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RESEARCH ARTICLE

THERMODYNAMIC PROPERTIES OF TERNARY LIQUID MIXTURE OF α-TOCOPHEROL ACETATE WITH CHLOROFORM AND DIETHYL ETHER AT 293 K

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Abstract

The reported study, measured the ultrasonic velocity (u), density (ρ) and viscosity (η) of ternary liquid mixtures of α-Tocopherol acetate with chloroform and diethyl ether in the concentration range (0 to 0.1 M) at 293K. These experimental parameters can be used to calculate various thermodynamic parameters like free volume (V_f), internal pressure (π_{in}), Vander-Wall Constant (b) and Gibb's free energy (ΔG^*) etc. to identify the strength of molecular interaction. The results so obtained support the formation of complex structure and molecular aggregation through intermolecular hydrogen bonding in the ternary liquid system of α -Tocopherol acetate with chloroform and diethyl ether.

Introduction:-

In the past few years, many studies have focused on examining the physio-chemical behaviour and interactions of binary and ternary liquid mixtures based on their thermoacoustic properties[1-8]. These properties of liquid mixtures can be applied to design calculations and heat absorption pumps[9]. The basic parameters such as density, viscosity, and ultrasonic velocity are useful for equipment and molecular design[10]. Despite these basic parameters, researchers have studied various thermodynamic parameters of binary and ternary liquid mixtures and found potential applications in pharmaceutical, medicine, chemical, and biological sciences[11].

A literature review suggested that the majority of research has been done on the thermodynamic properties of peptides, ligands, bio-materials, polymers, water-soluble vitamins, organic liquids, etc. However, no such significant work has been recorded on α-tocopherol acetate with chloroform and diethyl ether. Therefore, the present work is undertaken to study their interaction for industrial purpose.

In this report, the ultrasonic velocity, density, and viscosity and related thermodynamic parameters i.e free volume (V_f), internal pressure (π_{in}), Vander-Wall Constant (b) and Gibb's free energy (ΔG^*) of α-Tocopherol acetate in chloroform and diethyl ether at 293K have been studied. These parameters vary according to molar concentrations and are useful to determine the strength of molecular interaction in the interacting components.

Materials and Method:-

The chemicals, α-Tocopherol acetate, chloroform and diethyl ether, used in this work are 99.9% purified and obtained from the MERCK company. The various concentrations of liquid solution were made and immediately utilised for the measurement of density, viscosity and ultrasonic velocity. An ultrasonic Pulse echo velocity meter

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with a 2 MHz frequency from Vi-Microsystem was used to determine ultrasonic velocity. The viscosity of the solution was measured by calibrated Ostwald viscometer. A digital electronic stopwatch was used to measure the flow time of solution with an accuracy of ± 0.01 s. The density of experimental liquid was determined using the Pycnometer method, utilizing a 25 ml specific gravity bottle with an accuracy of ± 0.5%. The mass of the solution was measured using digital weighing with an accuracy of ± 0.1 mg. The solution was maintained constant at 293 K using a water bath of accuracy± 0.1 K.

Result and Discussion:-

The measured ultrasonic velocity and related thermodynamic parameters such as free volume (V_f), internal pressure (π_{in}), Vander-Wall Constant (b) and Gibb's free energy (ΔG^*) of α -Tocopherol acetate with chloroform and diethyl ether at 293K are shown in fig.1 to 6.

As shown in Fig.-1, the correlation between the ultrasonic velocity and the molar concentration of α -Tocopherol acetate is nonlinear. This suggest the formation of complex structures and aggregation of molecules might be due to hydrogen bond formation[12-13]. This behaviour indicates the structure forming and breaking effect of α -Tocopherol acetate. This further demonstrates the hydrophilic and hydrophobic properties of α-Tocopherol acetate in relation to diethyl ether and chloroform. The relative peak of ultrasonic velocity at 0.04M concentration indicates strong hydrogen bonding between the molecules of α-Tocopherol acetate, chloroform and diethyl ether.

