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# Study of Ultrasonic Wave Velocity in Organic Binary Mixture Liquids of Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$) at 308.15K

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**ABSTRACT** The measurement and investigation of the ultrasonic velocity (U), density ($\rho$), viscosity ($\eta$), adiabatic compressibility ($\beta_a$), intermolecular free length ($L_f$), Gibb's free energy (G), molecular volume ($V_m$), available volume ($V_a$), free volume ($V_f$) and specific acoustic impedance (Z) studied in binary liquid mixtures of Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$) at 308.15K.

**KEYWORDS** Molecular volume, Binary liquid and Methyl Propyl Ketone.

## Introduction

The physio-chemical behaviour of hydrogen bounded organic compounds or mixture liquids can be studied by the measurements of the ultrasonic velocities. Rowlinson(1959) studied the velocities of ultrasonic waves in the liquids and the mixture liquids of organic compounds[1]. Fort and Moore (1965) studied the binary liquid mixtures of polar, non-polar compounds showed that none of these compounds obey the simple additive law[2]. Ramamoorthi and Varadachari (1973) discussed the interaction in the liquid mixtures using ultrasonic velocity and density data[3]. Shrivastava et al.(1985) studied the strength of interactions in the liquid mixtures in molecular term[4]. Roy and Choudhary (1992) investigated of the sound velocity in the organic liquid mixtures[5]. Sudhanshu and Choudhary (1996) have studied the excess properties of binary and ternary polar and non-polar liquid mixtures[6]. Singh et al. (1991) Measured the the density, velocity and other parameters and their excess values[7]. Ali et al. (2001) used eighteen binary mixtures of ACN (Aconitrile) to calculate all the related parameters of the mixtures and their excess values[8]. Gandole et al.(2010) presented the system of binary mixture for simulation, processing ans measurement in the graphical user representation and obtained the same result as obtained in the experiment[9]. Ubagaramary and Neeraja (2012) measured ultrasonic velocity, density and other related paramaeters and their excess values in the mixtures containing IBMK and aniline & IBMK and ethyle aniline[10]. Sanwal, Manish and Bhatt (2015) studied the characteristics of the binary liquid of n-hexane acetic acid and obtained the same result to the experimental fact[11]. Bahadur Alisha et al. (2017) measured the density and ultrasonic velocity in

binary liquid mixtures of benzene with alcohol of related parameters and excess values at 308.15K[12]. Raoo et al. measured the ultrasonic velocities and densities of mixtures of trichloroehelene with three alcohols experimentallyand obtained good result between experimental and theoretical values[13].
In the present paper, we have measured and investigated the ultrasonic velocity (U), density ($\rho$), viscosity ($\eta$), adiabatic compressibility ($\beta$), intermolecular free length ($L_f$), Gibb's free energy(G), molecular volume ($V_m$)available volume ($V_a$), free volume ($V_f$), specific acoustic impedance (Z), enthalpy (H).

## THEORETICAL MODEL USED FOR THIS WORK

The information regarding the behaviour of the organic mixture liquids are provided by the investigations of derived parameters such as adiabatic compressibility ($\beta$), intermolecular free length ($L_f$), Gibb's free energy of activation flow (G), Wada constant(W), Rao constant ($R_n$), free volume ($V_f$), Molecular volume ($V_m$) specific acoustic impedance (Z), enthalpy (H) etc. and their excess values.

$$\beta_a = \left(\frac{1}{\rho}\right)u^2 \qquad V_m = \frac{M}{\rho} \qquad V_a = V_m\left[1-\frac{U}{U_m}\right]$$

$$V_f = \left(\frac{Mu}{k\eta}\right)^{3/2} \qquad Z = \rho u$$

## RESULTS

**Binary organic mixture liquids of the system III [Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$)]**:

In this case, we have investigated the binary organic mixture liquids of the system III consisting of Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$) at 308.15K. The measured values of ultrasonic velocity (U), density ($\rho$), viscosity ($\eta$) at the temperature 308.15K over the entire composition range for the binary mixtures of carbon tetra chloride and propyl ethyl ketone ($CCl_4$+PEK) system given in the table 1 and their excess values are given in the table 2.

**Table 1: Bezaldehyde and Metyl propyl Ketone ($C_6H_5CHO$+MPK) at 308.15K**

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| **S N.** | **$X_1$** | **Velocity (U) (m/s)** | **Density ($\rho$) (kg/m$^3$)x10$^{-4}$** | **Viscosity ($\eta$) (NSm$^{-2}$)** | **Molecular volume $V_m = \frac{M}{\rho}$ (m3/mole)x10$^{-6}$** |
| 1. | 0.0000 | 1403.1 | 1050.71 | 13.4210 | 102.6012 |
| 2. | 0.1085 | 1370.8 | 1010.62 | 12.3812 | 101.9228 |
| 3. | 0.2890 | 1315.2 | 1000.32 | 10.3608 | 100.5426 |
| 4. | 0.3670 | 1289.5 | 960.520 | 8.2340 | 100.1172 |
| 5. | 0.4252 | 1272.8 | 914.231 | 6.6540 | 98.2501 |
| 6. | 0.5071 | 1248.7 | 895.125 | 6.2114 | 94.3258 |
| 7. | 0.6112 | 1226.9 | 880.142 | 5.6068 | 93.4070 |
| 8. | 0.7370 | 1209.6 | 846.701 | 4.3340 | 92.6867 |
| 9. | 0.8925 | 1190.5 | 810.682 | 4.1012 | 91.3412 |
| 10. | 1.0000 | 1175.6 | 798.254 | 3.9508 | 90.2365 |

