IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Evaluation of ultrasonic velocities and allied parameters in Binary Liquid Mixtures of Amino Acid in NaBr at different temperatures

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Abstract

Acoustic and thermodynamic parameters have been used to indagate the properties of liquids and liquid mixtures. Such studies have been found to provide information regarding the intermolecular interactions and the structure of liquid state. In the present research work, attempts are made to investigate the behaviour of amino acids at various concentrations and at different temperatures. The measurements of ultrasonic velocity (U), density (ρ) and viscosity (η) have been carried out for D-proline in sodium bromide at different temperature. To get more information about the nature and strength of molecular interactions in the liquid mixtures, related acoustical parameter such as adiabatic compressibility (β), acoustic impedance (z), free length (L_f), classical absorption (α/f^2), and internal pressure (Pi) are calculated from measured experimental data. The variations of these derived acoustical parameters with different concentration of the solute at different temperatures are used to explain structural changes and molecular interactions occurring in a solutions.

Keywords: D-Proline, ultrasonic velocity, adiabatic compressibility, classical absorption, internal pressure.

Introduction:

Many researchers have an extensive interest on pure and binary liquid mixtures molecular interactions can be examined by means of ultrasonic velocity [1,2]. The variation in ultrasonic velocity gives valuable information about the bonding between molecules and formation of complexes at various concentration and temperature through molecular interactions. Knowledge of density and viscosity is important in designing the processes involving chemical separations, equipment design, solution theory, heat transfer, fluid flow and molecular dynamics [3].

Physicochemical properties of amino acids in mixed aqueous media are important in investigating the solute-solvent and solute-solute interactions, which help in understanding the complex mechanism of molecular interactions occurring in various biochemical processes in the human body [4–8]. The physicochemical properties of amino acids, peptides and their derivatives in aqueous solutions have been extensively studied to gain a better understanding of solute-solvent interactions and their role in the conformational stability of proteins [9–11].

In the present paper we have reported the ultrasonic velocity, density and viscosity of D-Proline with NaBr at 283 K and 288 K over the different molar concentration. From these experimental values, number of thermodynamic parameters namely adiabatic compressibility (β), acoustic impedance (z), free length (L_f), classical absorption (α/f^2), and internal pressure (Pi) have been calculated.

Methods :

All the chemicals used were of Analytical Reagent (AR) grades. The solutions of amino acid D-Proline are prepared by their weight. For the preparation of 0.01M solution, 0.034539 gm compound was added in 30 ml of an aqueous sodium bromide. In the same way, for 0.02M, 0.03M, 0.04M, 0.05M, 0.06M, 0.07M, 0.08M solutions, 0.069078gm, 0.103617gm, 0.138156gm, 0.17695gm, 0.207234gm, 0.241773gm and 0.276312gm resp. were added in 30ml of an aqueous sodium bromide respectively. And solutions were stored in a special air tight bottle to avoid the exposure of solution to air and evaporation. All the solutions were weighted using an electronic digital balance. An electronically digital operated constant bath has been

used to circulate water through the double walled measuring cell made up of steel containing the experimental solution at the desired temperature. An ultrasonic interferometer operating at a frequency of 2 MHz used for the velocity measurement at different temperatures. Density of stock solution and solute solutions were determined using a specific gravity bottle of 10 ml capacity. An Ostwald's viscometer used for viscosity measurement of solutions. Viscometer was immersed in the bath which kept at the experimental temperature. The time flow of solution was measured with digital stop watch. Temperature around the viscometer was maintained within 0.1K in an electronically controlled thermostatic water bath.

Results And Discussion:

The following formulae were used to calculate the acoustical parameters,

1) Adiabatic Compressibility (β) = $1/U^2 \rho$
2) Acoustic impedance (Z)= $\rho.U$
3) Classical absorption (α/f^2)=$8\pi 2\eta/3\ \rho u^3$
4) Free Length (L_f)= K ($\beta^{1/2}$)
5) Internal pressure (Pi) =$bRT(K\eta/u)^{1/2}(\rho^{2/3}/M_{eff}^{7/6})$

The symbols have their usual meaning.

The experimental data relating to viscosity, density and ultrasonic velocity at 288K and 283K for the frequency 2MHz for the mixturare shown in Table no. 1.

Table 1: Ultrasonic velocity, density, and viscosity of D-Proline in aqueous solution of sodium bromide at 288K and 283K.