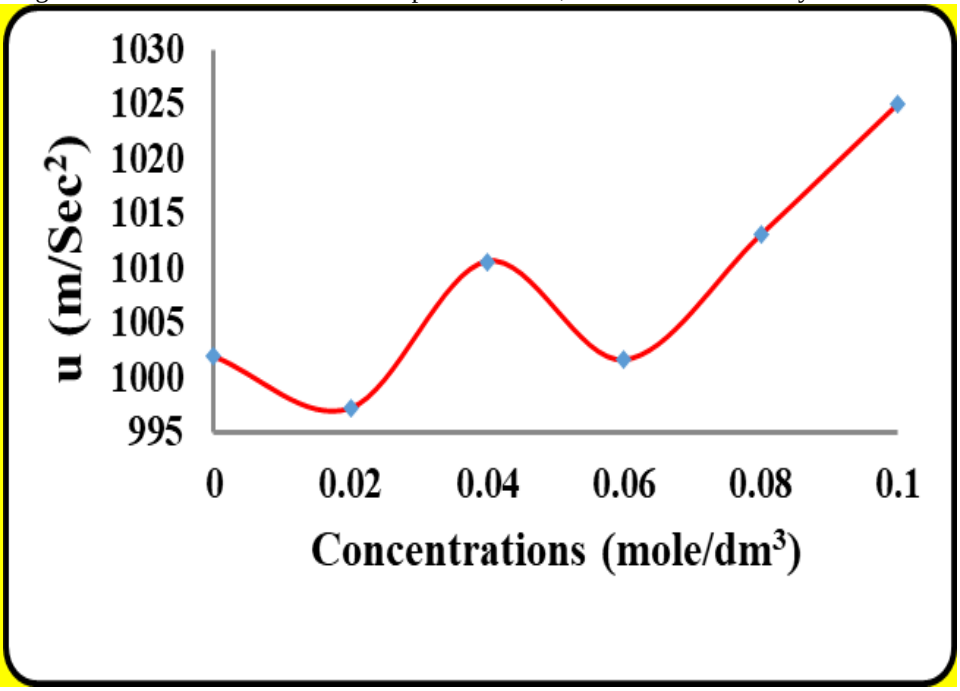

Fig. 1:- Variation of ultrasonic velocity with concentrations.

Free volume is one of the parameters used to measure the binding forces between the solute and the solvent molecules[14].The Free volume varies with molar concentrations, as presented in Fig.-2. As the concentration of α -Tocopherol acetate increases, molecules of chloroform and diethyl ether can move away from each other. This reduces the possibilities of interactions, which further decreases the cohesive force and ultimately increases the free volume[15].

Internal pressure is one of the tool used to measure the cohesive forces between the interacting molecules. As seen in Fig.3, internal pressure decreases with an increase in the concentration of α -Tocopherol acetate. This indicates the dissociative tendency of molecules due to reduced molecular interactions between the interacting components.[16].

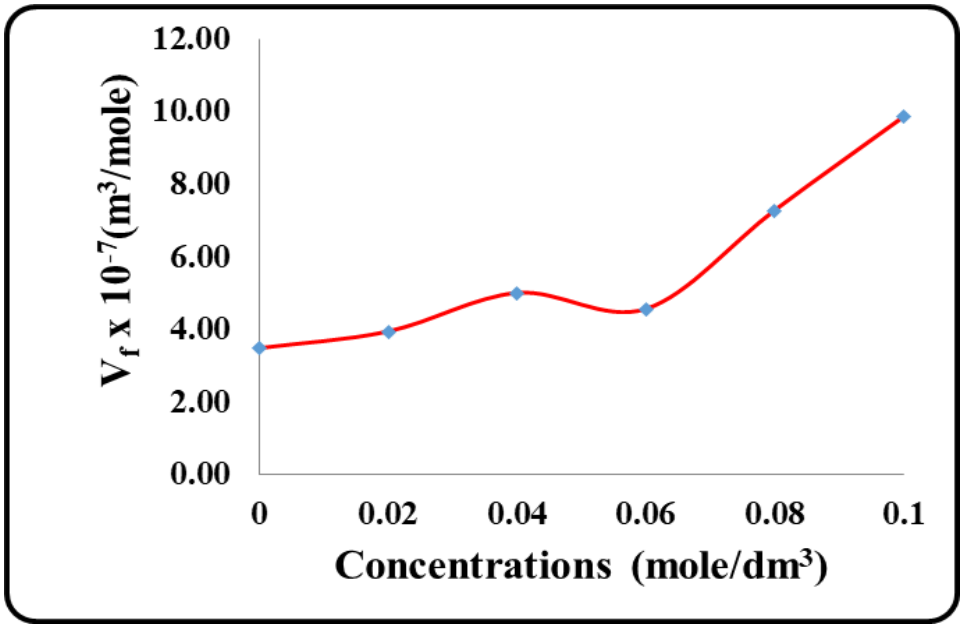

Fig. 2:- Variation of Free Volume with concentrations.

