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STUDY OF ACOUSTICAL PARAMETERS OF BINARY LIQUID MIXTURES AT 298K AND 2 MHZ FREQUENCY

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Abstract: Ultrasonic velocity, density and viscosity of a binary system of Methylmethacrylate in Acetone have been measured at 298K and 2 MHz frequency. Experimental data of the ultrasonic sound velocity, density and viscosity have been used to calculate various acoustical parameters such as adiabatic compressibility (β_a), intermolecular free length (L_f), free volume (V_f), excess values of adiabatic compressibility (βa^E), excess values of free length (L_f^E) and excess values of free volume (V_f^E). It is observed from these acoustical parameters that, weak intermolecular interactions are confirmed in this system. Dipole inducement in the system is found to be more predominant. The nonlinear behavior of all these parameters throws more light on the various interactions among the molecules.

Keywords: Acoustical parameters, Methylmethacrylate, binary liquid mixture, Acetone, molecular interactions and ultrasonic velocity.

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INTRODUCTION

The non-linear variation of ultrasonic velocity, density, viscosity and other calculated acoustic parameters, such as adiabatic compressibility (β_a), intermolecular free length (L_f) and free volume (V_f), along with their excess values in binary liquid mixtures with respect to mole fractions of one components are of large importance for industrial applications in recent years. The ultrasonic study of binary liquid mixtures containing polar and non-polar components find various applications, as such liquid mixtures with appropriate properties provide a wide range of solutions [1-4].

Ultrasonic velocity measurements are used to study physicochemical behavior and molecular interactions in pure liquids and liquid mixtures. The ultrasonic velocity gives information about the bonding of molecules and formation of complexes at various temperatures through molecular interactions. To study important thermodynamic parameters of solutions, it is necessary to use their ultrasonic velocity, density and viscosity. Ultrasonic velocity and viscosity measurements have been used widely in molecular interactions and structural evaluations [5-7].

In the present work, the binary solutions of Methylmethacrylate in Acetone were studied, in terms of adiabatic compressibility, intermolecular free length, free volume according to the ultrasonic measurement results at 298K. The observations can be interpreted in terms of molecular interaction between the components of the mixtures.

I. MATERIALS AND METHODS

The chemicals Acetone and Methylmethacrylate, used in the present work were of AR grade. Solutions of different concentrations were prepared with all precautions to minimize the possible experimental error. Ultrasonic velocity (U) of the liquid mixtures were measured at 298K by using an ultrasonic interferometer (Mittal Enterprises, Model F-81) working at 2 MHz. The accuracy of sound velocity was ±0.1m/s. Constant temperature water bath was used in which water was circulated through double walled measuring cell made up of steel containing at 298K. Densities of pure liquids and the mixtures were measured by using pycknometer with an accuracy of ±0.1Kgm^{-3}. An Ostwald's viscometer was used for the viscosity measurement with an accuracy of ±0.0001NSm^{-2}. The temperature fluctuation around the viscometer and pycknometer was maintained within ±0.1K.

II. RESULTS AND DISCUSSION

The experimental data of ultrasonic sound velocity, density and viscosity were used to calculate various acoustical parameters, such as adiabatic compressibility (β_a), intermolecular free length (L_f), free volume (V_f), by using the following equations (1-3):

$\beta_a = (U^2 \rho)^{-1}$ ...... (1)

$L_f = K_T \beta a^{1/2}$ ..... (2)

$V_f = (M_{eff} U/\eta K)^{3/2}$ ...... (3)

where, K_T in equation (2) is the temperature dependent constant having a value of $205.8336*10^{-8}$ in MKS system at 298K, K in equation (3) is a constant equal to $4.28*10^9$ in MKS system, $M_{eff} = \Sigma x_i m_i$, where x_i is the mole fraction and m_i is the molecular weight of the component. The excess values like V_f^E, β^E, L_f^E have been calculated using the following standard relation: $A^E = A_{exp} - A_{id}$. Where, $A_{id} = \Sigma A_i X_i$, where, Ai is any acoustical parameter and Xi is the mole fraction of liquid component.

The measured parameters *viz*., density (ρ), ultrasonic velocity (U) and viscosity (η) and calculated parameters such as adiabatic compressibility (β_a), intermolecular free length (L_f) and free volume (V_f) for the system 298K are shown in figure I-VI for the binary system of Methylmethacrylate in Acetone at 298K.

Figure shows that, density increases with concentration of Methylmethacrylate in Acetone But the ultrasonic velocity decreases in the system. Viscosity increases in the system, suggesting thereby more association between solute and solvent molecules.