Concentration (Mole)	Ultrasonic Velocity (m/s)		Density (kg/m^3)		Viscosity ($Kg/ms.10^{-3}$)	
	At T=288K	At T=283K	At T=288K	At T=283K	At T=288K	At T=283K
0.01	1487.528	1471.329	1.0211	1.04110	1.1843	1.3474
0.02	1488.676	1471.643	1.0291	1.04512	1.1964	1.3661
0.03	1489.250	1472.205	1.0424	1.05344	1.2084	1.3972
0.04	1489.825	1472.767	1.0429	1.06046	1.2142	1.4171
0.05	1490.976	1473.329	1.0431	1.07452	1.2196	1.4425
0.06	1491.553	1474.455	1.0452	1.0860	1.2325	1.4898
0.07	1492.707	1475.019	1.0466	1.10287	1.2499	1.5398
0.08	1493.284	1475.583	1.0575	1.13324	1.2681	1.6048

Table 2: Adiabatic compressibility, acoustic impedance and free length of D-Proline in aqueous solution of sodium bromide at 288K and 283K.

Concentration (Mole)	Adiabatic compressibility (β) ($*10^{-11}m^2/N$)		Acoustic impedance(Z) ($*10^6 Kgm^{-1}s^{-1}$)		Free length(L_f) ($*10^{-10}$)	
	At T=288K	At T=283K	At T=288K	At T=283K	At T=288K	At T=283K
0.01	43.4755	44.7915	1.5463	1.5174	0.41284	0.41904
0.02	43.3459	44.4919	1.5497	1.5273	0.41222	0.41746
0.03	43.2544	43.7996	1.5524	1.5508	0.41179	0.41437
0.04	43.2003	43.4773	1.5537	1.5617	0.41153	0.41285
0.05	43.1295	42.8740	1.5551	1.5831	0.41119	0.40997
0.06	43.0095	42.3552	1.5588	1.6013	0.41062	0.40749
0.07	42.8815	41.6781	1.5622	1.6266	0.41001	0.40422
0.08	42.4107	40.5290	1.5789	1.6721	0.40775	0.39861

Table 3: Classical Absorption and Internal Pressure of D-Proline in aqueous solution of sodium bromide at 288K and 283K.

Concentration (Mole)	Classical Absorption (α/f^2)($*10^{-15}s^2m$)		Internal Pressure (P_i) ($*10^5N^2/m$)	
	At T=288K	At T=283K	At T=288K	At T=283K
0.01	9.0998	10.7839	9.3929	9.8469
0.02	9.1581	10.8589	9.4458	9.8942
0.03	9.2279	10.9292	9.4987	10.1653
0.04	9.2569	10.9991	9.5213	10.2793
0.05	9.2744	11.0359	9.5375	10.4588
0.06	9.3434	11.2520	9.5984	10.7004
0.07	9.4398	11.4386	9.6689	10.9851
0.08	9.4692	11.5880	9.8041	11.4171

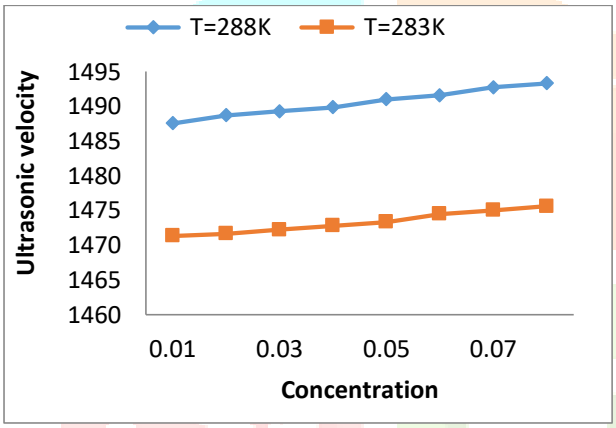

Fig. (a)

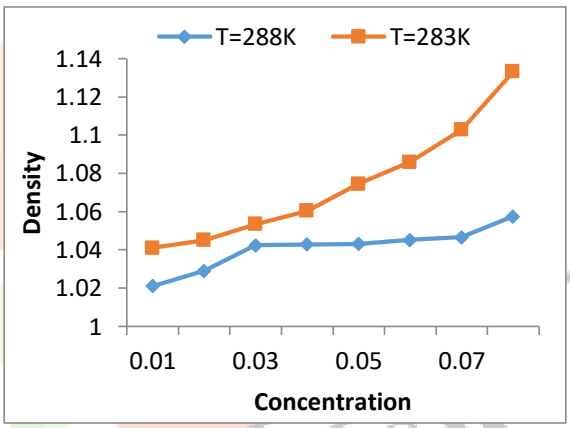

Fig. (b)

