IOSR Journal of Applied Chemistry (IOSR-JAC)
e-ISSN: 2278-5736.Volume 12, Issue 1 Ser. I (January. 2019), PP 34-37
www.iosrjournals.org

Acoustical Studies of Sucrose in Aqueous Medium and Non Aqueous Medium At 303.15 K

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Abstract: *The density and acoustical properties such as ultrasonic velocity adiabatic compressibility (β_s), apparent molal volume (ϕv), apparent molal compressibility (ϕ_K), intermolecular free length (L_f), of sucrose in aqueous medium and non aqueous medium (5%,10% ethanol-water) have been measured and from measured ultrasonic velocities (U) and densities (ρ) of the sucrose solutions of concentrations 0.1-0.9 M at 303.15 k. The changes in acoustical properties with enhancing percentage of ethanol have been employed to know the variation in molecular interactions between water, ethanol and sucrose and to understand the structure making and breaking property of sucrose in aqueous and non aqueous medium of different concentration.*

Keywords: *ultrasonic velocity, adiabatic compressibility, intermolecular free length, apparent molal volume, apparent molal compressibility,*

Date of Submission: 14-01-2019 Date of acceptance: 29-01-2019

I. Introduction

Ultrasonic investigation in aqueous solutions and non aqueous solution of sucrose provides the useful information in understanding the behavior of liquid systems, due to intramolecular and inter molecular association, complex formation and related structural changes affect the compressibility of the system , internal pressure etc. In recent years, determinations of ultrasonic velocity and absorption coefficient have provide the methods for studying molecular and structural properties of liquids. A. Ali studied the physico-chemical studies of non- aqueous binary liquids mixtures at various temperatures [1].R. Palani et ,al have studied the ultrasonic studies on molecular interaction of arginine in aqueous Disaccharides at 298.15 k [2]. S.A. Shah et,al [3] have studied the thermodynamic parameters and ultrasonic studies of intermolecular interactions in some carbohydrates at 298.15 k .Many researchers have studied the thermodynamics of binary mixtures amide-water[4-6],alcohol-water[7]. Hence acoustical study by the measurement of density and ultrasonic velocity of aqueous and non-aqueous systems at 303.15 k temperatures with different concentrations of solute and in different percentage of organic solvents have been done. In recent years, ultrasonic velocity and absorption studies in case of electrolyte solutions have led to new insight into the process of ion-association and complex formation. Density, ultrasonic velocity and viscosity measurements of pharmacologically significant drugs in methanol at 25°C have been studied by D. V. Jahagirdar et al [8].the study of molecular interactions in liquid mixtures provides an important insight into the conformational stability and unfolding behavior of globular proteins [9]. No significant work has been reported on the ultrasonic studies of sucrose in aqueous medium and different percentage of ethanol- water medium, which will provide the information about molecular interactions between two solvents with different percentage in the presence of solute sucrose. Hence the present work is undertaken to study the acoustical behavior of the sucrose in 0.1-0.9M concentration in aqueous medium and different percentage of non aqueous medium to discuss the interactions of unlike molecule of solvents in presence of solute.

II. Experimental

All the chemicals were A.R. grade sucrose from Merck chemicals purity of 99.9% ethanol from S.D. fine chemical minimum assay of 99.9% which are used without further purification .The purities of the chemicals were checked by density determination at 303.15 k the uncertainty is less than $\pm 1\times10^{-4}$gcm^{-3}.The water used for the preparation of solution was double distilled .The molar aqueous and non Aqueous solution of sucrose, 5%,10 % ethanol-water system were prepared by utilizing digital electronic balance [Model-HR300 japan] of concentration 0.1-0.9 M at temperature 303.15 K. The densities of aqueous and non-aqueous solution of sucrose were measured by utilizing specific gravity bottle by relative measurement method with accuracy of ±0.1 kgm^{-3}. The viscosities were measured by means of Ostwald's viscometer which was kept in equilibrium with elite thermostat water bath ($\pm$ 0.1^{o}c).sucrose solution of different concentration were prepared in aqueous

medium, 5%, 10% ethanol-water medium. For each measurement sufficient time was allotted to attend thermal equilibrium in thermal state.

III. Results And Discussion

The principle used in the measurement of velocity (U) is based on the accurate determination of the wavelength (λ) in the medium, equation (1)

$$d = \lambda/2 \quad (1)$$

Where, d is the distance traveled by micrometer screw to get one maxima in ammeter in mm and λ is wavelength. From the knowledge of wavelength (λ), the velocity (U) can be obtained by the relation (2)

$$U = \lambda \times \nu_{ins.} \times 10^3 \quad (2)$$

Where, U is the sound velocity in m/sec and ν_{ins}. is the frequency of instrument (2 MHz). The acoustical properties like adiabatic compressibility of solution (β_s)[13], , intermolecular free length (L_f) were calculated by using equations (3-6) [11]

$$\beta_S = \frac{1}{U_s^2 \times \rho_s} \quad (3)$$

$$L_f = K'\sqrt{\beta_s} \quad (4)$$

Where, (U_s) ultrasonic velocity in solution , (ρ_s) and (ρ_0) are density of solution and solvent mixture respectively and K' is temperature dependent Jacobson's constant [13].

