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Study of Ultrasonic Parameters of Aqueous Solution of Citric Acid Trisodium Salt at Different Temperature

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ABSTRACT

At concentration range (0.01 to 0.6) mol/kg and temperature range T = (298.15 and 303.15) K, densities (ρ) , ultrasonic speeds (u) and viscosities (η) of aqueous solutions of Citric Acid Trisodium Salt were measured. From these experimentally measured values the parameters such as Adiabatic Compressibility (β_a), Free Length (L_f), Acoustic Impedance (Z) have been evaluated. The results have been interpreted in terms of solute-solvent and solute-solute interactions in these systems. It has been observed that there exist strong solute-solvent interactions in these systems and these interactions increases with concentration of solute in aqueous medium.

Keywords : Density, Ultrasonic speed, Viscosity, molecular interaction

I. INTRODUCTION

The study of propagation of ultrasonic waves in liquid systems and solids is now well established as an effective means of examining certain physical properties of the materials. It is particularly well adapted to examining changes in such physical properties at the macro level. The data obtained from ultrasonic propagation parameters in liquid mixtures and solutions viz., ultrasonic velocity and attenuation, and their variation with concentration of one of the components, helps to understand the nature of molecular interactions in the mixtures. The study of physiochemical behavior and molecular interactions in liquid mixtures is of considerable importance and a number of experimental techniques have been used to investigate the interactions between the components of binary liquid mixtures. In recent years, the measurement of ultrasonic velocity has been extensively applied in understanding the nature of molecular systems, physicochemical behavior and molecular interactions in liquid mixtures.

Ultrasonic velocity measurements have been employed extensively to detect and assess weak and strong molecular interactions in binary and ternary mixtures, because mixed solvents find practical applications in many chemical and industrial processes. To meet the needs of applications, ultrasound velocity measurements are generally carried out at different temperatures. The parameters such as ultrasound velocity (u), density (ρ) and viscosity (η) and computed parameter such as Adiabatic Compressibility (β_a), Free Length (L_f), Acoustic Impedance (Z), provide

better inside into intermolecular interaction. The present investigation is carried out to study molecular interactions in aqueous Citric Acid Trisodium Salt at the temperatures 298.15 K and 303.15 K.

II. MATERIAL AND METHOD

Aqueous Citric Acid Trisodium Salt having molecular weight of 258.07 was obtained from Sigma Aldrich chemicals Ltd. The molecular structure of this compound is as follows

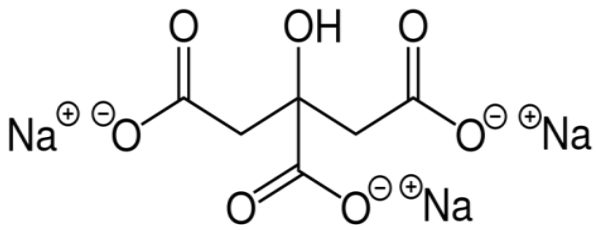

Fig 1. Citric Acid Trisodium Salt

The aqueous solutions of aqueous Citric Acid Trisodium Salt of different concentrations were freshly prepared by using double distilled water. The required amount of solute was measured by using a digital weighing machine. The solutions were made on the basis of molality and stored in special airtight bottles to avoid contamination and evaporation. The densities measurements have been done by using specific gravity bottle (10ml). Ultrasonic velocities have been determined by using digital ultrasonic pulse echo velocity meter (VCT -70A). The viscosities of the solutions were measured by using Ostwald's type viscometer. The instrument has been calibrated with double distilled water at certain temperatures before taking measurements. The flow time has been measured with a digital stopwatch and average flow times were taken for each series of liquid solutions.

III. RESULT AND DISCUSSION

The experimental values of basic parameter of Ultrasonic velocity (u), Density (ρ) and Viscosity (η) obtained are given in table 1 and by using these basic parameter the various acoustic parameter of aqueous Citric Acid Trisodium Salt. Such as Adiabatic Compressibility (β_a), Free Length (L_f), Acoustic Impedance (Z) etc. are calculated in table 2.

Table 1 : Velocity (u), Density (ρ), and Viscosity (η)

