ⁻³)		Viscosity ($\eta \times 10^{-3}$ /Nsm ⁻²)		Ultrasonic velocity (u/ms ⁻¹)	
	Observed value	Literature value	Observed value	Literature value	Observed value	Literature value
298.15	981.3 (S7)	980.8 ^a	0.7743 (S7)	0.7688 ^a	1396.3 (S7)	1398.8 ^c
	982.1 (S8)	986.8 ^b	0.7806 (S8)	0.9109 ^b	1399.1 (S8)	
		980.5 ^c				
		982.7 ^d				

^a From ref.46, ^b from ref.47, ^c from ref.48, ^d from ref.49, ^e from ref.50

The values of adiabatic compressibility (β) from figure no.9 and 10 shows increasing trend of β with increasing TEGMBE, thus it leads to a loose packing of the medium and thereby interactions are weak. The variation of trends with concentration which suggest the making and breaking of H-bonding[54]. The molar sound velocity (R) indicates the cube root of sound velocity through one molar volume of solutions called as Rao's constant; it measure interaction existing in the solution. The observed values of molar sound velocity and molar compressibility in the present system show trends which indicating that the magnitudes of interactions. The solute occupies the interstitial space of water and tends to break the original ordered state of water due to its self association; but with increase in temperature, it show a structural rearrangement as a result of hydration[64] leading to a comparatively more ordered state. The intermolecular free length depends upon the intermolecular attractive and repulsive forces. The values of density and viscosity of any system vary with increase or decrease in concentration of solutions[51]. Eyring and Kincaid[65] have proposed that (L_f) is a predominating factor in determining the variation of ultrasonic velocity in aqueous system. The increase in relaxation strength shown by table no.-1 and 2 suggests that presence of solute-solute interactions. A detailed observation of the table no. 1 and 2 shows that the surface tension of the mixture decreases with the mole fraction. According to Baskarana et al[66] σ value rises with mole fractions then interactions in the mixture are not strong while in the present research work surface tension decreases with increasing mole fractions it results interactions are strong.

The intermolecular free length (L_f) is again a predominant factor in determining the existing interactions among the components of the mixture. Analyzing the table no. 1 and 2, the (L_f) reflects a similar trend as that of (β). The increasing trends in these parameters suggest the strengthening of interactions among the components. The trend of molar adiabatic compressibility (W) called as Wada's constant which depends on the adiabatic compressibility of one molar volume solutions may be taken as a confirmation for existing interactions. The higher compressibility values predict that the medium is loosely packed where as the lower compressibility is an indication of maximum interaction.

The present reserch work having aqueous amino acids in both systems [Aqueous glycine with TEGMBE (S1) and Aqueous l-proline with TEGMBE (S2)] then there is hydrogen bonding between H-atom of water with O-atom of $>C=O$ group of amino acid and hydrogen bonding between H-atom of water molecule and N-atom of $-NH_2$ group of amino acid again H-atom of $-OH$ group of amino acid with O-atom water molecule this condition only when aqueous amino acid in the system but when start addition of TEGMBE in the system then concentration of aqueous amino acid decreases and concentration of TEGMBE increases thus hydrogen bonding interactions decreases it results interactions becomes weak hence density, viscosity and ultrasonic velocity decreases.

The temperature increases it results decrease interactions within the system due to increase in thermal energy of the system which causes a volume expansion and density, viscosity and ultrasonic velocity decreases hence an

increase in intermolecular free length and compressibility. The regular increase in free length is due to the loose packing of the molecules inside the shield, which may be brought by declining of molecular interaction. It is noticed that as the concentration of TEGMBE increases, free volume increases whereas the internal pressure decreases. This suggests that the strength of interaction decreases gradually with increase in solute concentration and this represents the existence of weak interaction between the solute and solvent molecules. When the temperature is increased, there is a affinity for the solute molecules to move away from each other, falling the possibility for interaction, which may further diminish the cohesive force and ultimately leads to an increase in free volume. The value of acoustic impedance (z) is found to be decreased, when an acoustic wave travel in a medium, there is a variant of pressure from particle to particle. The relation of the instantaneous pressure excess at any particle of the medium to the instantaneous velocity of that particle is known as 'specific acoustic impedance' of the medium. This aspect is governed by the inertial and elastic properties of the medium. It is important to observe specific acoustic impedance in relation to concentration and temperature. The decrease in specific acoustic impedance indicates significant interaction between the component molecules, Pavai R E et al[67].