apparent molal compressibility (ϕ_K) was calculated by using equation (5).

$$\varphi_k = \frac{1000\left(\beta s.\rho o - \beta o.\rho s\right)}{m.\rho s.\rho o} + \frac{\beta s.M}{\rho s} \quad (5)$$

Where, β_s and βo are adiabatic compressibility of solution and solvent mixtures respectively, M is molecular weight of sucrose and m is the molality of solution.

$$\phi v = \left(\frac{M}{\rho_s}\right) + \left[\frac{(\rho_o - \rho_s).10^3}{m.\rho_s.\rho_o}\right] \quad (6)$$

Densities, ultrasonic velocity and measured acoustical properties in aqueous medium in 0.1-0.9 M solution of sucrose at 303.15K are given in Table (1) and variation in these properties with 5%,10% ethanol-water system are shown in the table (2) and (3). The apparent molal volume,ϕv of sucrose in aqueous medium and non aqueous medium at 303.15 k were calculated by finding difference in densities of solvent and solution, molecular weight and molality of compounds using equation (6).

Table-1: ultrasonic velocities (Us), densities (ρ_s) and measured acoustic properties of sucrose in aqueous medium at 303.15 k.

m	U_s (m/s)	ρ_s (10^3kg/m^3)	β_s 10^{-10}m^{2}N^{-1})	L_f (10^{-11}m)	ϕv(x10^3c m^{3}mole^{-1})	ϕ_K (10^{-6}m^{2}N^{-1})
0.1	1527.5	1.0118	4.23587	4.08352	177.4896	-126.1334
0.2	1528.1	1.0273	4.16869	4.05101	178.2337 3	-60.09622
0.3	1531	1.0422	4.09354	4.1433	178.7374	-41.5913
0.4	1532.9	1.0565	4.02812	3.98212	179.2495 4	-30.2921
0.5	1534.6	1.0703	3.96738	3.95198	179.6129 4	-22.9391
0.6	1538.9	1.0835	3.89718	3.91686	180.1131 0	-20.05711
0.7	1542.8	1.0962	3.83268	3.8843	180.6622 1	-17.2894
0.8	1544	1.1087	3.78348	3.85930	180.8736 8	-13.6099
0.9	1548	1.1206	3.72398	3.8288	180.9726 7	-12.1028

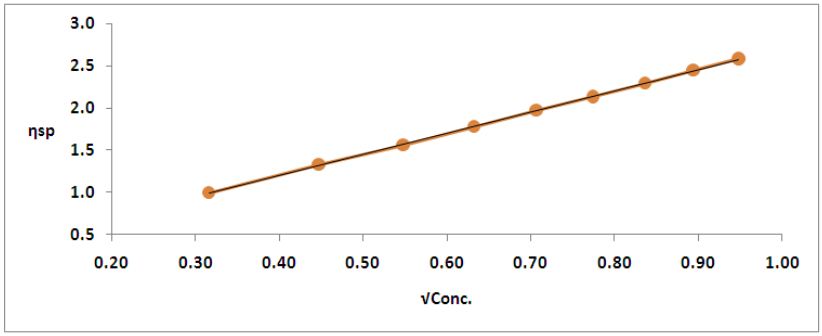

Fig. 1 $\sqrt{concentration}$ Verses Specific Viscosity in aqueous medium

Table-2: ultrasonic velocities (Us), densities (ρ_s) and measured acoustic properties of sucrose in 5% ethanol-water medium at 303.15 K .

m	U_s (m/s)	ρ_s ($x10^3 kg/m^3$)	β_s ($10^{-10} m^2N^{-1}$)	L_f (10^{-11}m)	ϕv ($10^3 cm^3 mole^{-1}$)	ϕ_K ($10^{-6} m^2N^{-1}$)
0.1	1528.9	1.0149	4.21978	4.07575	164.3733	-151.089
0.2	1529.3	1.0298	4.15204	4.04291	165.6091	-76.2480
0.3	1532.6	1.0462	4.06937	4.00246	165.9249	-55.6028
0.4	1533.9	1.0615	4.00392	3.97014	166.5773	-41.8764
0.5	1535.4	1.0763	3.94116	3.9389	167.4130	-33.4854
0.6	1539.7	1.0904	3.86849	3.9024	168.3801	-29.9155
0.7	1543.1	1.01043	3.80299	3.8692	168.7295	-26.7050
0.8	1545.7	1.1161	3.75013	3.8422	171.1399	-21.9705
0.9	1550.3	1.1308	3.68531	3.8089	171.5504	-20.6745

