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Study of Ultrasonic Wave Velocity in the Binary Mixture Liquids of Carbon Tetra Chloride and Propyl Ethyl Ketone (CCl_4+PEK)] At the Temperature 308.15K

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ABSTRACT In the present paper, we have measured and investigated the ultrasonic velocity (U), density (ρ), viscosity (η), adiabatic compressibility (β_a), intermolecular free length (L_f), molecular volume (V_m), available volume (V_a), free volume (V_f), specific acoustic impedance (Z), Gibb's free energy (G) in binary liquid mixtures of carbon tetra chloride and propyl ethyl Ketone (CCl_4+PEK)] at 308.15K.

KEYWORDS Propyl Ethyl Ketone, Adiabatic compressibility and Available volume.

INTRODUCTION

The physiochemical behaviour of hydrogen bounded organic compounds or mixture liquids can be studied by the measurements of the ultrasonic velocities. 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[1]. Shrivastava et al. (1985) studied the strength of interactions in the liquid mixtures in molecular term[2]. Sudhanshu and Choudhary (1996) have studied the excess properties of binary and ternary polar and non-polar liquid mixtures[3]. Singh et al. (1991) measured the the density, velocity and other parameters and their excess values[4]. Ali et al. (2001) used eighteen binary mixtures of ACN (Aconitrile) to calculate all the related parameters of the mixtures and their excess values[5]. 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[6]. 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[7]. Rao et al. measured the ultrasonic velocities and densities of mixtures of tri chloroehelene with three alcohols experimentally and obtained good result between experimental and theoretical values[8].

In the present paper, we have measured and investigated the ultrasonic velocity (U), density (ρ), viscosity (η), adiabatic compressibility (β), 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) in binary liquid mixtures of carbon tetra chloride and propyl ethyl Ketone (CCl_4+PEK)] at 308.15K.

THEORETICAL ASPECTS

The ultrasonic methods are extensively used to study the physio-chemical behaviour of liquid medium in pure and mixture forms. This is done by studying the ultrasonic velocity (U), density (ρ), viscosity (η) etc. in pure liquids and their mixtures. The variation from linearity in the behaviour of these observed parameters indicates the presence of interaction between the components of the mixtures. Information about the nature of the relative strength of such interactions are, however, not provided by the study of only the observed parameters like velocity, density, viscosity etc. These information are provided by the investigations of derived parameters such as adiabatic compressibility (β), intermolecular free length (L_f), Gibb's free energy of activation flow (G), internal pressure (P), free volume (V_f), specific acoustic impedance (Z), enthalpy (H) etc. and their excess values.

Model of Parameters Used in the Work

Adiabatic compressibility : $\beta_a = \left(\frac{1}{\rho}\right)u^2$,

Molecular volume: $V_m = \frac{M}{\rho}$

Available volume: $V_a = V_m\left[1-\frac{U}{U_m}\right]$,

Free volume: $V_f = \left(\frac{Mu}{k\eta}\right)^{3/2}$

Specific Acoustic Impedence: $Z = \rho u$

In this case, we have investigated the binary mixtures of cabon tetra chloride and propyl ethyl ketone (CCl_4+PEK) at 308.15K given in the table 1 & 2.

RESULTS

Table 1: Carbon tetra chloride and Propyl Ethyl Ketone (CCl_4+PEK) at 308.15K.

1	2	3	4	5	6
Sn.	X_1	Velocity (U) (m/s)	Density (ρ) (kg/m^3)x10^{-4}	Viscosity (η) (NSm^{-2})	Molecular volume $V_m = \frac{M}{\rho}$ (m3/mole)x10^{-6}
1.	0.00000	1125.10	764.19	3.3620	86.678
2.	0.12650	1075.18	930.32	4.2518	89.038
3.	0.28000	1040.38	1015.40	4.5620	91.631
4.	0.39978	1017.14	1065.30	5.2716	92.904
5.	0.54525	997.20	1082.33	5.4728	95.724
6.	0.65612	950.80	1136.14	5.7292	96.704
7.	0.75312	932.08	1224.38	5.8614	98.344
8.	0.82807	906.40	1386.24	6.3018	98.987
9.	0.91521	890.25	1412.17	7.5431	99.212
10.	1.00000	813.72	1497.18	7.9870	99.972

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 $\beta_a = \left(\frac{1}{\rho}\right)u^2$ xTPa^{-1}	Intermolecular free length $[L_f = \left(\frac{V_f}{V}\right)^{1/3} L]$ x10^{-2}Metre	Specific acoustic Impedence $(Z = \rho u)$ (gm/cc) m/s	Free volume $V_f = \left(\frac{Mu}{k\eta}\right)$ (m3/mole) x10^{-6}	Free Gibb's energy (G) KL/mole
23.675	838.12	60.13	90.301	0.4612	11.011
28.760	836.26	59.18	100.471	0.4025	11.678
32.689	828.17	58.98	102.342	0.3512	12.043
35.025	817.25	58.50	110.360	0.3318	12.342
37.084	814.30	58.20	117.216	0.3014	12.512
38.027	808.80	57.60	120.018	0.2816	12.830
38.987	804.71	57.40	123.631	0.2736	12.989
41.361	803.01	56.20	126.421	0.2612	13.086
42.221	802.25	55.12	130.363	0.2518	13.431
42.978	801.27	54.78	132.326	0.2421	13.986

Table 2: Excess values for Carbon tetra chloride and Propyl Ethyl Ketone [CCl_4+PEK] at 308.15K.

