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STUDY OF ACOUSTICAL PARAMETERS OF AQUEOUS POTASSIUM SULPHATE AT DIFFERENT TEMPERATURE AND CONCENTRATION

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ABSTRACT: Ultrasonic velocity (μ), viscosity (η) and density (ρ) have been measured in the aqueous solution of potassium sulphate + water having frequency 2MHZ at temperature 288.15K, 293.15K and 298.15K. Ultrasonic velocity, density and viscosity have been supported for the evaluation of acoustical parameters viz. Adiabatic Compressibility, Molar Volume, Available Volume, Lenard Jones Potential, Rao's Constant, Acoustic Impedance & Free Length from experimental data. The acoustical parameter proved the intermolecular interaction in the aqueous solution of potassium sulphate water. These provide important information about solute-solvent, ion-ion, dipole-dipole and ion-solvent interaction in the solution. The result has been interpreted in the light of various inter and intramolecular interactions of liquid mixture.

Key words: - Potassium sulphate, ultrasonic velocity, density, viscosity, acoustical parameters.

INTRODUCTION :

Ultrasonic is a non-destructive flexible method and is very useful in the investigation of variousphysical fieldslike residual pressure, stiffness, grain size microstructure, elastic constant etc. Different acoustical parameters will be calculated from the values determined by the ultrasonic velocity, density & viscosity. [1] Current advances have been made in the use of ultrasonic power in medicine, engineering, and agriculture. The ultrasonic method has become widely accepted for non-variance imaging of the human body and thus offers greater potential for further development in diagnostic medicine. Thus, characterization of material by the determination of ultrasonic wave propagation parameter is encouraged.

Due to the widespread use of ultrasonic in the field of Acoustic microscopy, Sono-chemistry, Drug Chemistry, textile industry, paint industry, food and oil industry, Metal Flaw Detector, Polymers, Surfactants, Binary and Ternary liquid, Computer technology, Underwater acoustics, Medical imaging technology, Electro-chemistry and many other industrial areas. [2] This type of research is very important in understanding the quality and type of solution.A Fertilizer is any material of natural or synthetic origin that is applied to soil or to plant tissues to supply one or more plant nutrients essential to the growth of the plant. Many sources of fertilizer exit both natural and industrial.[3]

Ultrasonic studies help in the understanding of various molecular interactions in the aqueous fertilizer through light on the nature of intermolecular interaction existing in the solution. Thus in this paper, we are reporting the various acoustical parameter of aqueous potassium sulphate. K_2SO_4 does not contain chloride, which can be harmful to some crops. The dominant use of potassium sulphate is as a fertilizer. Potassium sulphate is preferred for these crops, which include tobacco and some fruits and vegetables. Less sensitive crops may still require potassium sulphate for optimal growth if the soil accumulates chloride from irrigation water [4]. These data are useful to understand the nature of the biological molecule.

Experimental Details:

The solutions of various concentration of potassium sulphate were prepared in distilled water as the solvent. The densities of these solutions were determined accurately using 10 ml density bottle in an electronic balance with ±0.01mg accuracy. The basic parameter ultrasonic velocity had been measured on Digital Ultrasonic Interferometer with single frequency of 2MHz having an accuracy of 0.1%. Ostwald's viscometer calibrated the viscosities of the solutions with accuracy of ±0.001 Pa.sec. This basic parameter of potassium sulphate solution was measured at 288.15, 293.15 and 298.15K. The various acoustical parameters were determined from μ, η and ρ values by using following formulae.

