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Study the Interaction of Ascorbic Acid with NaOh Using Ultrasonic Technique

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Abstract: ***Ultrasonic velocity (U), density (ρ) and viscosity (η) have been measured at 2MHz frequency in the binary mixtures of ascorbic acid with NaOH over the entire range of concentration at 301°K using ultrasonic interferometer technique. The experimental data have been used to calculate the acoustical parameters namely adiabatic compressibility (β_a), free length (L_f), internal pressure and free volume with a view to investigate the nature and strength of molecular interaction in the binary mixture of ascorbic acid with NaOH. The obtained result support the occurance of Complex formation through intermolecular hydrogen bonding in these binary liquid mixtures.***

Key words*:* Ultrasonic velocity, binary mixture, molecular interaction, hydrogen bonding

1. Introduction

The study of intermolecular interaction plays an important role in the development of molecular sciences. A large number of studies have been made on the molecular interaction in liquid system by various physical methods like infrared, Raman effect, Nuclear Magnetic Resonance (NMR), Dielectric constant, Ultraviolet & ultrasonic method[1].

The nature & Strength of the molecular interaction between the components of the liquid mixtures have been successfully investigated by the ultrasonic method. These interaction help in better understanding the nature of solute and solvent i-e whether the solute modifies or distorts the structure of the solvent .The measurement of the ultrasonic velocity enables the accurate determination of some useful acoustical and thermodynamic parameters [2].

Vitamin C, also known as ascorbic acid or ascorbate, is a six-carbon compound naturally found in many fruits and vegetables. It is required in many “reactions involved in body processes, including collagen synthesis, carnitine synthesis, tyrosine synthesis and catabolism, and neurotransmitter synthesis”[3], etc. Nevertheless, vitamin C is not just an essential nutrient for maintaining human health. In fact, due to its multiple biological and chemical properties, vitamin C plays a useful role in different areas [4], such as food and cosmetic industries.

In food industry, vitamin C has a dual role: it acts as a nutrient as well as a food antioxidant and product improver[4]. Due to its physical structure, vitamin C is highly unstable[3]. It is extremely heat-sensitive and can be easily destroyed under various conditions, such as enzymatic reaction, exposure to oxygen or light, use of inappropriate containers, and the presence of antioxidants or preservatives[5].Vitamin C can be significantly reduced during food manufacturing and storage process [5]. In order to replace the loss, vitamin C is restored back to the food products [4]. The use of vitamin C is not only limited to food related areas; actually its applications extend to areas other than just the food and beverages industry. Like the role of vitamin C plays in food industry, its excellent reducing capacity makes it an effective ingredient in cosmetic products [6]. It protects and strengthens skin tissues and cells against external attacking factors such as oxidation damage resulting from attack of free radical and oxygen-derived species[3], ultra violet radiation, pollutants and other exogenous agents which lead to formation of wrinkles, deposition of pigment, lose of elasticity of skin, etc [6,7]. Besides the protection effect, vitamin C also stimulates collagen synthesis and involves in depigmentation[6]. All these contributions of vitamin C make it a desirable topical treatment agent in cosmetic industry.

In the present study, we report the value of density, viscosity and ultrasonic velocity at 0.00 to 0.1 molar concentration of ascorbic acid with NaOH solution at 301°K. The various physical and thermodynamic parameters like adiabatic compressibility (β_a), free length (L_f), internal pressure and free volume were calculated from density, viscosity and ultrasonic velocity data. All these parameters were discussed in term of solute-solvent interaction occurring in the binary mixture of ascorbic acid & NaOH.

2. Experimental Section

2.1 Materials

Ascorbic acid used in the present work was of Analytical Reagent (AR) grades with a minimum assay of 99.9%, they are used without purification. The various concentration of solution was prepared by adding sufficient amount of solvent NaOH to ascorbic acid.

2.2 Methods

The ultrasonic velocity(U) have been measured in ultrasonic interferometer (Model-F-05) supplied by mittal enterprises ,New Delhi operating at a frequency of 2 MHz with an accuracy of 0.1%.The viscosities (η) of binary mixtures were determined using Ostwald’s viscometer by calibrating with double distilled water. The density (ρ) of these binary solution were measured accurately using 25 ml specific gravity bottle in an electronic balance precisely and accurately using weighting is 0.1mg.These basic parameter U, η and ρ were measured at 301 K and at various concentration (0.00 M to 0.1M) .The acoustical parameters were calculated from U, η, and ρ value using standard formulae.