1	**2**	**3**	**4**	**5**	**6**
Sn.	X_1	V_m^E (m^3/mole)	β_a^E (TPa^{-1})	η^E (Nsm^{-1})	G^E (KJ/mole)
1.	0.00000	0.0000	0.0000	-0.0000	0.0000
2.	0.12650	0.0896	-1.734	-0.4238	36.718
3.	0.28000	1.4720	-32.567	0.1098	62.712
4.	0.39978	1.7895	3.402	1.5078	83.600
5.	0.54525	2.9878	2.086	-3.9812	26.130
6.	0.65612	3.1224	24.180	-6.2413	6.870
7.	0.75312	2.3740	19.860	-9.1218	-36.718
8.	0.82807	1.5786	2,720	-8.8761	-19.613
9.	0.91521	1.3210	2.121	7.7809	23.852
10.	1.00000	0.0000	0.000	0.0000	0.000

Continued.....

7	**8**	**9**	**10**	**11**
V_a^E (m^3/mole)x10^{-6}	V_f^E (m^3/mole)x10^{-6}	V_m^E (m^3/mole)	L_f^E (Mterer)x10^{-13}	Z^E ($kgm^{-2}s^{-1}$)x10^{-4}
0.000	0.0000	0.0000	0.0000	0.0000
1.5500	0.0021	0.0896	0.7862	1012.63
2.9872	0.0448	1.4720	1.3612	-1712.24
2.5421	-0.0532	1.7895	0.9872	3807.20
2,4381	-0.0077	2.9878	1.5620	-1847.78
3.1504	0.0126	3.1224	8.3540	-2350.47
2.5612	0.0419	2.3740	6.3032	-2030.46
2.3678	0.0405	1.5786	7.4238	-1872.63

2.0023	0.3421	1.3210	5.8753	-1765.87
-0.000	0.0000	-0.0000	0.0000	0.0000

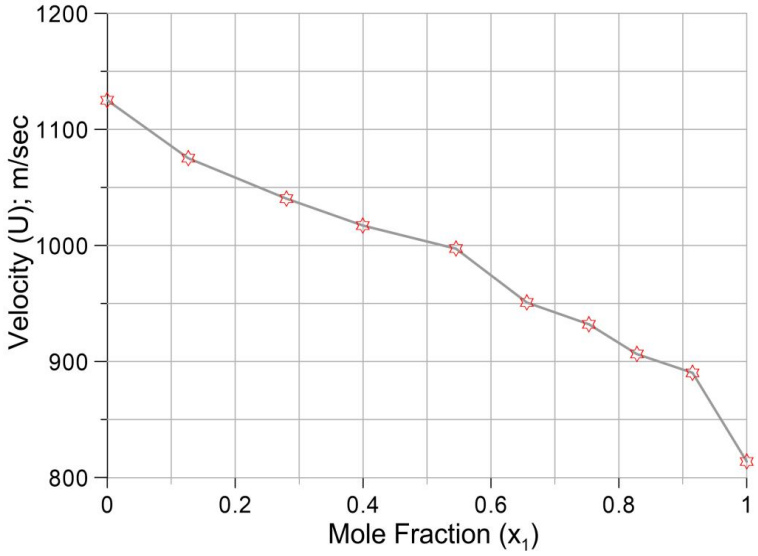

Figure 1: The figure shows the graph plotted between mole fraction and velocity of the ultrasonic waves for organic binary mixture liquids of carbon tetra chloride and propyl ethyl Ketone (CCl_4+PEK)] at the temperature 308.15K

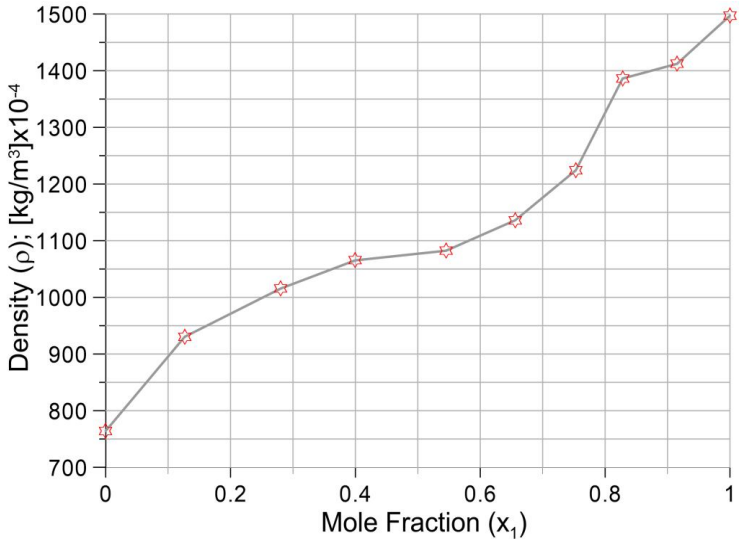

Figure 2: The figure shows the graph plotted between mole fraction and density for organic binary mixture liquids of carbon tetra chloride and propyl ethyl Ketone (CCl_4+PEK)] at the temperature 308.15K