The trend of r , initially decreasing and then increasing trend of τ and $(\alpha/f^2)Cl$ with increase in concentration of TEGMBE support our interpretation for initially structure breaker and then structure maker capacity of the solute[68-74]. A variation of internal pressure (π_i) (table no.1 and 2) shows the orientation of the solvent molecules around the solute, it may be due to the influence of electrostatic field of ions. This means solution becomes less compressible. It shows the associating tendency of the molecules in the solute solutions. Conversely, the reduction in π_i shows dissociating tendency of the molecules in the solutions[75]. As increase of free volume (V_f) (decrease of π_i) may be due formation of thin or loose solvation layer. The increasing tendency indicates the presence of some specific interaction which may be due to dipole-induced dipole interaction between unlike molecules in the components. Internal pressure plays an important role in explaining molecular interaction, as this represents the resultant of the forces of attraction and repulsion between the molecules[76]. The physicochemical parameter viz. apparent molar volume (ϕ_v) are highly sensitive to the extrinsic experimental conditions and therefore it suggested to be relevant to extract information, especially with regard to the existence of solute-solute and solute-solvent intermolecular interactions[77]. The hydrogen bond forming or dissociating properties can be correlated with change in density and viscosity[74]. Hence it can be concluded that there is significant interaction of solute-solute or solute-solvent or solvent-solvent type due to which the structural arrangement is also affected. Thus it is confirmed from the above parameters shows hydrophobic in nature this is due to a weak association between solute-solvent interactions in present systems.

The viscosity data have been analysed by Jones-Dole equation[76].

$$\eta - 1/\sqrt{C} = \eta_{sp}/\sqrt{C} = A + B C$$

Where, A = Falkenhagen coefficient; B = Jones-Dole coefficient; C = concentration of solutions

Table 4 Jone-Dole Equation Coefficient

Temperature	Aqueous Glycine & Triethylene glycol monobutyl ether (S7)		Aqueous L-Proline & Triethylene glycol monobutyl ether (S8)	
	A	B	A	B
298.15K	1.212	0.316	1.212	0.316
303.15K	1.212	0.316	1.212	0.316
308.15K	1.212	0.316	1.212	0.316
313.15K	1.212	0.316	1.212	0.316

The Falkenhagen coefficient (A) is measured the solute-solute interactions. The Jones-Dole coefficient (B) is measured the solute-solvent interaction. Hence we were obtained Jones-Dole equation $y = Bx + A$ from figure 11 and 12 by plotting the graph $(\eta-1/\sqrt{C} \text{ Vs } \sqrt{C})$ of System-1 and System-2. The values A = Falkenhagen coefficient and B = Jones-Dole coefficient are obtained from Jones-Dole equation those values are put into table-4.

The relation between viscosity and concentration of solution represented by plotting the graph $\eta-1/\sqrt{C} \text{ Vs } \sqrt{C}$. This proves validity of Jones-Dole equation. The large values of 'A' show the solute-solute interaction respectively as shown by graph Deosarkar et al[77]. The values of Jones-Dole coefficients (B-Coefficients) are the slope of graph $\eta-1/\sqrt{C} \text{ Vs } \sqrt{C}$. The values of Falkenhagen coefficient (A-Coefficient) are the intercept of graph of $\eta-1/\sqrt{C} \text{ Vs } \sqrt{C}$. The constant A is related to the long-range interionic forces[78-79]. The value of B-Coefficient may be either positive or negative. The positive B coefficient indicates a tendency for the solute to enhance water-water interactions[80-81]. The coefficient B is related to the interaction between the ions and the solvent and is interpreted as a measure of the structure forming and structure-breaking capacity of an electrolyte in solution[82]. The terms 'structure breaker' and 'structure former' were extensively used in the decades from 1950 to 1990. However their popularity waned towards the end of the century as more precise descriptions of ionic hydration were sought Gurney[83]. It measures of order or disorder introduced by solute in solvent. It is measured the effective hydrodynamic volume of solute and accounts for the ion-solvent interaction. In the present study, the value of B-coefficients is positive and which accounts for solute-solvent interaction, Pandey, et al[84]. The values of Falkenhagen coefficient (A-coefficient) is positive in present work, it measures ionic interaction. These conclusion confirmed the solute-solute, solute-solvent interactions.