3. Results & Discussion

The measured ultrasonic velocity, density and viscosity of ascorbic acid with NaOH & calculated acoustical parameters at 301 K were shown in table 1 & 2 and related graphical representation of these parameters are shown in fig.1 to 7.

Table 1: Ultrasonic velocity (u), density (ρ) and viscosity (η) value for binary mixture of ascorbic acid +NaOH at 301^{o}K

Mole Conc.	0	0.02	0.04	0.06	0.08	0.1
U (m/sec)	1512	1512	1516	1516	1508	1507
ρ (Kg/m^3)	1016.7	1021.8	1021.8	1022.8	1030.9	1012.3
η (mPa.Sec)	0.789	0.793	0.793	0.794	0.812	0.792

Table 2: Acoustical parameters for binary mixture of ascorbic acid +NaOH at 301^{o}K

Mole Conc.	0	0.02	0.04	0.06	0.08	0.1
β_a (Kg^{-1}.m.Sec^{-1})	4.302E-10	4.281E-10	4.258E-10	4.254E-10	4.266E-10	4.350E-10
L_f (A^o)	0.410	0.4090	0.4080	0.4078	0.4.08	0.4123
P_{in} (N/m^2)	1.02E+09	5.28E+08	3.46E+08	2.54E+08	2.03E+08	1.62E+08
V_f (m^3 /mol)	7.58E-08	1.77E-07	3.06E-07	4.54E-07	5.96E-07	8.02E-07

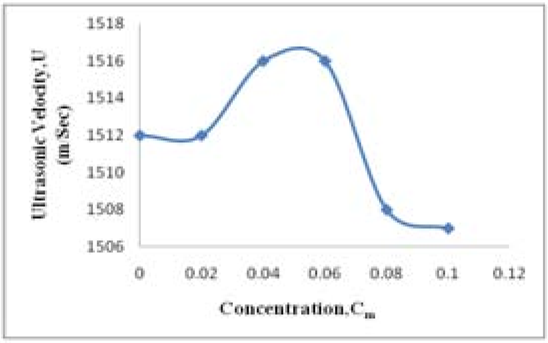

Figure 1: Variation of Ultrasonic velocity with C_m

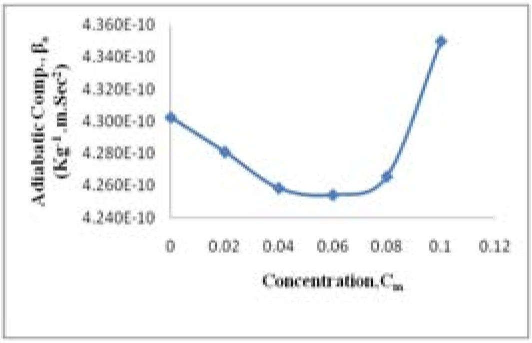

Figure 2: Variation of Adiabatic compressibility with C_m

From fig.1 and 2, it is observed that, ultrasonic velocity and adiabatic compressibility shows nonlinear variation with increase in molar concentration of ascorbic acid. This may be attributes to molecular association and complex formation. The complex formation and molecular association may be brought about through a hydrogen bonding possible between the molecules[8,] which describe the structure making and breaking effect of the ascorbic acid. This also indicates the hydrophilic and hydrophobic nature of ascorbic acid in NaOH.