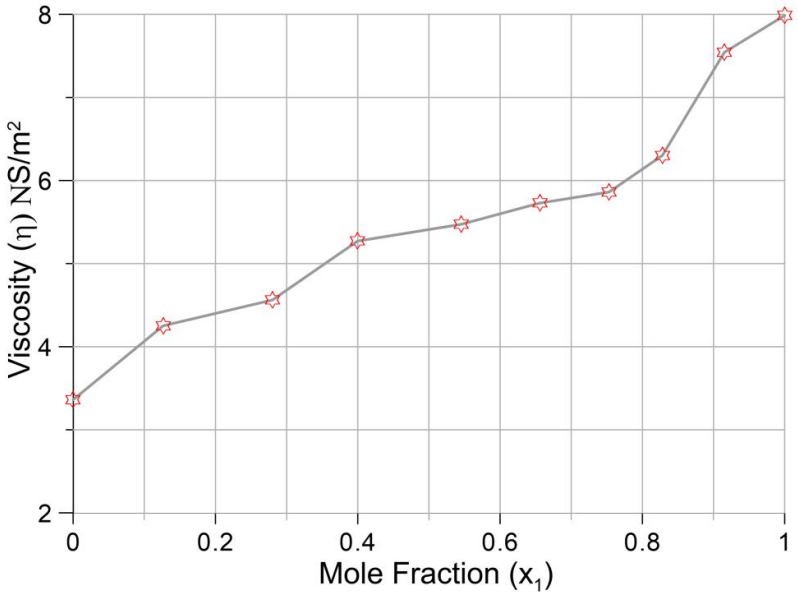

Figure 3: The figure shows the graph plotted between mole fraction and viscosity for organic binary mixture liquids of carbon tetra chloride and propyl ethyl Ketone (CCl_4+PEK)] at the temperature 308.15K

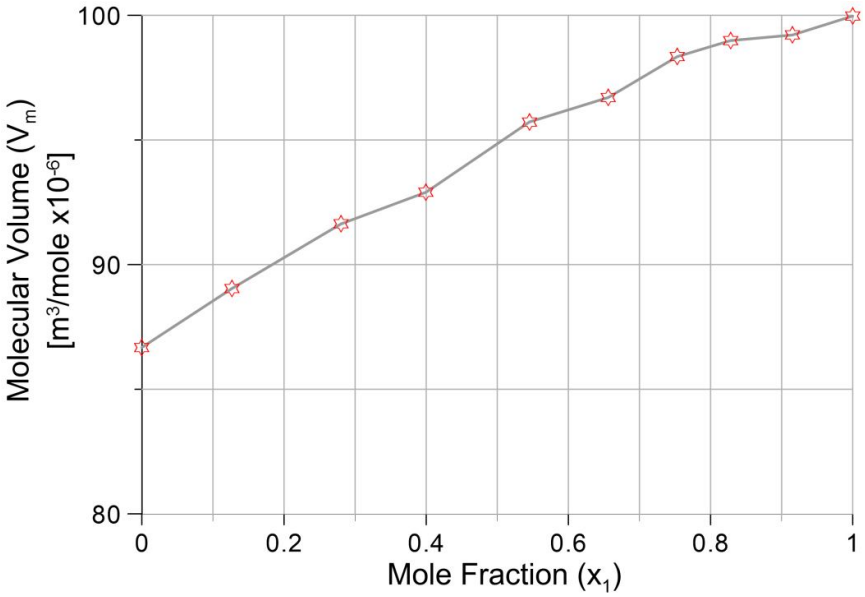

Figure 4: The figure shows the graph plotted between mole fraction and molecular volume for organic binary mixture liquids of carbon tetra chloride and propyl ethyl Ketone (CCl_4+PEK)] at the temperature 308.15K

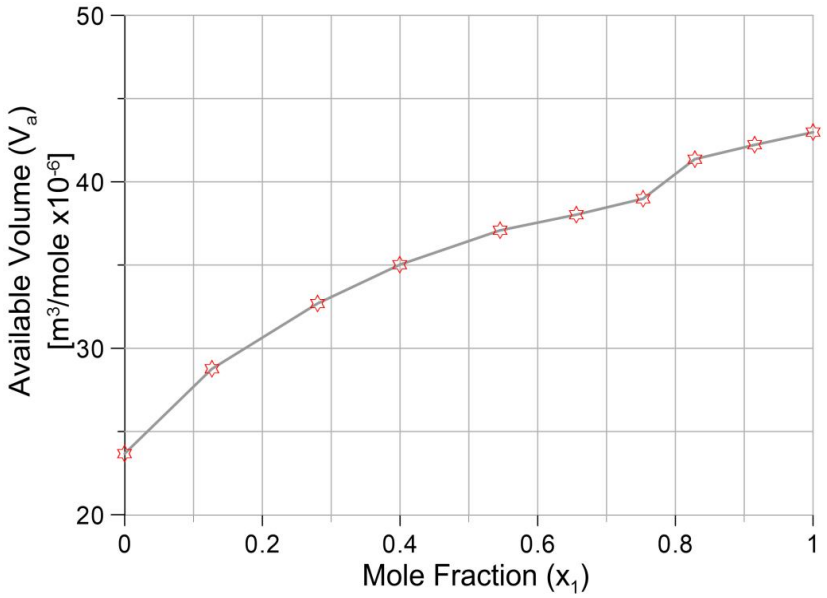

Figure 5: The figure shows the graph plotted between mole fraction and available volum for organic binary mixture liquids of carbon tetra chloride and propyl ethyl Ketone (CCl_4+PEK)] at the temperature 308.15K