**Continued.....**

| 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|
| Available volume $V_a = V_m\left[1-\frac{U}{U_m}\right]$ ($m^3$/mole) | Adiabatic compressibility $\beta_a = \left(\frac{1}{\rho}\right)u^2$ x$TPa^{-1}$ | Intermolecular free length $[L_f = \left(\frac{V_f}{V}\right)^{1/3} L]$ x$10^{-2}$Metre | Specific acoustic Impedence $(Z = \rho u)$ (gm/cc) m/s | Free volume $V_f = \left(\frac{Mu}{k\eta}\right)$ (m3/mole) x$10^{-6}$ | Free Gibb's energy (G) KL/mole |
| 13.768 | 492.42 | 45.110 | 140.841 | 0.1644 | 14.845 |
| 16.522 | 540.38 | 46.980 | 135.674 | 0.1792 | 14.601 |
| 17.623 | 604.18 | 48.712 | 126.368 | 0.2129 | 13.980 |
| 19.820 | 664.32 | 52.801 | 117,876 | 0.2413 | 13.651 |
| 20.210 | 676.18 | 53.461 | 114.675 | 0.2530 | 13.220 |
| 21.513 | 725.37 | 54.140 | 110.365 | 0.2704 | 12.996 |
| 22.618 | 769.25 | 56.982 | 106.378 | 0.2803 | 12.556 |
| 23.712 | 810.12 | 58.104 | 103.987 | 0.3252 | 12.298 |
| 24.803 | 870.40 | 60.192 | 98.345 | 0.3718 | 11.120 |
| 24.705 | 889.10 | 60.984 | 95.475 | 0.4598 | 11.002 |

**Table 2: Excess values for Bezaldehyde and Metyl propyl Ketone ($C_6H_5CHO$+MPK) at 308.15K.**

| 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|
| **S N.** | **$X_1$** | **$V_m^E$ ($m^3$/mole)** | **$\beta_a^E$ ($TPa^{-1}$)** | **$\eta^E$ ($Nsm^{-1}$)** | **$G^E$ (KJ/mole)** |
| 1. | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 2. | 0.1085 | -0.0854 | -1.4052 | -40.632 | 10.9842 |
| 3. | 0.2890 | -0.0008 | -0.7842 | -85.437 | 22.0432 |
| 4. | 0.3670 | 3.3475 | 24.1012 | -12.478 | 21.6112 |
| 5. | 0.4252 | 3.5020 | 27.0852 | -125.400 | 23.8024 |
| 6. | 0.5071 | 3.6113 | 19.9870 | -112.670 | 34.0842 |
| 7. | 0.6112 | 2.7514 | 21.7542 | -80.987 | 56.7012 |
| 8. | 0.7370 | 0.7518 | -1.3038 | -52.925 | 47.5018 |
| 9. | 0.8925 | 0.8113 | 12.7120 | -21.471 | 40.6836 |
| 10. | 1.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

**Continued.....**

| 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|
| $V_a^E$ ($m^3$/mole)x$10^{-6}$ | $V_f^E$ ($m^3$/mole)x$10^{-6}$ | $V_m^E$ ($m^3$/mole) | $L_f^E$ (Mterer)x$10^{-13}$ | $Z^E$ ($kgm^{-2}s^{-1}$)x$10^{-4}$ |
| 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| 1.084 | -1.0200 | -0.0854 | 0.1224 | -150.082 |
| 1.743 | -1.0465 | -0.0008 | 1.4520 | -260.721 |
| 3.421 | -0.03089 | 3.3475 | 10.4502 | -751.362 |
| 3.542 | -0.0531 | 3.5020 | 12.6334 | -742.350 |
| 3.284 | -0.0698 | 3.6113 | 9.2840 | -712.603 |
| 3.101 | -0.0670 | 2.7514 | 9.2530 | -640.780 |
| 1.504 | -0.0540 | 0.7518 | 0.5070 | -283.842 |

| | | | | |
|---|---|---|---|---|
| 1.280 | -0.0432 | 0.8113 | 4.3780 | -230.742 |
| 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |

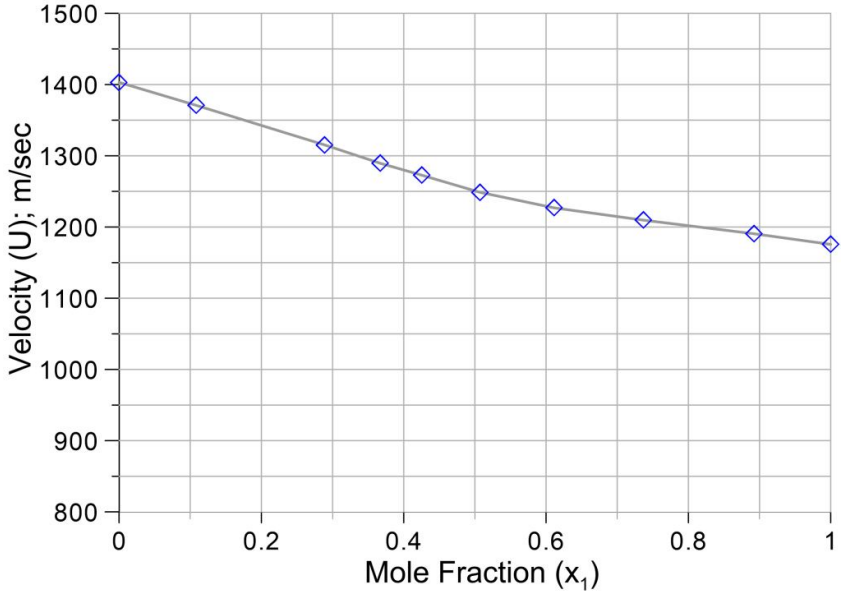


**Figure 1:** The figure shows the graph plotted betⁿ mole fraction and velocity of the ultrasonic waves for organic binary mixture liquids of Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$) at 308.15K.