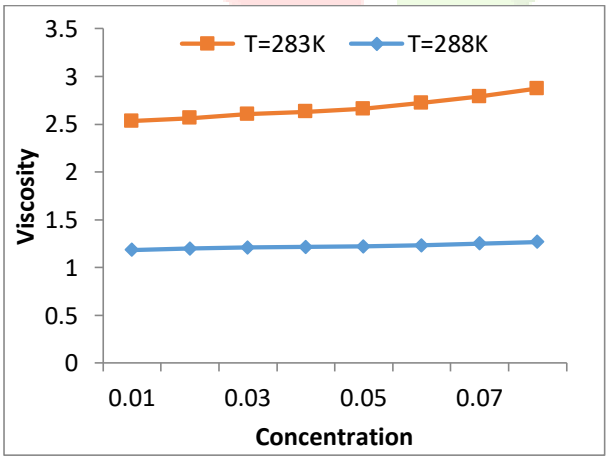

Fig.(c)

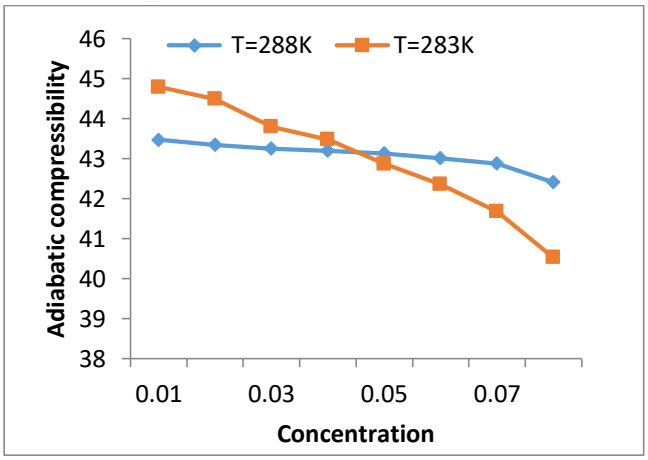

Fig.(d)

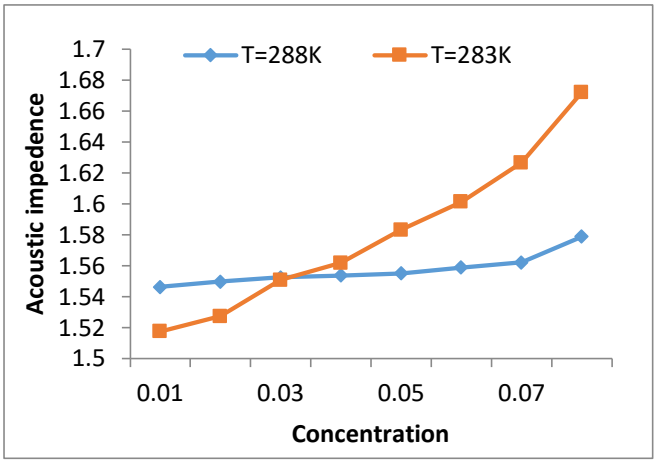

Fig.(e)

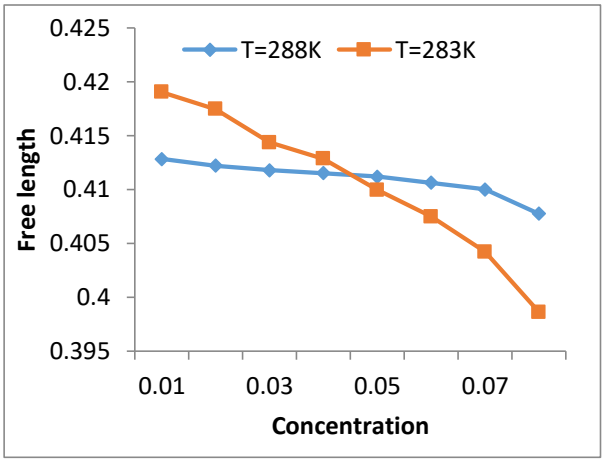

Fig.(f)