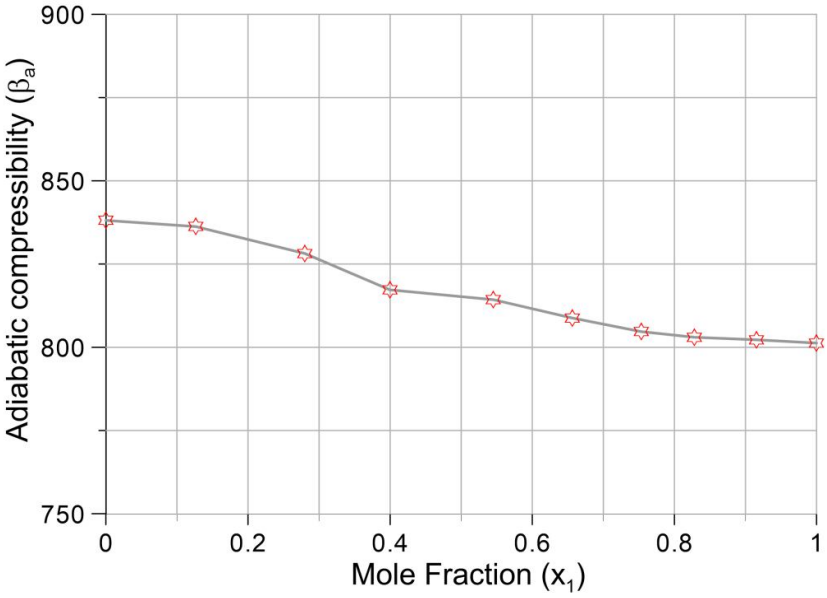

Figure 6: The figure shows the graph plotted between mole fraction and adiabatic compressibility for organic binary mixture liquids of carbon tetra chloride and propyl ethyl Ketone (CCl_4+PEK)] at the temperature 308.15K

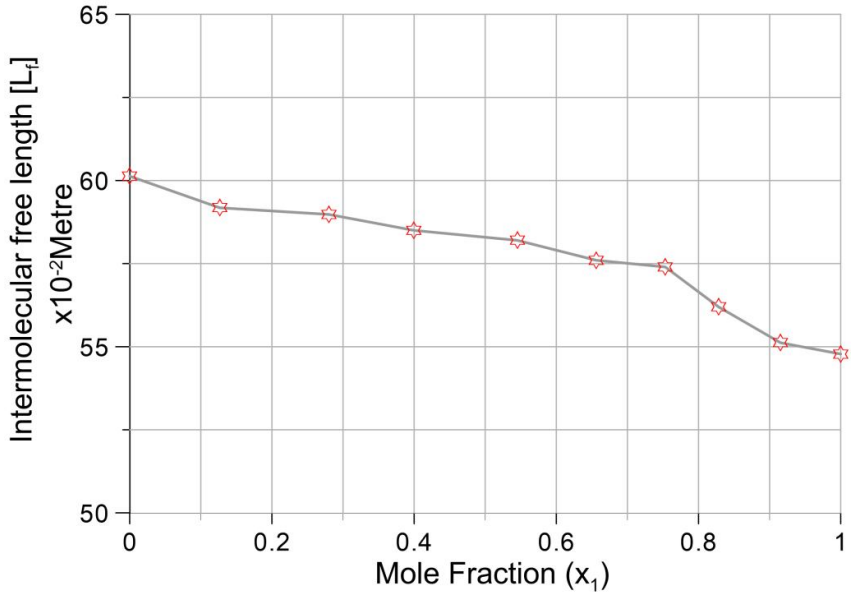

Figure 7: The figure shows the graph plotted between mole fraction and intermolecular free length for organic binary mixture liquids of carbon tetra chloride and propyl ethyl Ketone (CCl_4+PEK)] at the temperature 308.15K

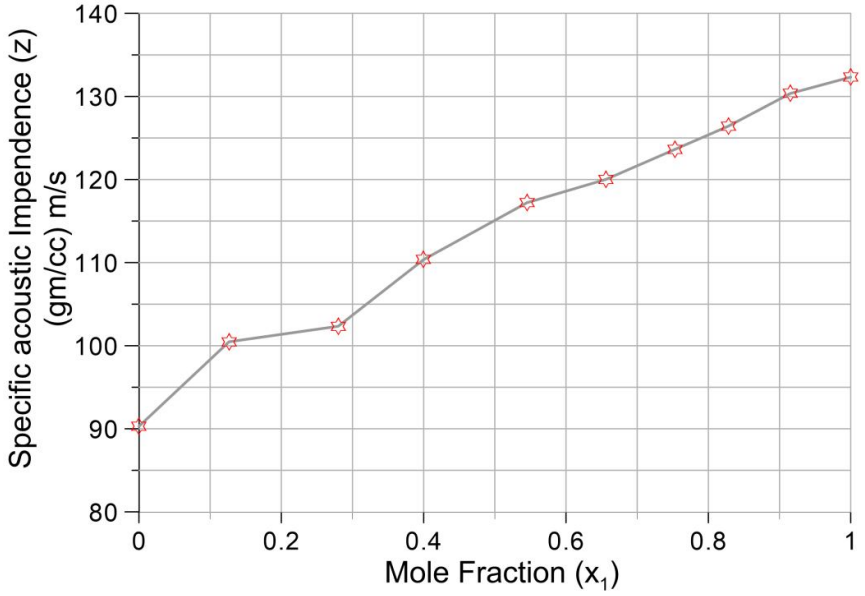

Figure 8: The figure shows the graph plotted between mole fraction and specific acoustic impedance for organic binary mixture liquids of carbon tetra chloride and propyl ethyl Ketone (CCl_4+PEK)] at the temperature 308.15K