The standard state (infinite dilution) partial molal volumes were obtained from the relation[85-86]

$$\phi_v = \phi_v^0 + S_v m$$

where, ϕ_v^0 is the limiting apparent molar volume at infinite dilution that is also referred to as the partial molar volume of the solute and S_v is the volumetric interaction coefficient[85-88], S_v is the experimental slope and is a measure of solute-solute interactions, ϕ_v^0 provides information regarding solute-solvent interaction. The ϕ_v^0 and S_v values were obtained from the intercept and slope of $\phi_v \text{ Vs } m$ plots. The evaluated values of ϕ_v^0 and S_v are summarized in Table no.5 and 6.

Table 5 Apparent Molar Volume Coefficient

Temperature K	S_v $N^{-1}m^{-1}mol^{-1}$	ϕ_v^0 $m^3.mol^{-1}$
298.15	-0.062	0.273
303.15	-0.106	0.322
308.15	-0.074	0.286
313.15	-0.091	0.303

Where, constant (S_v), limiting apparent molar volume (ϕ_v^0)

This is the table of system-1(S1) Aqueous glycine and triethylene glycol monobutyl (TEGMBE) ether at different temperatures and concentrations.

The volume behaviour of a solute at infinite dilution is effectively represented by ϕ_v^0 which is independent of solute-solute interactions and reflects solute-solvent interactions. The positive values of ϕ_v^0 suggest solute-solvent interactions and vice-versa[85]. The ϕ_v^0 value initially increases and then decreases again increases as temperature increases. However such variations are non-linear of solute-solvent interactions. Negative values of S_v for the system illustrate weak ion-ion/solute-solute interactions[84]. The negative S_v values initially increase then decrease again increases with rise in temperature, it indicates that the solute-solute interaction also non-linear.

Table 6 Apparent Molar Volume Coefficient

Temperatue K	Sv N ⁻¹ m ⁻¹ mol ⁻¹	ϕ_v^0 m ³ .mol ⁻¹
298.15	-0.322	0.505
303.15	-0.291	0.478
308.15	-0.286	0.472
313.15	-0.270	0.454

This is the table of System-2(S2) Aqueous l-proline and triethylene glycol monobutyl ether at different temperatures and concentrations.

This table-6 shows ϕ_v^0 value greater than table-5 it clearly indicate that solute- solvent interactions are more stronger of this system-2 than system-1 while negative values of Sv for this system-2 greater than system-1 it clearly indicate that this system has more weak ion-ion/solute-solute interactions than system-7. The existence of solute-solute as well as solute-solvent interactions in the system, but solute-solvent interactions dominates over the solute-solute interactions.

Applications

- 1) To study of the molecular interactions of ions and proteins are useful in the separation and purification processes and to understand the physiological systems²⁶⁻³⁰.
- 2) The proteins as amino acids play an important role in metabolism and neurochemical mechanisms such as pain transmission, reflex action, hormones mechanism³¹⁻³².
- 3) The various solution properties in recent studies consisting of polar as well as non polar components find applications in industrial and technology processes⁴².
- 4) They have many applications in pharmaceutical industries and also used as food additives. The variations of physical parameter related to aqueous system attributed to structural changes⁹².
- 5) The amino acid data proved that some of the novel molecules can stabilize the biochemical part of living beings^{75,93-95}.
- 6) The measured and calculated thermo-chemical parameters are useful to know the interactions.

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