Defining Relations:

Acoustical and volumetrical parameters can be calculated using the following relations:

1. Adiabatic compressibility (βa):$\beta_a = 1/u^2\rho$
2. Molar volume(V_m): $V_m = \frac{Meff}{\rho}$
3. Available volume(V_a) : $V_a = V_m(1-u/u_\infty)$
4. Lenard Jones Potential (L.J.P.): L.J.P.=6-$(\mathbf{V_m/V_a})$ $-\mathbf{13}$
5. Rao's Constant (Ra): Ra = $(M_{eff}/\rho)\ (u)^{\frac{1}{3}}$
6. Acoustic Impedance (Z):Z = uρ
7. Free Length (L_f):L_f = K $(\beta_a)^{\frac{1}{2}}$

RESULTS AND DISCUSSION:

From fig.1, it is observed that ultrasonic velocity is found to increase with the increase in temperature & concentration. The greater association is due to dipole-dipole, ion-dipole and hydrogen bonding between solute (potassium sulphate) and solvent (water) molecules. [5] Now Fig.2 show that density increase with the increase in concentration it may be due to closed packing of the solute-solvent interactions among the particles of the mixture. Thus Increase in density indicate the structure-maker of the solvent due to the added solute. Also found is that density decreases as the temperature of the system increases. As the temperature increases, the thermal motion of the particles also increases. Thus particles become loosely packed to cause a decrease in density. [6]

The viscosity of potassium sulphate solution is found to increase in fig. 3 with the increase in concentration. The strong association in potassium sulphate solution may be due to the intermolecular hydrogen bonding between solute and solvent molecules. It is found that viscosity decreases as the temperature of the system increases. This is because as the temperature increases, the kinetic energy of the molecules increases which diminishes the viscosity of the medium. [7]

The adiabatic compressibility (βa) decreases with an increase in the concentration of potassium sulphate is due to interaction between the ions and the water molecules show in fig. 4 and decreases with increases in temperature because of the molecular interaction of solute and solvent molecules.[8] Fig.5 Show the trend of Molar volume (V_m) expressing the solute-solvent interaction in the solution. It shows that, as value decrease in the percentage of concentration at 288.15k, 293.15k, and 298.15k. Molar volume decreases with an increase in concentration & temperature and the available volume of the solution decreases with the rise in concentration but increases with the rise in temperature as expected due to the thermo-molecular interaction of solute and solvent molecules show in fig. 6. [9]

Fig.7 Show that the Lenard Jones Potential values are negative and increase in all the systems. The small negative values show that the repulsive forces are higher and the attractive forces are lesser in these systems. It is increasing as an increase in concentration indicated that the dipole-dipole attraction is stronger. [10]

From fig. 8 found that the variation of Rao'sconsant with concentration and temperature.The decreasing trend of Rao's constant with increases in temperature exhibit the interaction among the compound of solute and solvent.

Acoustic impedance of potassium sulphate solutions is increase in concentration. Hence acoustic impedance increases with the strong association in the solution.[11] It is found that acoustic impedance decreases as the temperature of the system increases. This is because acoustic impedance is inversely related to the temperature of the medium.[12] and also from graph 10 it is observed that the value of Intermolecular free length (L_f) decreases steadily with an increase of concentration. This indicates the significant dipole-induced dipole interaction between solute and solvent due to which structural arrangement is affected.

CONCLUSION:

The variation of ultrasonic velocity, density and viscosity and other related thermodynamic parameters such as adiabatic compressibility, molar volume, available volume, Lenard Jones Potential, Rao's constant, Acoustic Impedance & Free Length at various concentrations and temperature in potassium sulphate shows the non-linear increase or decrease behavior. The non-linearity observed the presence of solute-solvent, ion-ion, dipole-dipole, ion-solvent interactions. This suggests information about inter and intramolecular interaction of liquid mixture.

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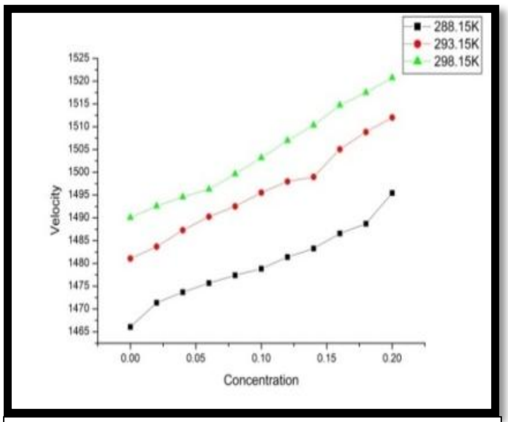

Fig .1. Variation of Velocity with molar conc.