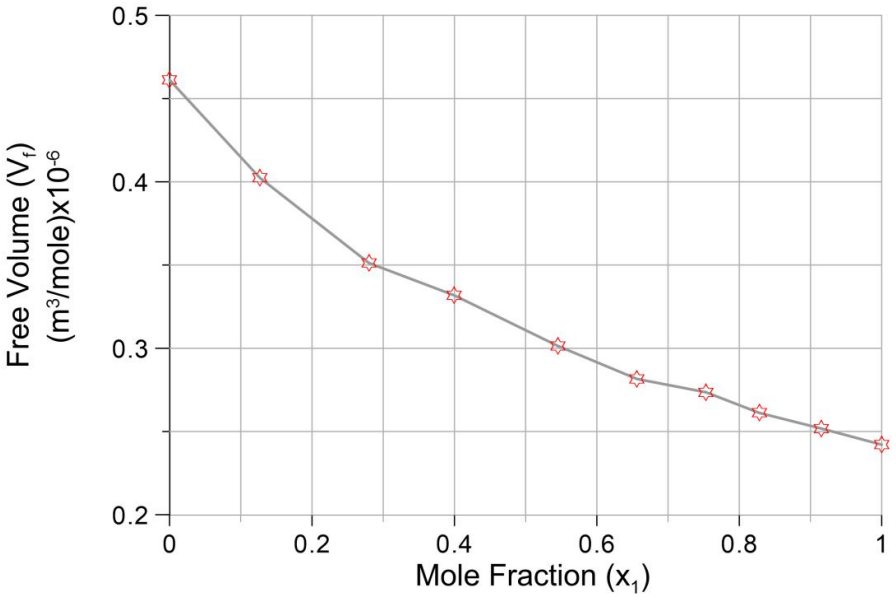

Figure 9: The figure shows the graph plotted between mole fraction and free volume for organic binary mixture liquids of carbon tetra chloride and propyl ethyl Ketone (CCl_4+PEK)] at the temperature 308.15K

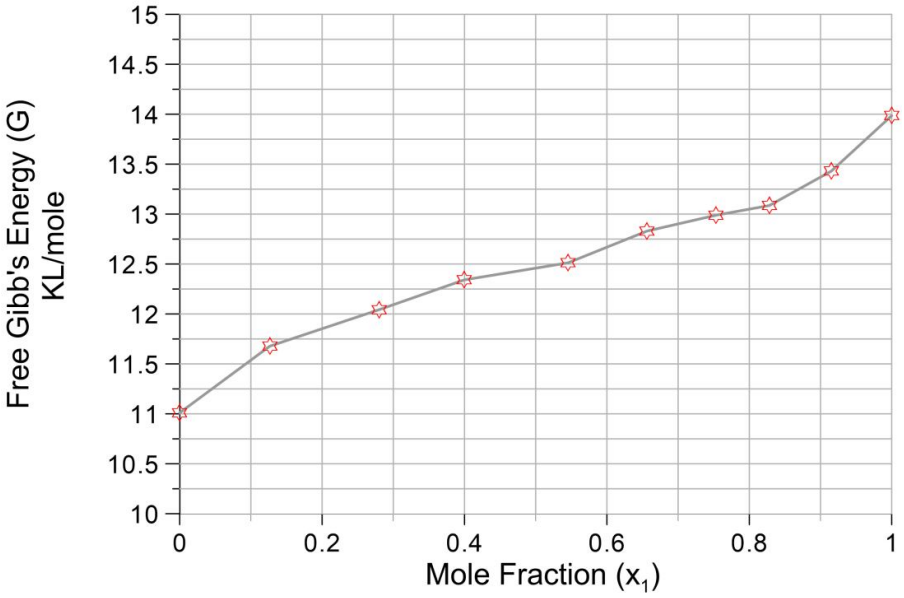

Figure 10: The figure shows the graph plotted between mole fraction and free Gibb's energy for organic binary mixture liquids of carbon tetra chloride and propyl ethyl Ketone (CCl_4+PEK)] at the temperature 308.15K