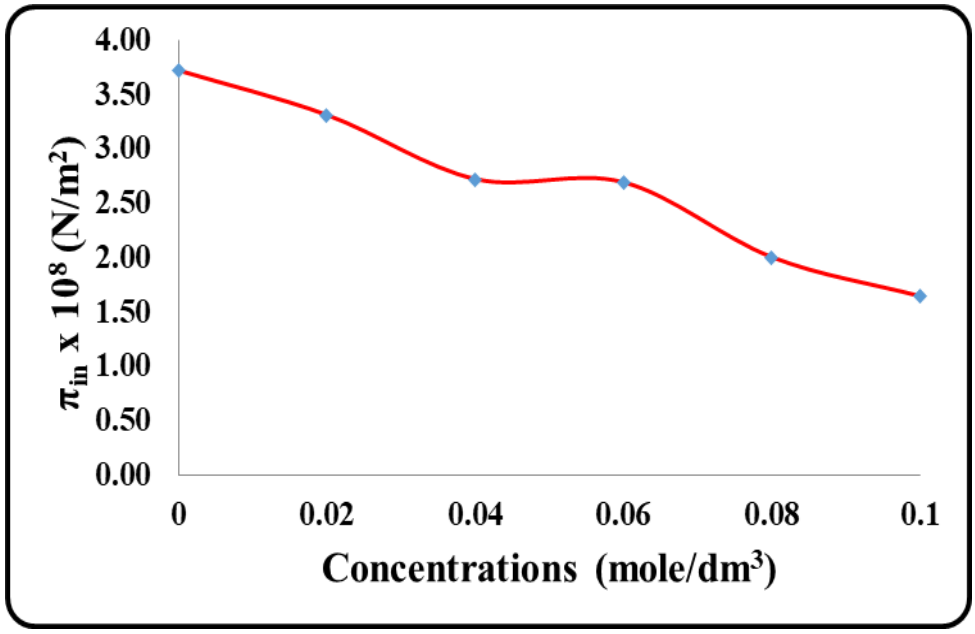

Fig. 3:- Variation of Internal pressure with concentrations.

The intermolecular geometry of solute and solvent molecules is reflected in Vander Waal's constant (b). The Vander Waals constant varies with molar concentration, as shown in Fig.4. It is observed that the Vander Waals constant increases with molar concentration, causing a densely packed structure of interacting molecules within the shell.

The Gibb's free energy (ΔG^*) suggests the existence of molecular interactions between unlike molecules. The value of Gibb's free energy increases and shows a maximum peak at 0.06 molar concentration [Fig-5]. This indicates that intermolecular forces cause unlike molecules to bring closer. The peak at 0.06 molar concentration shows the maximum association of interacting molecules. After 0.06 molar concentration, Gibb's free energy suddenly decreases, resulting in a smaller time for the co-operative process in the mixture due to the dissociative tendency of molecules.[17-18]