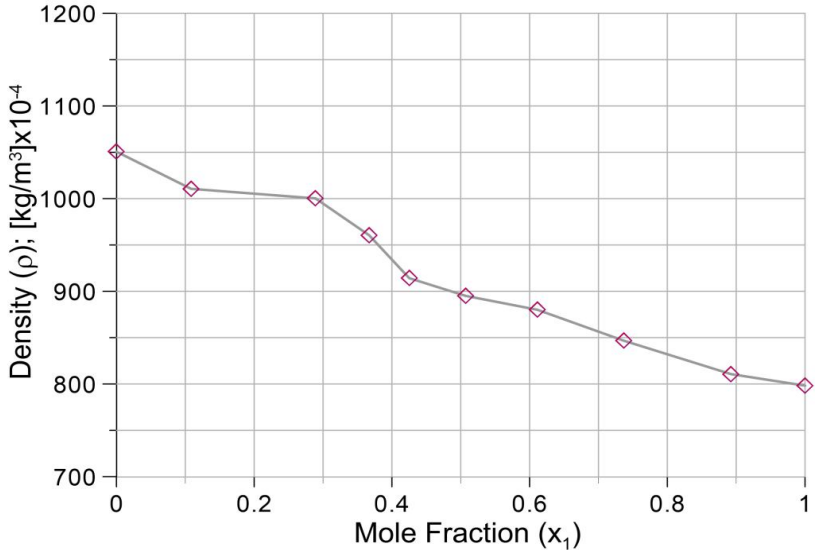


**Figure 2:** The figure shows the graph plotted betⁿ mole fraction and density for organic binary mixture liquids of Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$) at 308.15K.

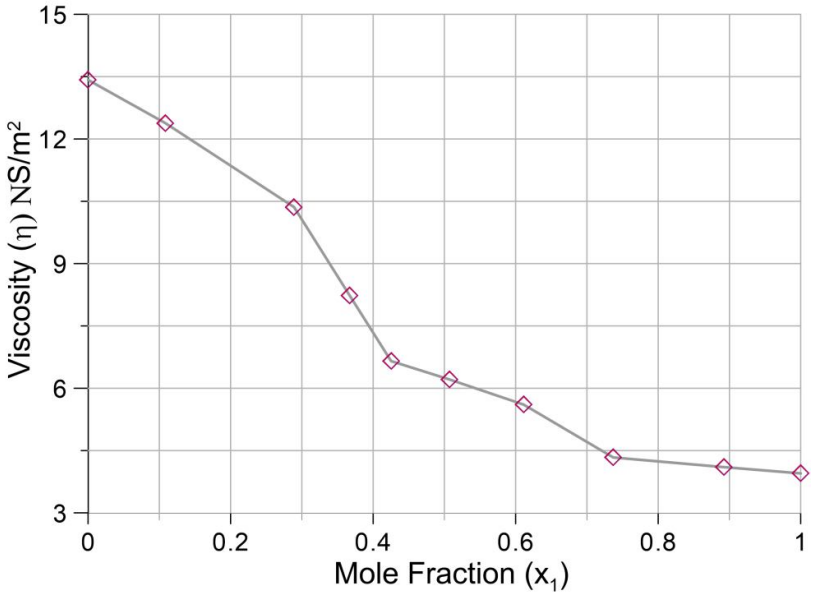


**Figure 3:** The figure shows the graph plotted betⁿ mole fraction and viscosity for organic binary mixture liquids of Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$) at 308.15K.

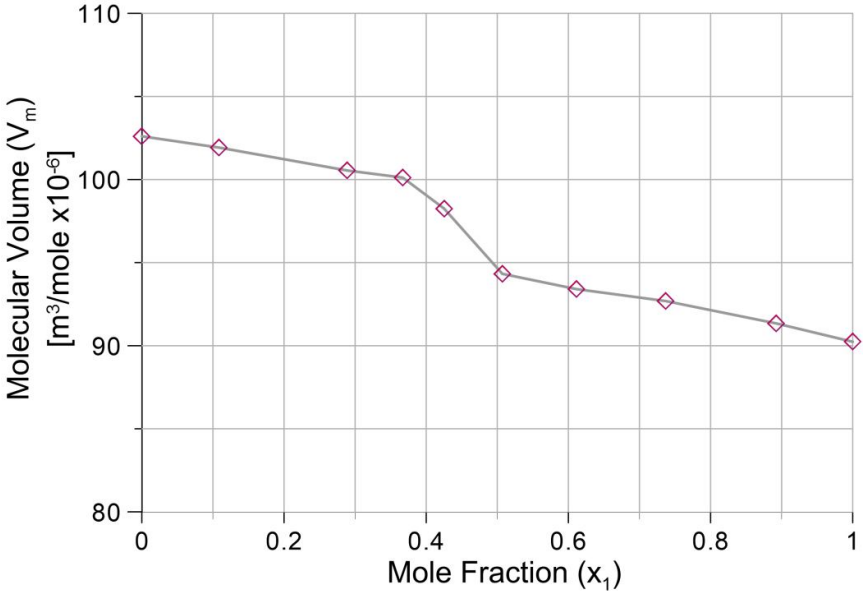


**Figure 4:** The figure shows the graph plotted betⁿ mole fraction and molecular volume for organic binary mixture liquids of Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$) at 308.15K.