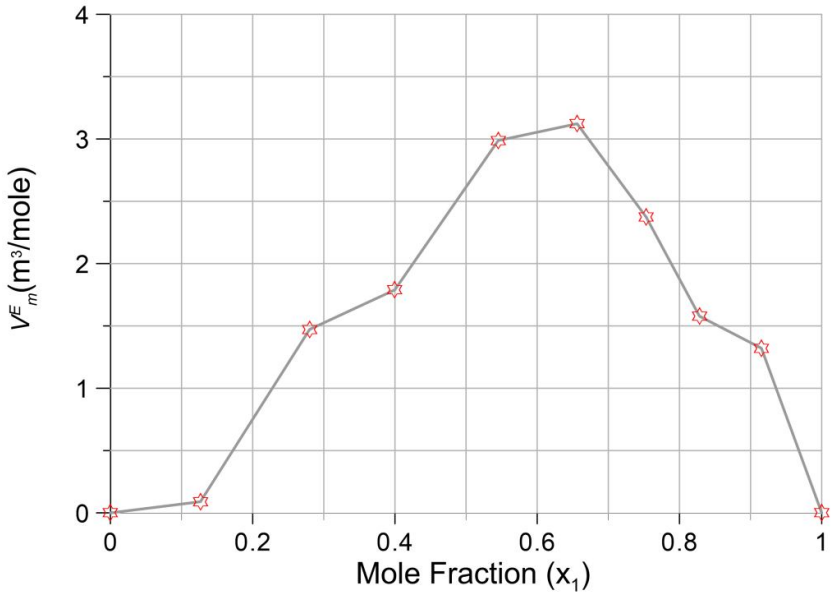

Figure 11: The figure shows the graph plotted between mole fraction and excess values of molecular volume for organic binary mixture liquids of carbon tetra chloride and propyl ethyl Ketone (CCl_4+PEK)] at the temperature 308.15K.

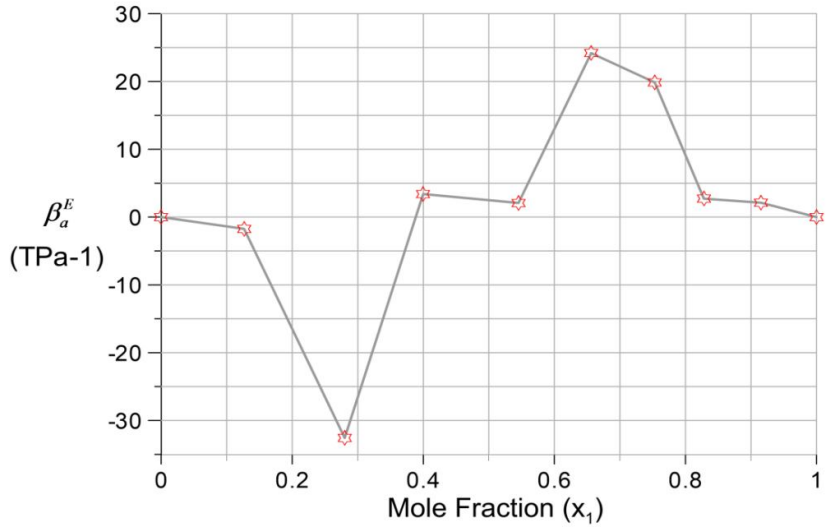

Figure 12: The figure shows the graph plotted between mole fraction and excess values of adiabatic compressibility for organic binary mixture liquids of carbon tetra chloride and propyl ethyl Ketone (CCl_4+PEK)] at the temperature 308.15K.

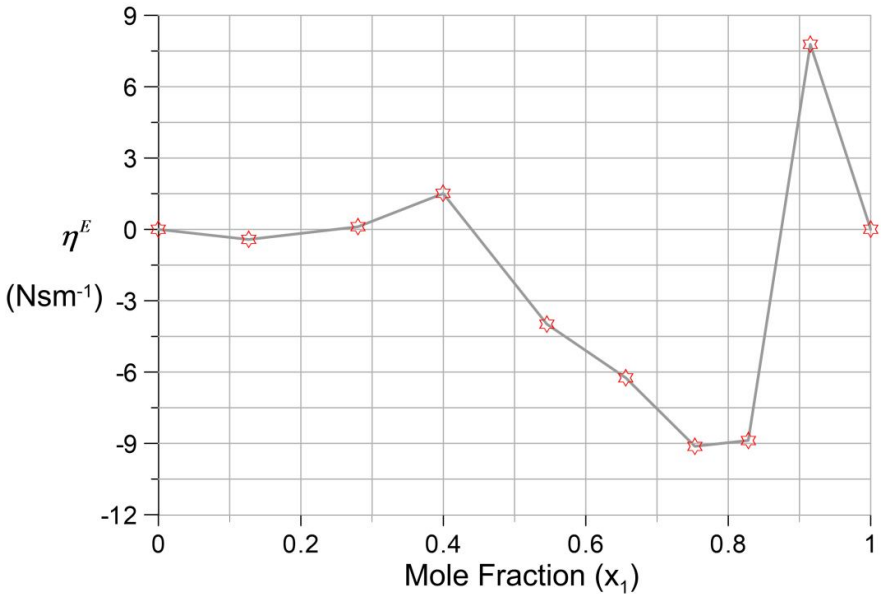

Figure 13: The figure shows the graph plotted between mole fraction and excess values of viscosity for organic binary mixture liquids of carbon tetra chloride and propyl ethyl Ketone (CCl_4+PEK)] at the temperature 308.15K.