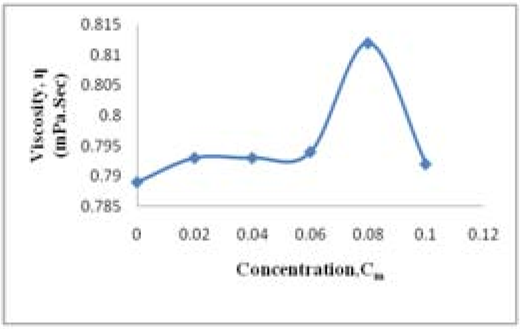

Figure 3: Variation of Viscosity with C_m

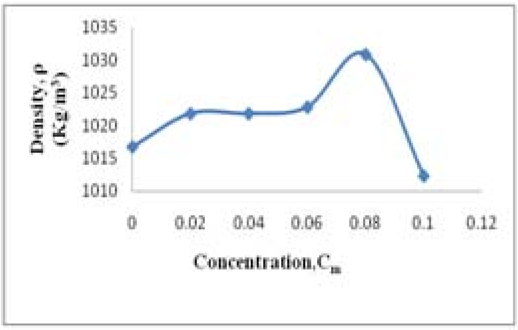

Figure 4: Variation of density with C_m

The viscosity and density are the important parameter in understanding the structure as well as strength of molecular interaction between the interacting molecules[9]. Fig. 3 and 4 shows the nonlinear variation of viscosity and density with molar concentration indicates molecular interaction between components molecules. The peak at 0.08 M concentration indicates strong association between interacting molecules at this concentration.

Free length[10] shows similar effect as adiabatic compressibility. Free length and adiabatic compressibility shows an opposite effect to ultrasonic velocity. Fig. 5 shows at lower concentration free length decreases and at higher concentration it goes on increases with increase in molar concentrations,can takes place due to structure making and breaking property of hydrogen bonding at lower and higher concentrations respectively.

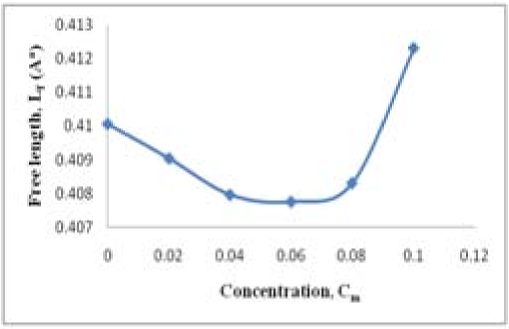

Figure 5: Variation of Free length with C_m this shows molecular association and dissociation

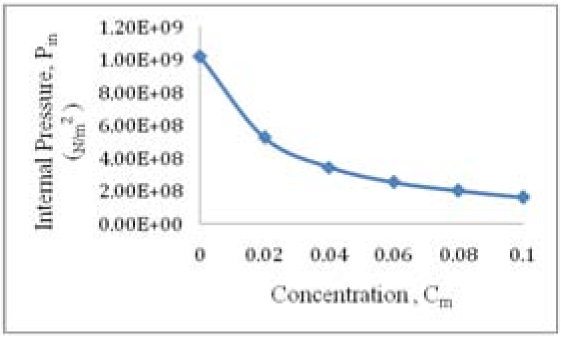

Figure 6: Variation of Internal pressure with C_m

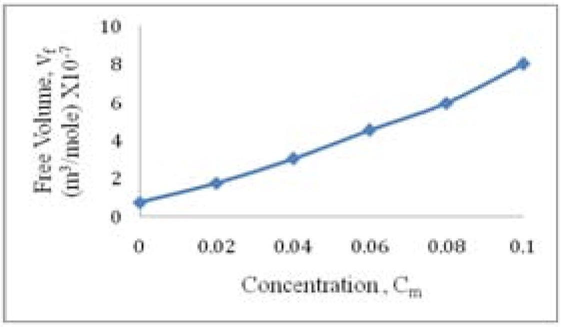

Figure 7: Variation of Free Volume with C_m

The internal pressure (P_{in}) is a measure of cohesive force, which is the resultant of attractive and repulsive forces between the molecules of ascorbic acid and NaOH. From Fig.6 it shows decreasing trends with increase in molar concentrations which is due to the decrease of cohesive forces leading to the breaking up of the structure of NaOH molecules[11] .Whereas free volume shows increasing trend with increase in molar concentration (Fig. 7),this occur due to dissociation of interacting molecules due to intermolecular forces.

4. Conclusion

The observed nonlinear variation of ultrasonic velocity, density, viscosity and related thermo acoustical parameters with molar concentration shows there exists intermolecular forces between molecules of ascorbic acid and NaOH. The complex formation and molecular association in these mixtures may be due to formation of hydrogen bonding in the molecules. The heteromolecular interactions are present in binary liquid mixture.The cohesion among the molecules increases or decreases by breaking or making the open structure in binary liquid mixture. The hydrogen bond formation are responsible for observed heteromolecular interaction in the binary mixture.

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