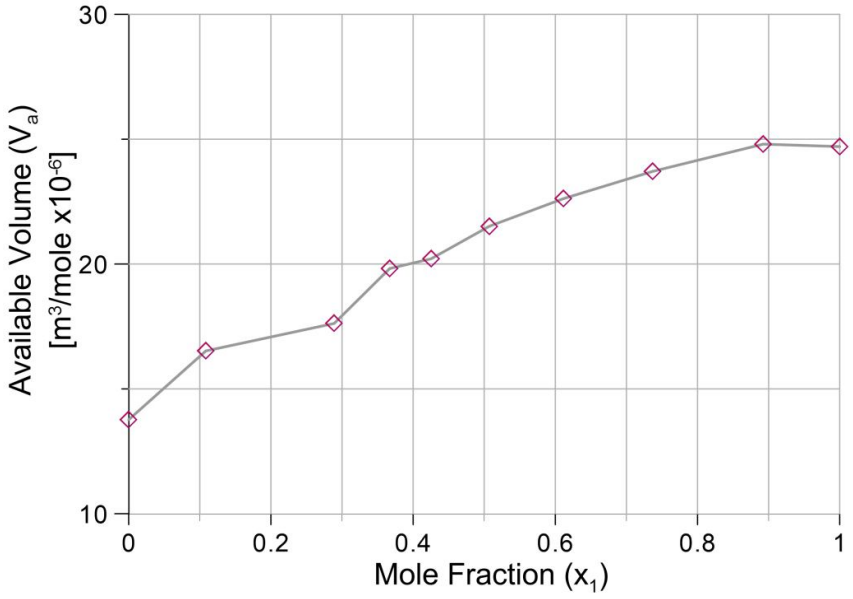


**Figure 5:** The figure shows the graph plotted betⁿ mole fraction and available volume for organic binary mixture liquids of Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$) at 308.15K.

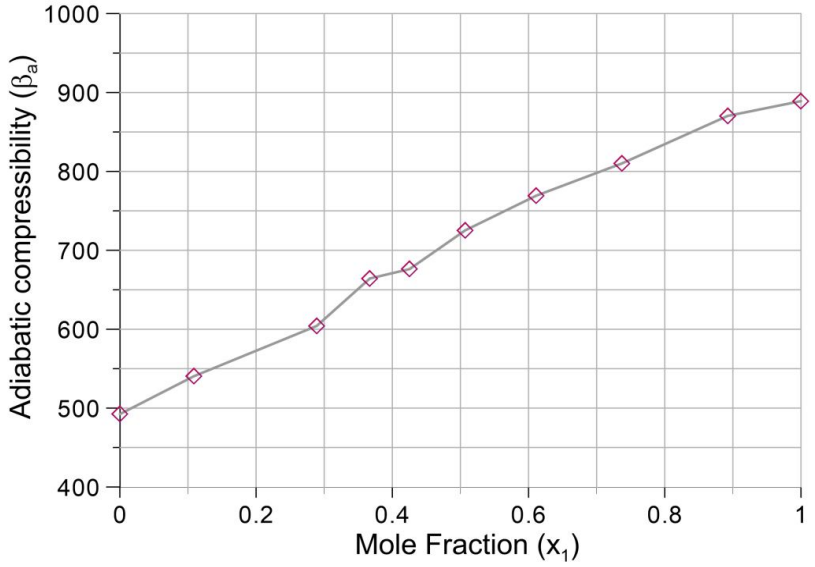


**Figure 6:** The figure shows the graph plotted betⁿ mole fraction and adiabatic compressibility for organic binary mixture liquids of Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$) at 308.15K.

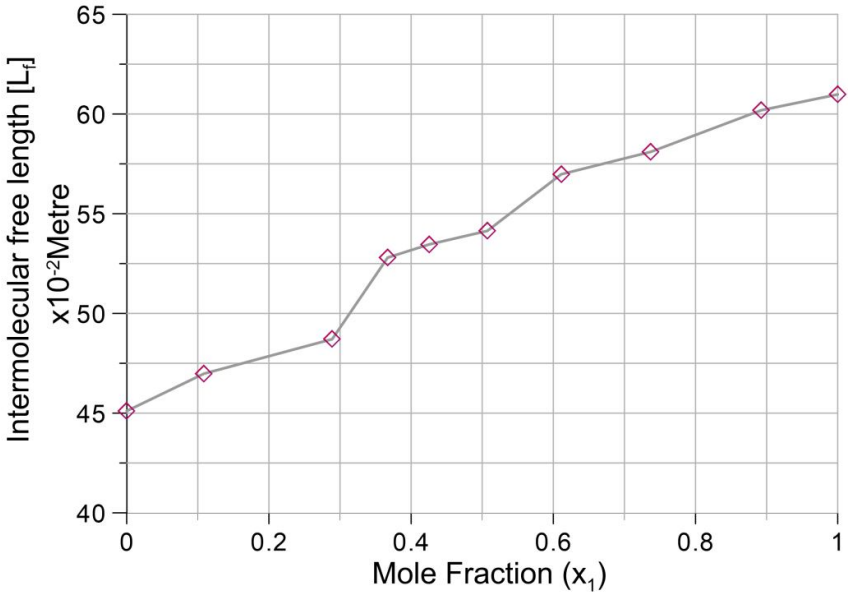


**Figure 7:** The figure shows the graph plotted betⁿ mole fraction and intermolecular free length for organic binary mixture liquids of Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$) at 308.15K.