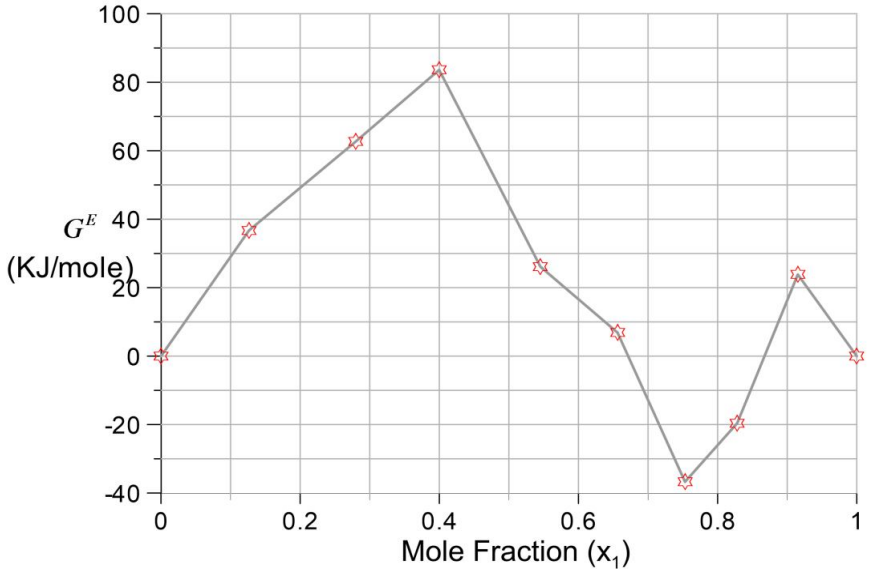

Figure 14: The figure shows the graph plotted between mole fraction and excess values of Gibb's free energy for organic binary mixture liquids of carbon tetra chloride and propyl ethyl Ketone (CCl_4+PEK)] at the temperature 308.15K.

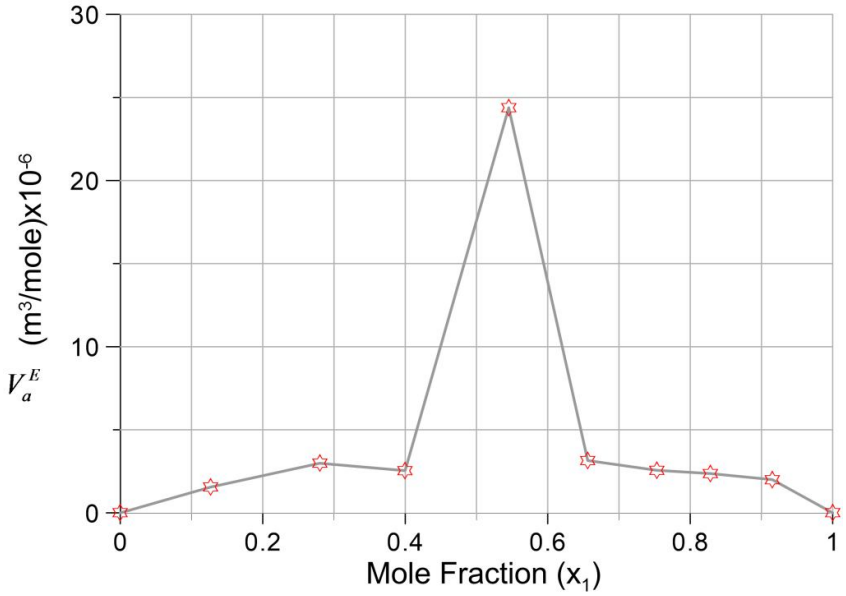

Figure 15: The figure shows the graph plotted between mole fraction and excess values of available volume for organic binary mixture liquids of carbon tetra chloride and propyl ethyl Ketone (CCl_4+PEK)] at the temperature 308.15K.

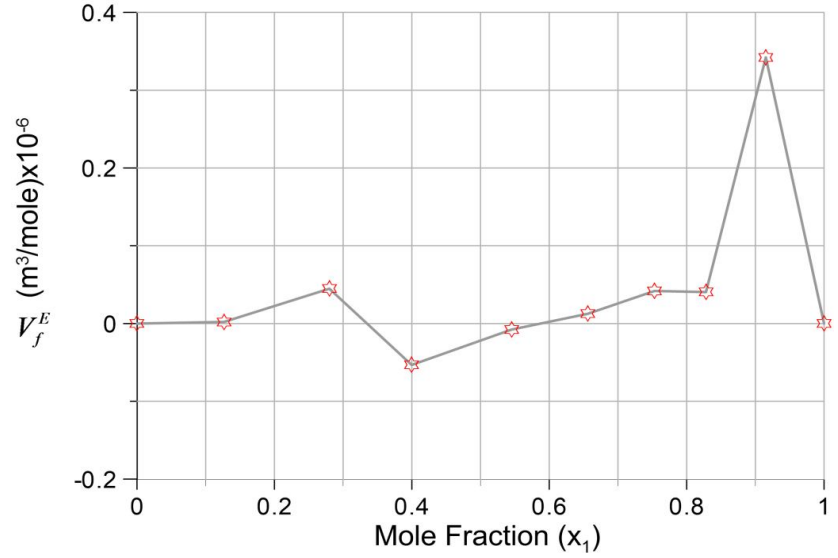

Figure 16: The figure shows the graph plotted between mole fraction and excess values of free volume for organic binary mixture liquids of carbon tetra chloride and propyl ethyl Ketone (CCl_4+PEK)] at the temperature 308.15K.