From the figure, the adiabatic compressibility and free length decreases with increase of mole fraction of the Methylmethacrylate. This may lead to the presence of specific molecular interaction between the molecules of the liquid mixture. The adiabatic compressibility and free length are the deciding factors of the ultrasonic velocity in liquid systems. Decrease in intermolecular free length in the system leads to negative deviation in compressibility. This indicates that the molecules are nearer in the system.

The free volume increases with increasing mole fraction of the solute in this system. Then it decreases upto 0.4 mole fraction and again free volume increases with increasing mole fraction. The increase in free volume show that the strength of interaction increases gradually with the increase in Methylmethacrylate concentration. It represents that there is molecular interaction between the Methylmethacrylate and Acetone molecules. Thus, a progressive increase in free volume in mixtures clearly indicates the existence of intermolecular interaction, due to which the structural arrangement is considerably affected.

Fig. VII and VIII indicates that βa^E and L_f^E are negative over the entire mole fraction range. The negative βa^E clearly suggests that weak dispersive interactions between the components of the mixture. The trends of fig. shows that βa^E and L_f^E are increasingly negative as Methylmethacrylate mole fraction is increased. Thus, strong dipolar interactions are restricted more and more whereas the weak dispersive interactions are predominating and are maximum around 0.4 mole fractions. As the molecular symmetry is retained to a greater extent at 0.9 mole fraction, βa^E and L_f^E are found to decrease. However, V_f^E for the system is mostly negative fig. IX, existing weak dispersive interactions [8-11].

Figure I - IX: The variations of Density (ρ), Ultrasonic velocity (U), Viscosity (η), adiabatic compressibility (β_a), free length (L_f) and free Volume (V_f) and their excess parameters w. r. to mole fraction (x) of system Methylmethacrylate in Acetone at 298K are shown in Figure I, II, III, IV, V, VI, VII, VIII and IX respectively.