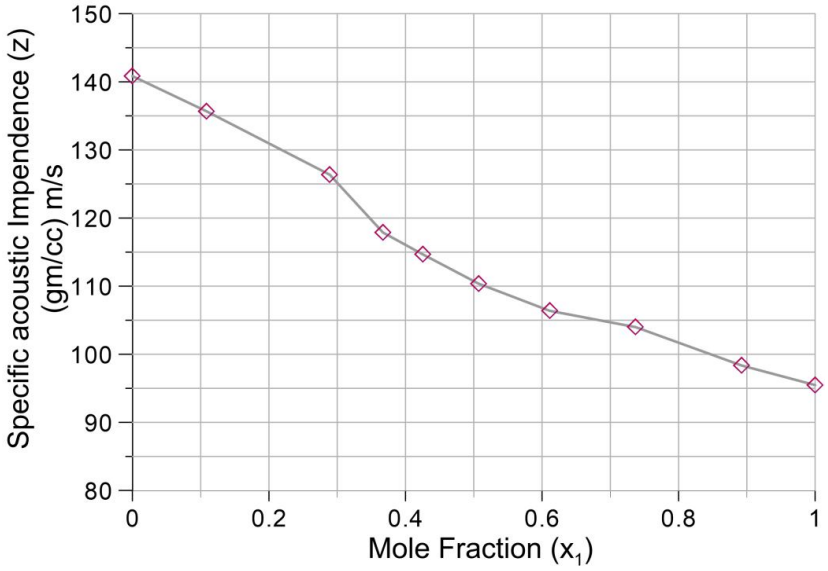


**Figure 8:** The figure shows the graph plotted betⁿ mole fraction and specific acoustic impedance for organic binary mixture liquids of Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$) at 308.15K.

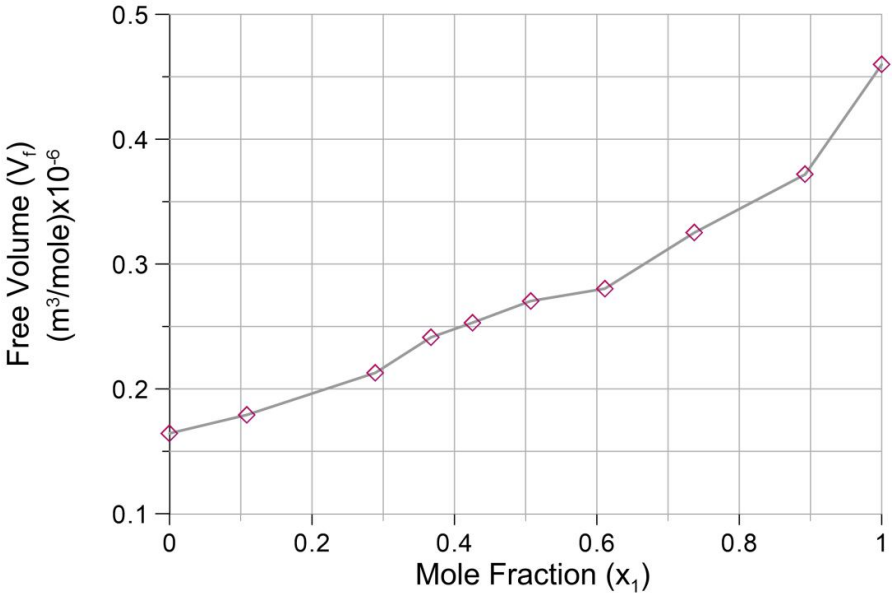


**Figure 9:** The figure shows the graph plotted betⁿ mole fraction and free volume for organic binary mixture liquids of Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$) at 308.15K.

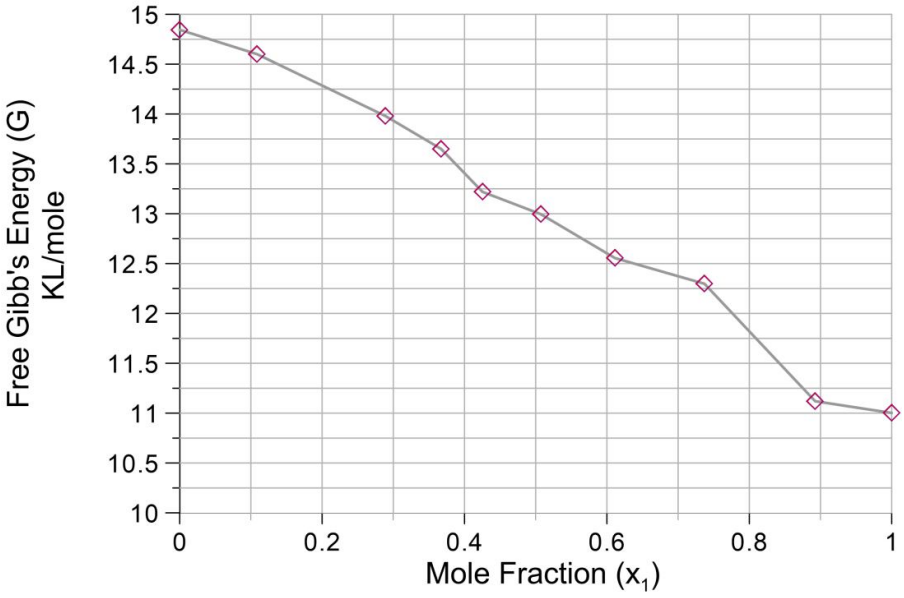


**Figure 10:** The figure shows the graph plotted betⁿ mole fraction and free energy for organic binary mixture liquids of Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$) at 308.15K.