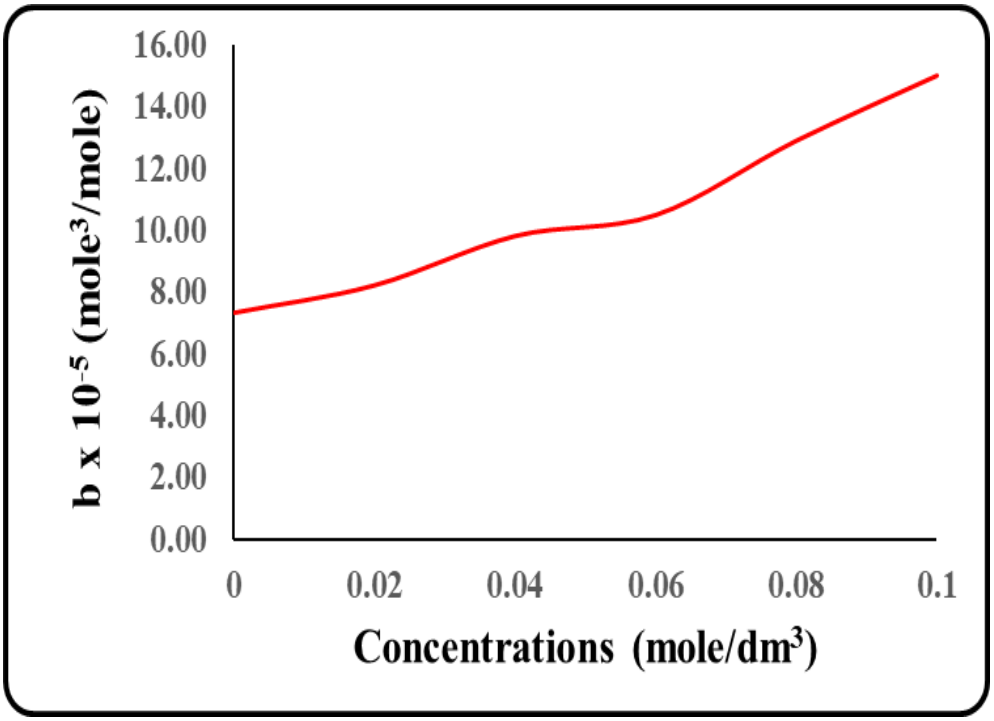

Fig. 4:- Variation of Vander Waal's constant with concentrations

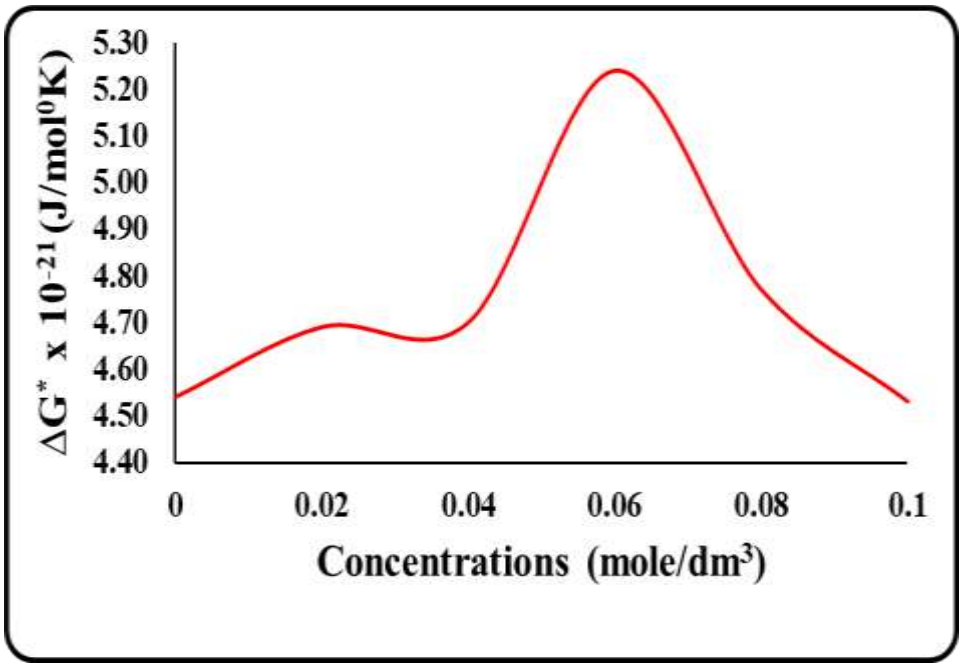

Fig. 5:-Variation of Gibb's free energy with concentrations.

Conclusions:-

The thermodynamic parameters were computed using ultrasonic velocity, density and viscosity data. The system favours molecular interactions between the solute and solvent, as evidenced by complex and hydrogen bond formation in the solutions, and therefore, a change occurs in the thermodynamic properties of liquid mixtures. Hence, it may be inferred that there exists a strong interaction between the solute (α-tocopherol acetate) and solvent (diethyl ether and chloroform) molecules at 293K.

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