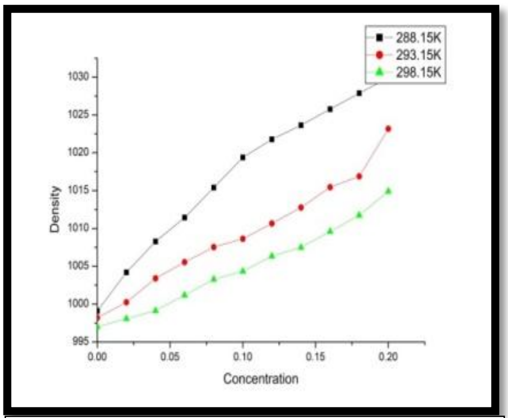

Fig 2. Variation of Density with Molar conc.

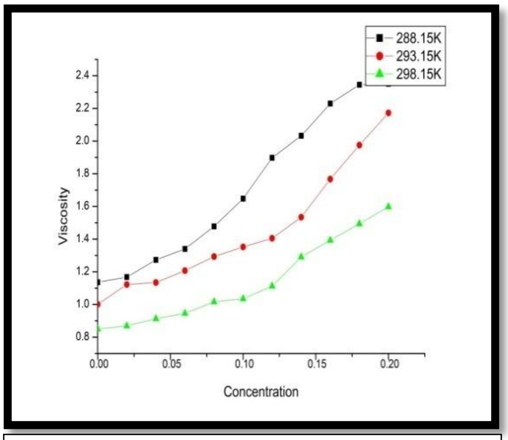

Fig. 3 Variation of Viscosity with molar conc.

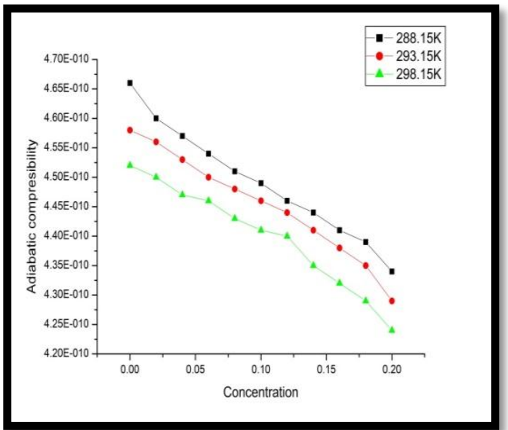

Fig. 4 Variation of Adiabatic Compressibility with molar conc.

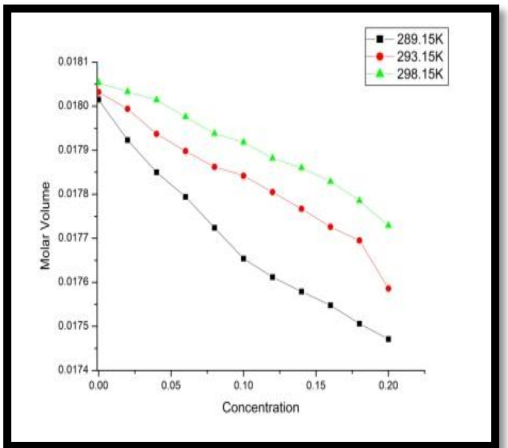

Fig. 5 Variation of Molar Volume with molar conc.