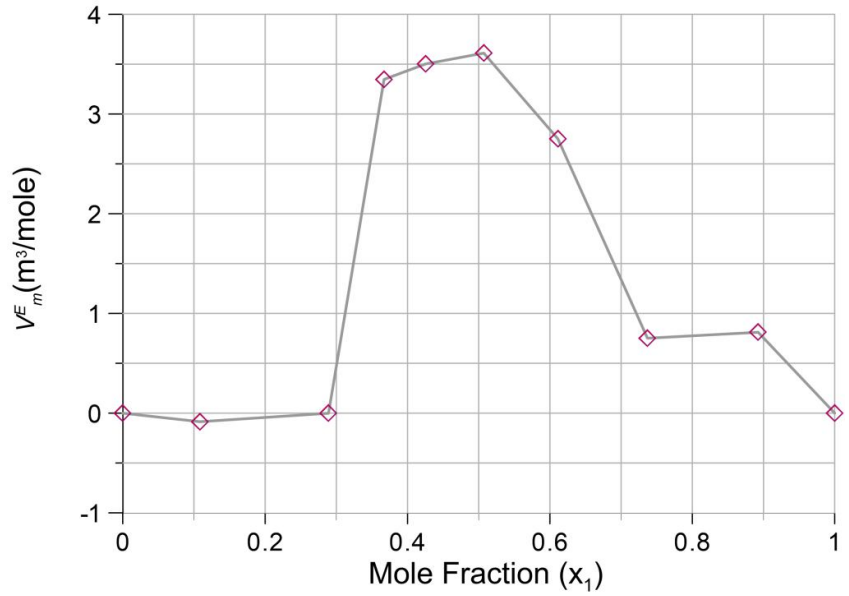


**Figure 11:** The figure shows the graph plotted betⁿ mole fraction and excess value of velocity of ultrasonic wave for organic binary mixture liquids of Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$) at 308.15K.

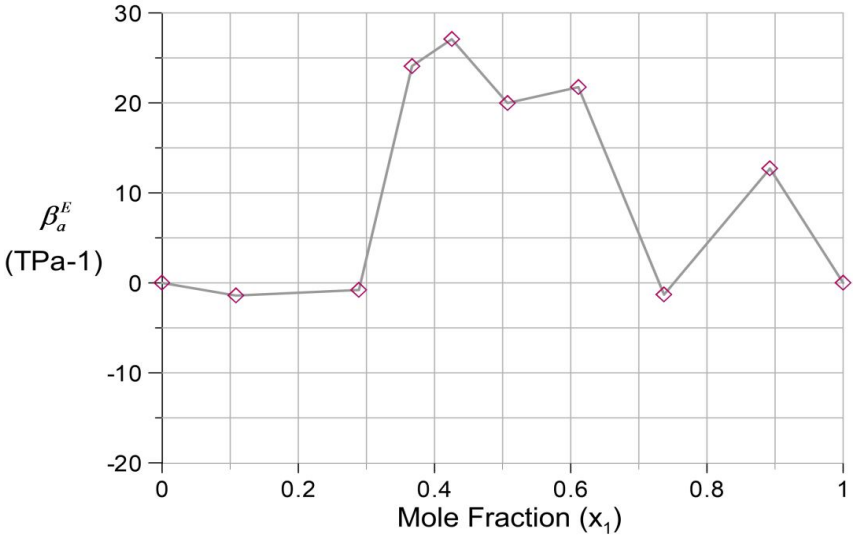


**Figure 12:** The figure shows the graph plotted betⁿ mole fraction and excess value of adiabatic compressibility for organic binary mixture liquids of Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$) at 308.15K.

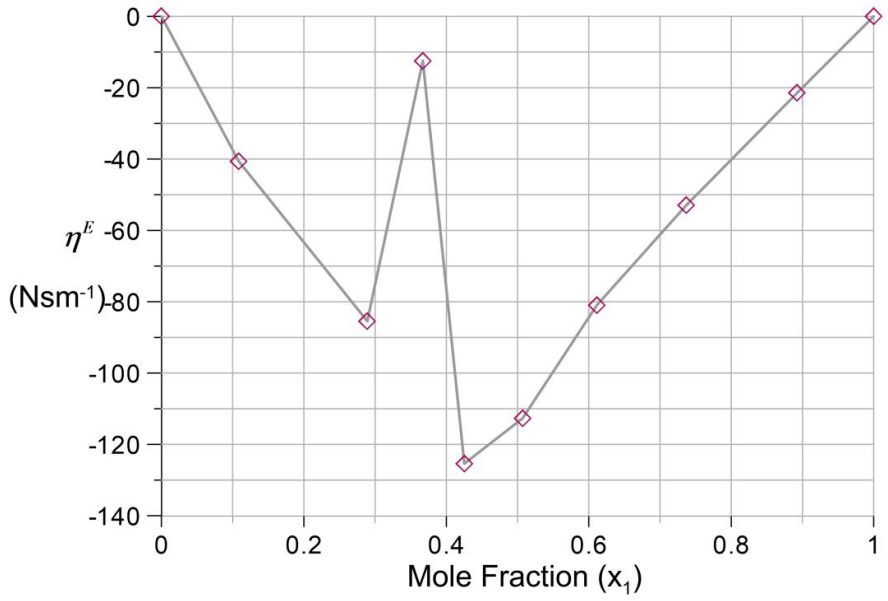


**Figure 13:** The figure shows the graph plotted betⁿ mole fraction and excess value of viscosity for organic binary mixture liquids of Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$) at 308.15K.