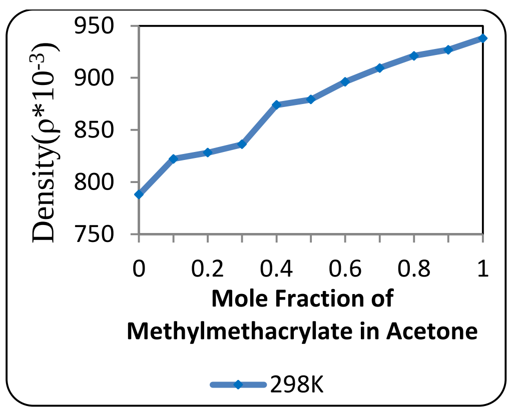

Fig. I

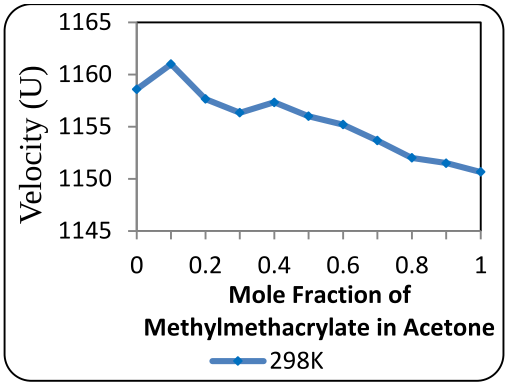

Fig. II

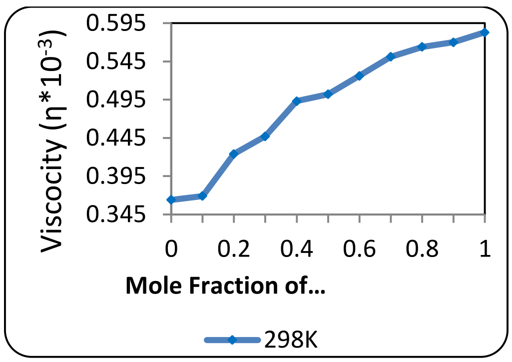

Fig. III

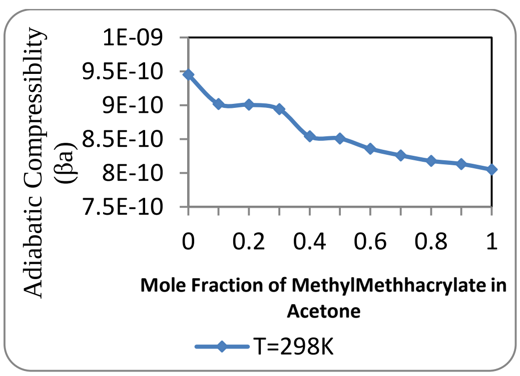

Fig. IV

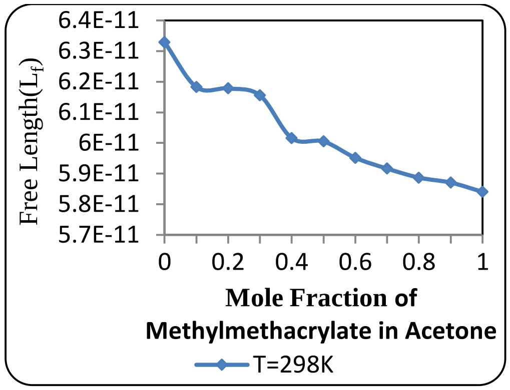

Fig. V

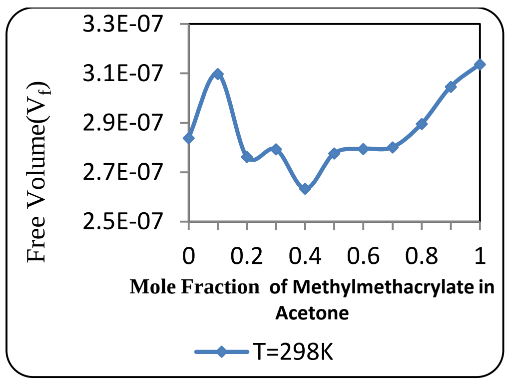

Fig. VI

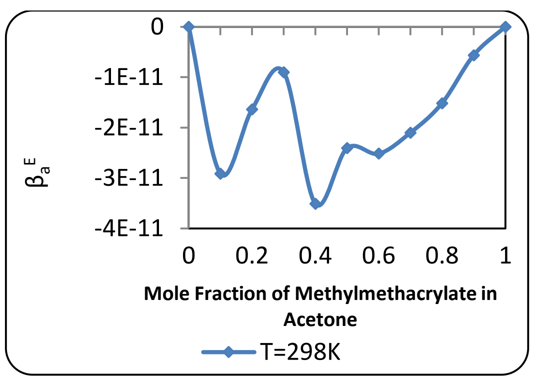

Fig. VII

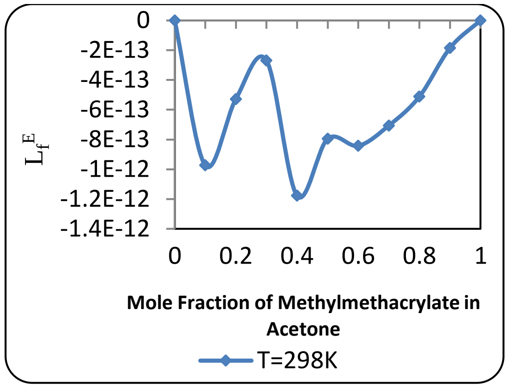

Fig. VIII

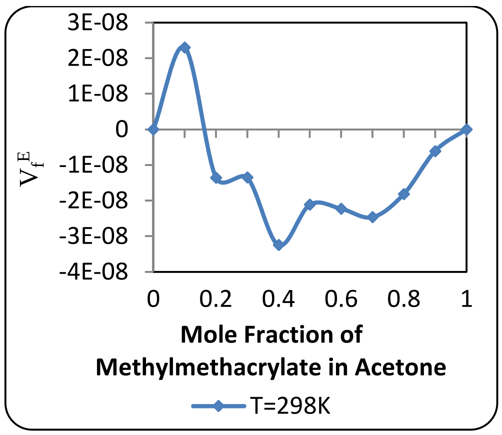

Fig. IX

III. CONCLUSIONS

The existence of solute-solvent type molecular interaction is favored in system studied, confirmed from the U, ρ, η, βa, L_f and V_f data. The variation in all parameters is non-linear. Ultrasonic velocities of the system decreases, depending on the concentration of Methylmethacrylate. The nonlinear behavior confirms the presence of solute-solvent and solvent-solvent interactions. As Methylmethacrylate and Acetone are polar in this system; dipole - dipole interaction is present. The excess parameters give a measure of non-ideality of system as a consequence of associative or of other interactions. Measurements of acoustic parameters and their excess values are strongly correlated with each other.

IV. ACKNOWLEDGEMENT

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