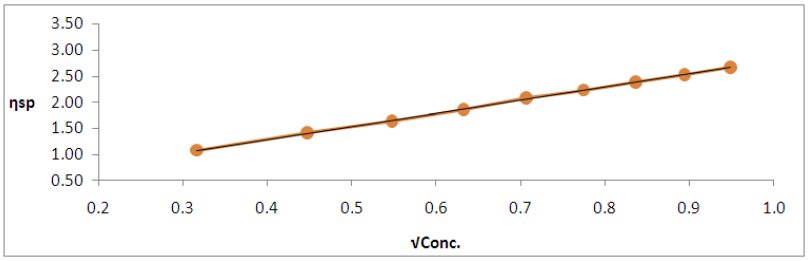

Fig. 2 $\sqrt{concentration}$ Verses Specific Viscosity in non aqueous medium (5 %)

Table 3: Ultrasonic velocities (Us), densities (ρ_s) and measured acoustic properties of sucrose in 10% ethanol-water medium at 303.15 K

m	U_s (m/s)	ρ_s ($x10^3 kg/m^3$)	β_s ($x10^{-10} m^2N^{-1}$)	L_f ($x10^{-11}$m)	ϕv ($x10^3 cm^3 mole^{-1}$)	ϕ_K ($x10^{-6} m^2N^{-1}$)
0.1	1530.5	1.0348	4.20681	4.06397	149.2808	-168.5497
0.2	1531.9	1.0407	4.12554	4.02999	150.0395	-94.1673
0.3	1533.8	1.0488	4.04753	3.99170	151.8717	-68.6921
0.4	1534.9	1.0542	3.97922	3.95787	153.5249	-53.6842
0.5	1536.9	1.0622	3.91094	3.92377	154.9486	-44.9368
0.6	1540.7	1.0348	3.8381	3.8870	156.2944	-40.1532
0.7	1544.6	1.0407	3.76801	3.8514	156.7666	-36.5524
0.8	1546.9	1.0488	3.71107	3.82219	158.4709	-32.2447
0.9	1551.8	1.0542	3.64174	3.7863	158.565	-30.9344

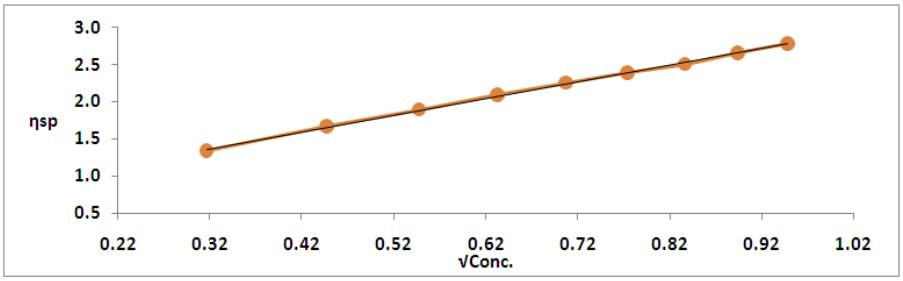

Fig. 3 $\sqrt{concentration}$ Verses Specific Viscosity in non aqueous medium (10 %)

Densities ,ultrasonic velocity and measured acoustical properties in aqueous medium of concentration ranges 0.1-0.9 M solution of sucrose at 303.15K are given in Table (1) and variation in Density, ultrasonic velocity & the acoustical properties of non aqueous medium (5%,10% ethanol-water system) are shown in the table (2) & (3). The ultrasonic velocity increases as shown in table (1) (2) and (3) respectively with increase in the percentage of ethanol. The values of adiabatic compressibility, βs decrease with increase in the percentage of ethanol which may be due to departure of solvent molecules around the ions[13] The apparent molal volumes (ϕv) is large in table (3) as compared to table (2) & (1) due to the access of solute molecules into the cavity of solvent structures thus causing an amendment in the solvent structure .It is shown in table(1) ,(2) and (3) that (ϕ_k) values decrease with increase in the percentage of ethanol because of loss of compressibility of solute due to strong electrostrictive solution of ions. From the observation table (1),(2) &(3) it is also seen that the intermolecular free length (L_f) decrease with increase in the percentages of ethanol this suggesting that the weaker interaction present between ions and solute molecules, indicating the structure promoting behavior of solute. This may also imply that the increase in free ions, indicating the occurrence of ionic dissociation because of weak ion-ion interaction.

We are thankful to Dr. Mrs. A. G Murugkar department of physics Dr. BAMU Aurangabad and Dr. M. L. Narwade, for their co-operation and valuable suggestion

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IOSR Journal of Applied Chemistry (IOSR-JAC) is UGC approved Journal with Sl. No. 4031, Journal no. 44190.

Javed Khan. " Acoustical Studies of Sucrose in Aqueous Medium and Non Aqueous Medium At 303.15 K." IOSR Journal of Applied Chemistry (IOSR-JAC) 12.1 (2019): 34-37.