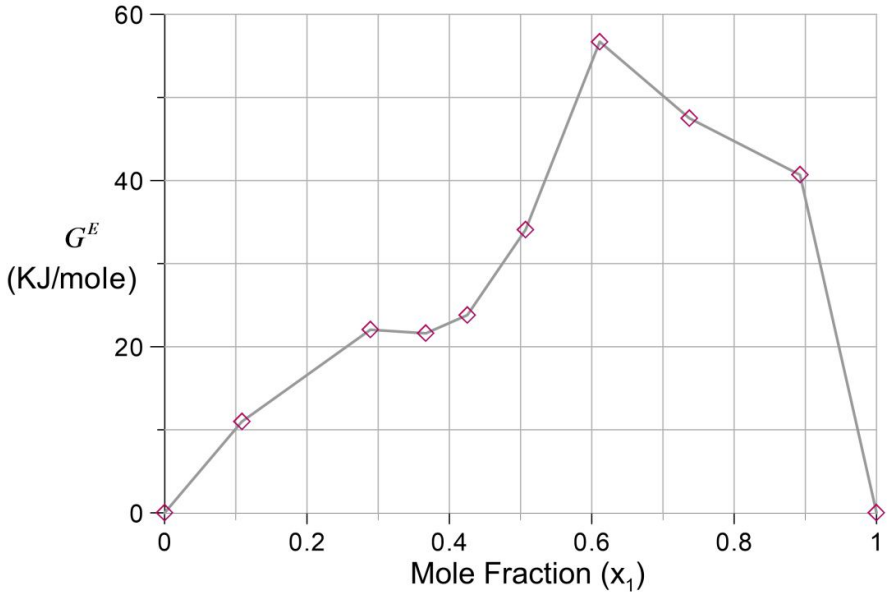


**Figure 14:** The figure shows the graph plotted betⁿ mole fraction and excess value of free energy for organic binary mixture liquids of Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$) at 308.15K.

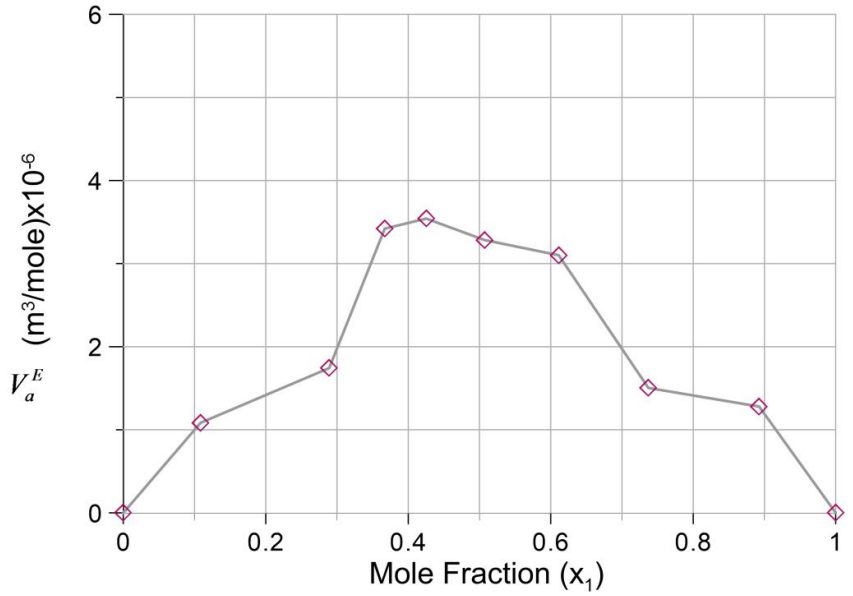


**Figure 15:** The figure shows the graph plotted betⁿ mole fraction and excess value of available volume for organic binary mixture liquids of Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$) at 308.15K.

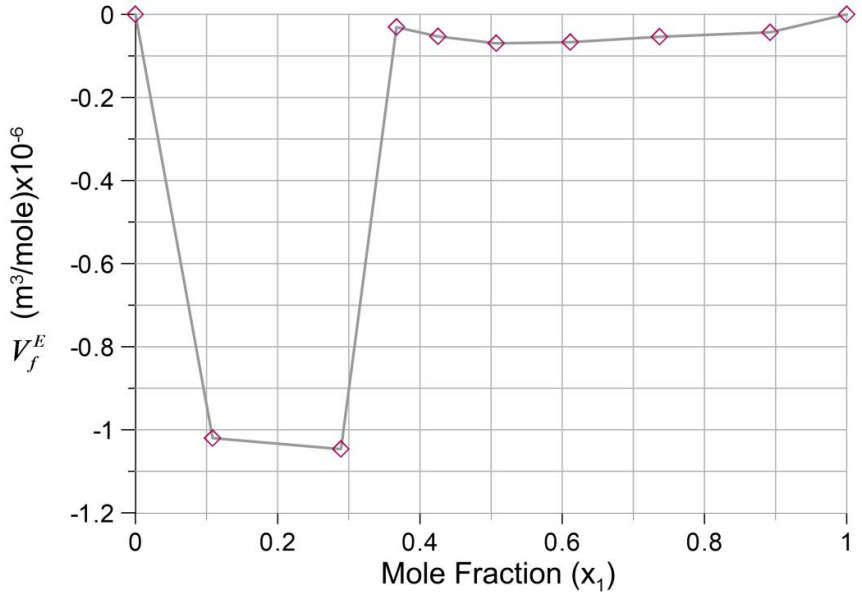


**Figure 16:** The figure shows the graph plotted betⁿ mole fraction and excess value of free volume for organic binary mixture liquids of Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$) at 308.15K.