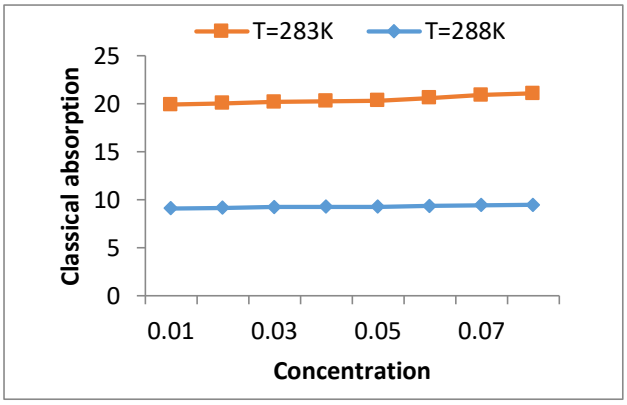

Fig.(g)

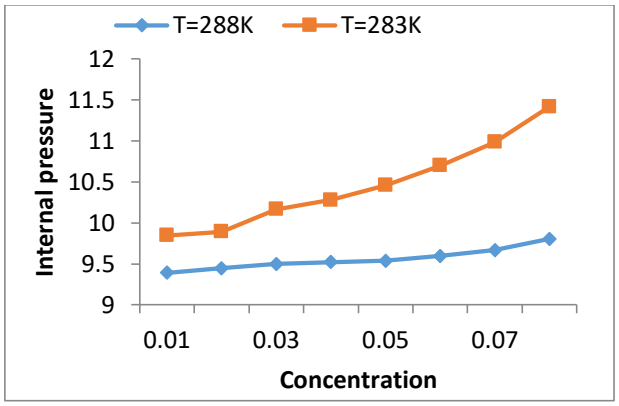

Fig.(h)

The experimental values of ultrasonic velocity, density and viscosity of D-Proline with sodium bromide measured over the composition range at 288 K and 283 K are listed in **Table 1**. In order to understand the intermolecular interactions in the binary mixture, several acoustical and thermodynamic parameters such as adiabatic compressibility, free length, internal pressure, acoustic impedance and classical absorption have been computed using the measured values of U, η and ϱ. The variations of these parameters with mole fraction and temperature are listed in **Table 2 and Table 3**. The values of ultrasonic velocity depend on the structures of the solute. When solute is dissolved in the solvent, due to the changes in molecular free length, the values of ultrasonic velocity also changes which can be explained on the basis of Eryingand Kincarl [14] model. The ultrasonic velocity increases as concentration increases which shows that that there may be formation of hydrogen bond between solute and solvent molecules leads to the closed packed structures.

The adiabatic compressibility (β), a forceful thermodynamic parameter is used to calculate the molecular interactions in liquid mixture [12]. From the variation of (β) with mole fraction (Fig.(d)), it is observed that (β) decreases with increase in mole fraction which gives the information regarding the associations or disassociation of the components. As the temperature increases, (β) increases, may be because of expansion of liquids. Similar behavior is observed in the variation of free length (L_f) shown in (Fig.(f)). This indicates the looser packing of molecules and hence the interaction between the component molecules of D-Proline and sodium bromide becomes weak.

Internal pressure (Pi) is the resultant of the force of attraction and repulsion between the molecules in a liquid [13]. In the present work, the internal pressure is found to increases with increase in solute concentration at all temperatures (Fig.(h)). This shows that the association interaction in the solution.

Acoustic impedance (Z) determines the resistance offered to the propagation of ultrasonic wave in a material. The values of acoustic impedance increase with molar concentration as shown in Fig. (e). The increase in acoustic impedance with composition of the mixture suggests significant interaction between the component molecules

Conclusion:

Ultrasonic investigation in the liquid mixtures is a powerful probe for characterizing the physico-chemical properties and existence of molecular interactions. In this present case, several thermodynamic parameters like, adiabatic compressibility, free length, internal pressure etc., have been evaluated from the measured values of ultrasonic velocity, density and viscosity for the binary system of D-Proline and sodium bromide at different temperature in order to better understand the structural arrangements and intermolecular interactions between the unlike molecules. From this study it is apparent that dispersive force exists among the component of molecules attributed to the presence of weak molecular interactions.

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