Composition M(mol/kg)	298.15 K			303.15 K		
	Velocity U(m/s)	Density ρ (kg/m^3)	Viscosity η (N.s.m^3)	Velocity U(m/s)	Density ρ (kg/m^3)	Viscosity η (N.s.m^3)
0.01	1494.73	996.292	9.27E-04	1503.75	1014.089	8.63E-04
0.02	1494.14	996.844	9.19E-04	1503.75	1008.922	8.43E-04
0.03	1494.36	995.741	9.08E-04	1503.75	1017.057	8.48E-04
0.04	1501.94	959.717	8.70E-04	1511.04	1023.350	8.58E-04
0.05	1503.75	994.489	9.42E-04	1531.49	1025.448	8.81E-04
0.06	1505.56	1004.309	9.59E-04	1514.71	1026.881	8.79E-04
0.07	1507.39	1004.459	9.35E-04	1517.17	1028.467	8.70E-04
0.08	1509.21	1010.071	9.40E-04	1519.02	1026.727	8.87E-04
0.09	1511.04	1010.973	9.57E-04	1520.87	1032.611	9.03E-04
0.1	1525.02	1010.321	9.40E-04	1519.63	1023.606	8.71E-04
0.2	1531.457	1021.444	1.02E-03	1540.287	1050.263	9.64E-04
0.3	1547.937	1035.773	1.10E-03	1556.959	1064.743	1.02E-03
0.4	1566.743	1063.530	1.16E-03	1575.322	1095.032	1.03E-03
0.5	1579.313	1074.603	1.24E-03	1572.011	1096.772	1.14E-03
0.6	1601.632	1075.705	1.36E-03	1593.443	1101.121	1.20E-03

Table 2: Adiabatic compressibility (βa), free length (L_f), Acoustic Impedance (Z)

Composition M(mol/kg)	298.15 K			303.15 K		
	Adiabatic Compre. βa ($10^{-10}N^{-1}.m^2$)	Free Length L_f ($10^{-11}m$)	Acoustic Imped. Z (kg. $m^{-2}.s^{-1}$)	Adiabatic Compre. βa	Free Length L_f ($10^{-11}m$)	Acoustic Imped. Z (kg. $m^{-2}.s^{-1}$)
0.01	4.492E-10	4.375E-11	1.489E+06	4.361E-10	4.310E-11	1.525E+06
0.02	4.494E-10	4.375E-11	1.489E+06	4.383E-10	4.321E-11	1.517E+06
0.03	4.497E-10	4.377E-11	1.488E+06	4.348E-10	4.304E-11	1.529E+06
0.04	4.619E-10	4.436E-11	1.441E+06	4.280E-10	4.270E-11	1.546E+06
0.05	4.447E-10	4.352E-11	1.495E+06	4.158E-10	4.209E-11	1.570E+06
0.06	4.393E-10	4.326E-11	1.512E+06	4.244E-10	4.252E-11	1.555E+06
0.07	4.381E-10	4.320E-11	1.514E+06	4.224E-10	4.242E-11	1.560E+06
0.08	4.347E-10	4.303E-11	1.524E+06	4.221E-10	4.241E-11	1.560E+06
0.09	4.332E-10	4.296E-11	1.528E+06	4.187E-10	4.223E-11	1.570E+06
0.1	4.256E-10	4.258E-11	1.541E+06	4.230E-10	4.245E-11	1.556E+06
0.2	4.174E-10	4.217E-11	1.564E+06	4.013E-10	4.135E-11	1.618E+06
0.3	4.029E-10	4.143E-11	1.603E+06	3.874E-10	4.063E-11	1.658E+06
0.4	3.830E-10	4.040E-11	1.666E+06	3.680E-10	3.959E-11	1.725E+06
0.5	3.731E-10	3.987E-11	1.697E+06	3.690E-10	3.965E-11	1.724E+06
0.6	3.624E-10	3.929E-11	1.723E+06	3.577E-10	3.904E-11	1.755E+06