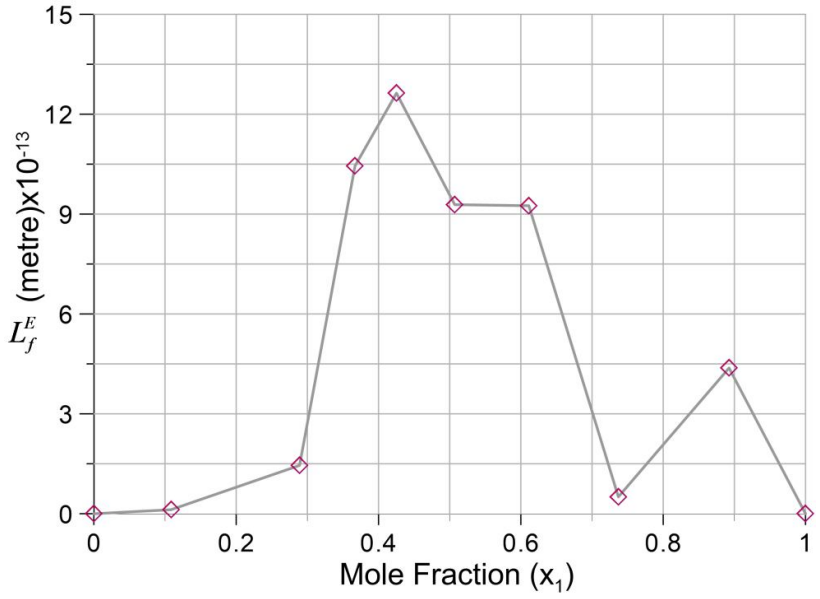


**Figure 17:** The figure shows the graph plotted betⁿ mole fraction and excess value of intermolecular free length for organic binary mixture liquids of Methyl Propyl Ketone and Bezaldehyde(MPK+$C_6H_5CHO$) at 308.15K.

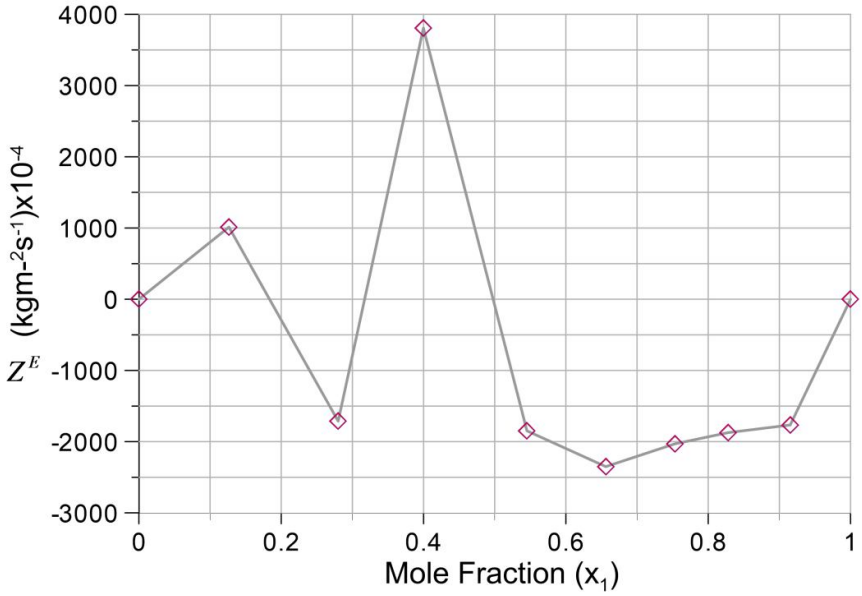


**Figure 18:** The figure shows the graph plotted betⁿ mole fraction and excess value of specific acoustic impedance for organic binary mixture liquids of Methyl Propyl Ketone and Bezaldehyde (MPK+$C_6H_5CHO$) at 308.15K.

## DISCUSSION

The main purposes of investing this system is to study that how the interaction between the components of binary mixture containing polar and polar components changes compared to the mixture containg non-polar + polar binary components. We have studied this liguid mixture at 308.15K. The binary mixture used in the experiment is methyl propyl ketone and benzaldehyde at th

temperature 308.15K. In this case, we have investigated the binary organic mixture liquids of the system consisting of Methyl Propyl Ketone and Bezaldehye (MPK+$C_6H_5CHO$) at 308.15K. The measured values of ultrasonic velocity (U), density ($\rho$), viscosity ($\eta$) at the temperature 308.15K over the entire composition range for the binary mixtures of bezaldehyde and propyl ethyl ketone ($CCl_4$+PEK) system given in the table 1 and their excess values are given in the table 2.

In the present work, we find that the concentration of benzaldehyde ($C_6H_5OH$+MPK) increases with ultrasonic velocity (U) decreases, but the density ($\rho$), viscosity ($\eta$) increases. The figures show that the behaviour of the ultrasonic velocity (U), intermolecular free length ($L_f$), adiabatic compressibility ($\beta_a$)and specific acoustic impedance (Z) as the function of $X_1$, the modification of the binary mixtures of bezaldehyde and methyl propyl ketone ($C_6H_5OH$+MPK) system over the entire composition range at 308.15K. The variations of these parameters as a function of mole fraction of the mixtures are shown in figures from 1 to 10.

In the table 2, for the binary mixtures of bezaldehyde and methyl propyl ketone ($C_6H_5OH$+MPK) system at 308.15K, the excess values of molecular volume ($V_m^E$), available volume ($V_a^E$) and free intermolecular distance ($L_f^E$) are positive, while Adiabatic compressibility ( $\beta_a^E$), free volume ($V_f^E$) are negative. The variations of these excess values of parameters as a function of mole fraction of the mixtures are shown in figures from 11 to 18.

## CONCLUSION

The adiabatic compressibility ($\beta_a$), intermolecular free length ($L_f$), molecular volume ($V_m$), available volume ($V_a$), free volume ($V_f$) increase with increase of the first mole fraction, while the ultrasonic velocity (U), density ($\rho$), viscosity ($\eta$), molecular volume ($V_m$) impedance (Z), Gibb's free energ (G), decrease with the increasing values of first mole fraction. For the case of the excess values, the characterising parameters like viscosity, free volume, molecular volume, impedance are negative and rest are positive to know about the information of the liquid mixtures taken into consideration are negative in binary liquid mixtures bezaldehyde and methyl propyl ketone ($C_6H_5OH$+MPK) system over the entire composition range at 308.15K.

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