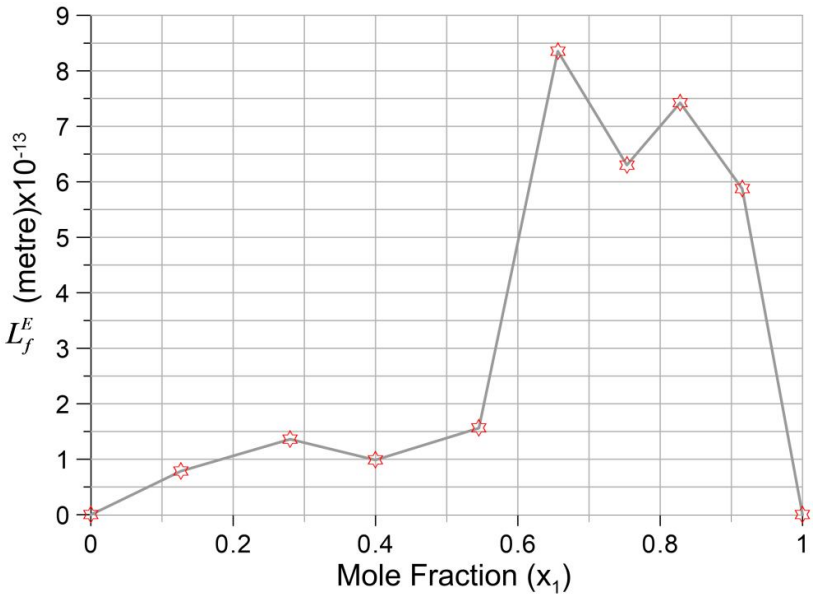

Figure 17: The figure shows the graph plotted between mole fraction and excess values of intermolecular free length for organic binary mixture liquids of carbon tetra chloride and propyl ethyl Ketone (CCl_4+PEK)] at the temperature 308.15K.

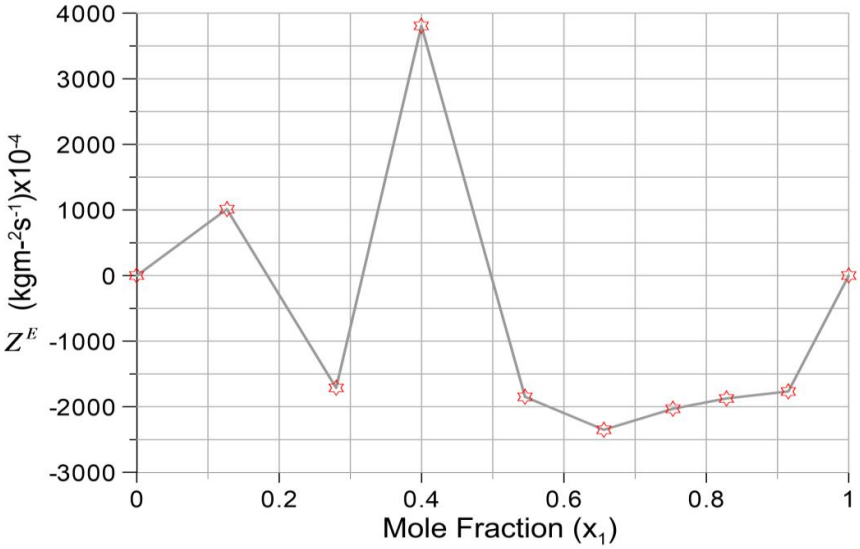

Figure 18: The figure shows the graph plotted between mole fraction and excess values of impedance for organic binary mixture liquids of carbon tetra chloride and propyl ethyl Ketone (CCl_4+PEK)] at the temperature 308.15K.

DISCUSSION

In this case, we have investigated the binary mixtures of cabon tetra chloride and propyl ethyl ketone (CCl_4+PEK) at 308.15K.

The measured values of ultrasonic velocity (U), density (ρ), viscosity (η) 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.

In the present work, we find from the table 1 that the concentration of cabon tetra chloride (CCl_4+PEK) increases with ultrasonic velocity (U) decreases, but the density (ρ), viscosity (η) increases. The figures show that the behaviour of the ultrasonic velocity (U), intermolecular free length (L_f), adiabatic compressibility (β_a)and specific acoustic impedance (Z) as the function of X_1, the modification of the binary mixtures of carbon tetra chloride and propyl ethyl ketone (CCl_4+PEK) system over the entire composition range at 308.15K. The variations of all the parameters in the table 1 with mole fraction are shown in figures from 1 to 10.

In the table 2, for the binary mixtures of cabon tetra chloride and propyl ethyl ketone (CCl_4+PEK) 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 (β_a^E), free volume (V_f^E) are negative. The variations of all the parameters for the excess values in the table 2 with mole fraction are shown in figures from 11 to 18.

CONCLUSION

From the above experimental fact, we may conclude as follows:

1. The velocity (U), adiabatic compressibility (β_a), intermolecular free length (L_f), and free volume (V_f) decrease with increasing value of mole fraction of the liquid mixtures for binary liquid mixtures of cabon tetra chloride and propyl ethyl ketone (CCl_4+PEK) at the temperature 308.15K.
2. The density, viscosity, Gibb's free energy (G), molecular volume (V_m), available volume (V_a) increase with increase of the first mole fraction, while the ultrasonic velocity (U), density (ρ), viscosity (η), impedance (Z) increase with the increasing values of first mole fraction for binary liquid mixtures of cabon tetra chloride and propyl ethyl ketone (CCl_4+PEK) at the temperature 308.15K.
3. For the case of the excess values, all the characterising parameters except viscosity and impedance to know about the information of the liquid mixtures taken into consideration are positive in binary liquid mixtures of cabon tetra chloride and propyl ethyl ketone (CCl_4+PEK) at the temperature 308.15K.

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