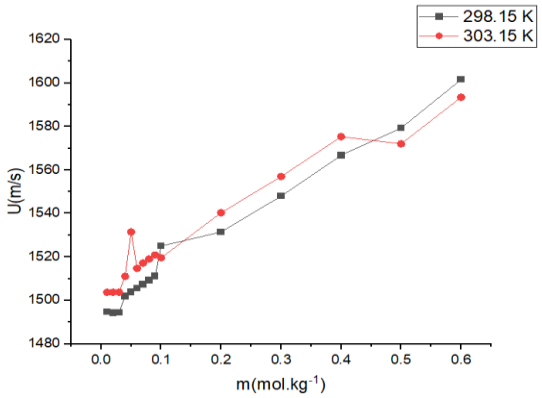

Fig.1 Variation of Ultrasonic Velocity with molality at 298.15K, 303.15K

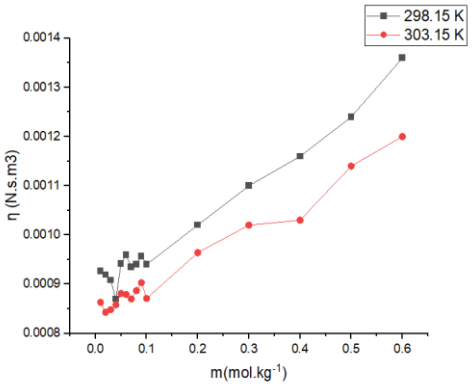

Fig.2 Variation of Viscosity with molality at 298.15K, 303.15K

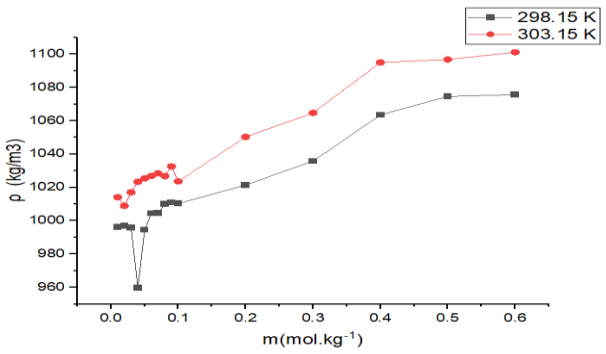

Fig.3 Variation of Density with molality at 298.15K, 303.15K

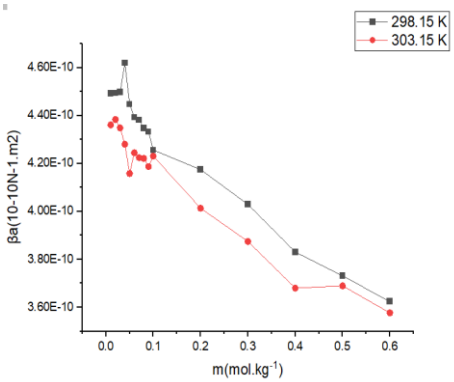

Fig.4 Variation of adiabatic compressibility with molality at 298.15K, 303.15K

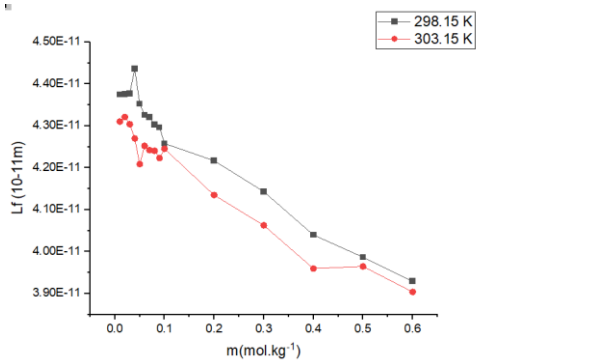

Fig.5 Variation of Free length with molality at 298.15K, 303.15K

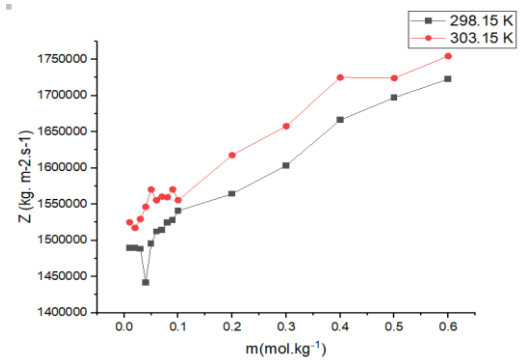

Fig.6 Variation of Acoustic impedance with molality at 298.15K, 303.15K

IV. RESULTS AND DISCUSSION

The experimental values of viscosity, density and ultrasonic velocity of aqueous solution of citric acid trisodium salt of different concentrations at 298.15K, and 303.15K are shown in Table - 1. The different values of acoustic parameters calculated from the basic parameters are shown in the Table 2.The plots basic and acoustic parameters verses concentration are shown in figure 1 - 6. Fig. 1 shows the ultrasonic velocity (u) of aqueous solution increase with the increase of concentration and temperature. This may be attributed to the increase of compactness of the medium with the increase in connection [1-2]. Fig. 2 shows that the viscosity (η) of aqueous citric acid trisodium salt increase with increase of concentration. The viscosity decreases with increase in temperature in aqueous citric acid trisodium salt. The variations observed in viscosity in the present system agreed with the results [3-4]. Fig. 3 shows that the densities (ρ) of aqueous citric acid trisodium salt increase with the increase of citric acid trisodium salt concentration. The densities decrease with the increase of temperature in aqueous citric acid trisodium salt. Because the sodium is heated, the thermal energy of molecules increase and accordingly intermolecular distance increase. This leads to the decrease of the density [5-6]. Fig.4 shows that the adiabatic compressibility (βa) also decreases with concentration. The decrease in adiabatic compressibility is attributed to the influence of the electrostatic field of ions which results in aggregation of solvent molecules around solute molecule indicating strong solvent - solute interaction. The adiabatic compressibility increases with increase the temperature due to increase in thermal agitation. The existence of solvent - solute interaction in studied solution is further confirmed by decrease of relaxation strength (r) and increase of acoustic impedance with

concentration. From fig. 5 the decrease in intermolecular free length (L_f) with increase in concentration is normal trend. Free length shows a similar behaviour as reflected by adiabatic compressibility brings the molecules to a closer peaking resulting into a decrease of intermolecular free length. In Fig. 9 The value of acoustic impedance (Z) of aqueous citric acid trisodium salt in water have been shown in table 6 at different temperature. it is shown from figure 6 that acoustic impedance increases with the increase in molality of amino acids. In increase Z with the molality of an amino acids shows that the concentration increases the ultrasound wave has to face resistance to flow. The position acoustic impedance is therefore an evidential parameter for solute - solvent interaction [7-8].

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