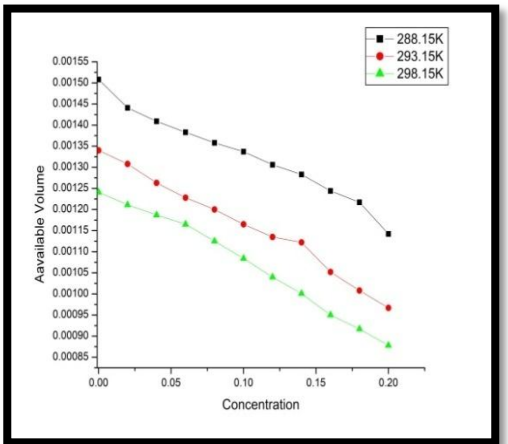

Fig.6 Variation of Available volume with molar conc.

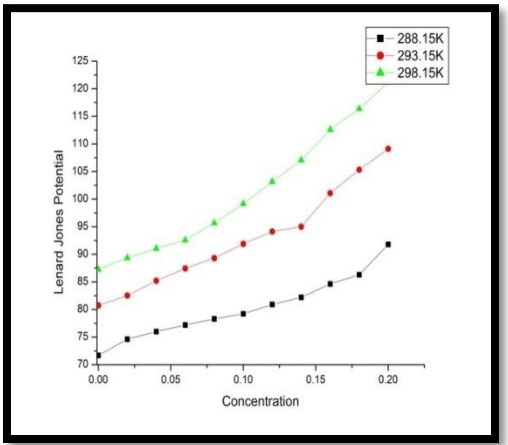

Fig. 7 Variation of Lenard Jones Potential with molar conc.

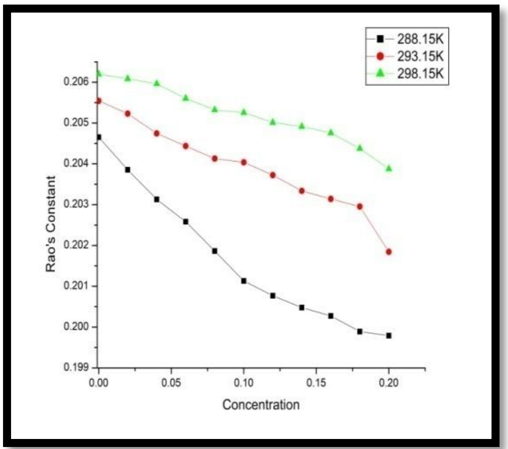

Fig. 8 Variation of Rao's Constant with molar conc.

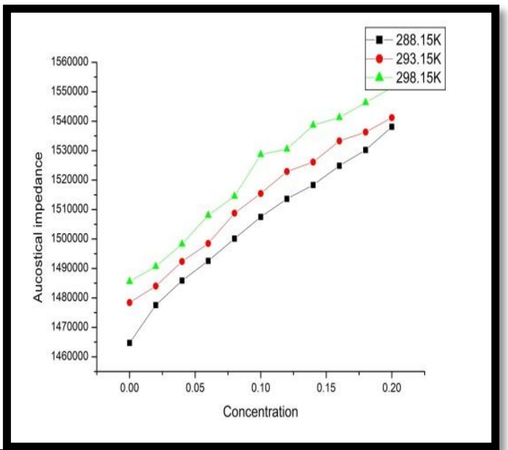

Fig.9. Variation of acoustical Impedance with Molar conc.

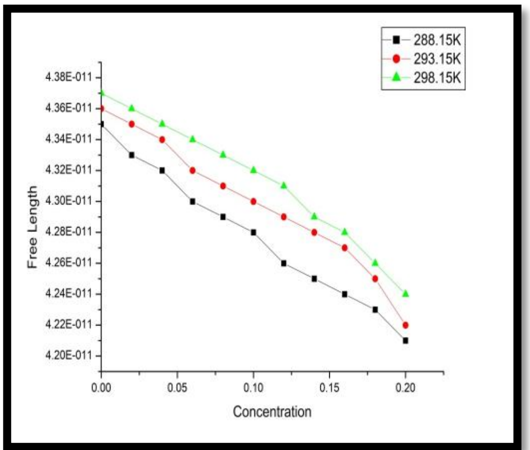

Fig .10.Variation of Free length with molar conc.