Physics

ULTRASONIC VELOCITIES, DENSITIES AND EXCESS THERMODYNAMIC PROPERTIES OF BINARY MIXTURES OF O - CHLOROPHENOL WITH HIGHER ALKANOLS FROM 303.15 TO 318.15K

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ABSTRACT The ultrasonic velocities U, densities ρ of Binary Mixtures of O - Chlorophenol with 1- hexanol, 1- heptanol and 1- octanol from 303.15 to 318.15K. Excess molar volume (VE), deviation in adiabatic compressibility (Δβad) and excess intermolecular free length (LfE) have been calculated from the measured experimental data. The values of VE, Δβad and LfEhave been fitted to Redlich – Kister polynomial equation to estimate binary coefficients and standard deviation between the experimental and computed values.

Introduction

Molecular studies lie in the ability to assess the information stored in the structure of molecule as a function of their physical and chemical properties. There had been many developments in Chemistry and Physics during the past two centuries particularly in the fields of statistical mechanics, thermodynamics and the nature of chemical bond. The ensuing atomistic view shall be presented and discussed in the context of molecular interactions. Molecular interactions are generally electrostatic in nature. The strength of these interactions and the forces among atoms, can be analyzed according to their thermodynamic and kinetic behaviour [1,2].

Ultrasonic velocities have been adequately employed in understanding the nature of molecular interaction in pure liquids, binary mixtures [3,4]. The method of studying the molecular interaction from the knowledge of variation of thermodynamic parameters and their excess values with composition gives an insight into the molecular process [5,6]. The present paper is part of our research work on thermodynamic properties of liquid-liquidmixtures [7-9]. This paper includes density and ultrasonic behaviour of binary mixtures of o – chlorophenol with 1 – hexanol, 1- heptanol and 1 - octanol over the entire composition range at 308.15 K.
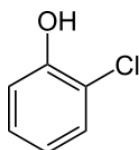
OCP is a particular compound has many applications, but is an intermediate in the poly chlorination of phenol. It is a liquid at room temperature, but all the other chlorophenols are solids. Most applications of chlorophenols are based on their toxicity and they are used as disinfectant agents and various pesticides, to control bacteria, fungi, insects, and weeds.

1-Hexanol is a colourless liquid with a fruity odour. It is used as a flavouring additive, as an insecticide, in the processing of leather, and in the manufacture of antiseptics, perfumes, plasticizers and other chemicals. 1-Heptanol is a clear colourless liquid with pleasant smell. It is mainly used as a synthesis intermediate in the fragrances and flavours industry, in lasticizers for polymers and in cosmetics.1-Octanol is a clear colourless liquid with a penetrating romatic odour. It issued for the synthesis of esters in perfumes and flavourings.

Literature survey reveals that Uthayakumar. B et.al [10] measured the densities and ultrasonic velocities of some O – chlorophenol binary mixtures at different temperatures and G.R.Satyanarayana et.al [11] studied molecular interactions in O – chlorophenol with alkoxy alkanols over the entire range of composition at four different temperatures 303.15, 305.15, 313.15 K and 318.15K. Many researchers have studied the molecular interactions in the binary mixtures of higher alkanols[12,13]. Density (ρ) and viscosity (η) have been measured for the binary mixtures of 3-chloroanilinewith 1-alkanols (1-hexanol, 1-heptanol, 1-octanol, 1- decanol) over the entire composition range at (303.15,308.15, 313.15, and 318.15) K, using this data, the excess volume (V^E)have been calculated[14].

Keeping these important aspects in mind, the present study deals with ultrasonic and thermodynamic study of O – chlorophenol (OCP) with higher alkanols (1- hexanol, 1- heptanol and 1- octanol) over the entire mole fraction range from 303.15 to 318.15K. The liquids under investigation have been chosen on the basis of their multifold applications.Ultrasonic velocities, densities and viscosities of the studied binary mixtures are measure and using the experimental data, excess molar volume, deviation in adiabatic compressibility and excess inter molecular free length are reported in this paper. The results have been used to estimate the molecular interactions in the constituent molecules

Experimental Techniques

Ultrasonic velocities(U) and densities(ρ)of pure liquids and all liquid mixtures in the present study were measured by employing a pulse-echo interferometer (MODEL M-81) supplied by the Mittal Enterprises, New Delhi and a 10−5 m3 double-arm pycnometer respectively at (303.15, 308.15, 313.15 and 318.15)K as described by Nikam et al.[15]. Double-arm pycnometer is calibrated using conductivity water with 995.61 kg m−3 as its density at 303.15 K. To maintain the constant temperature, a thermostat is employed with an accuracy of±0.01K. The weighings are carried using METTLER TOLEDO (Switzerland make) ABB5-S/F ACT digital balance with an accuracy of ±0.01mg. The experimental samples, Di methyl malonate, alkanol such as 1- hexanol, 1- heptanol and 1- octanol used in the present study are of AR grade quality, obtained from S.D. Fine chemicals, India with purity > 99%. Experimental values are compared with literature values and are shown in Table-1 [11,16]. It is evident fromTable1, that there is good agreement between the experimental and reported values.

- Mean molar volume (V) evaluated by the equation $V = M / \rho$
- Excess volume (VE): $VE = V - (V_1 X_1 + V_2 X_2)$
- Adiabatic compressibility (β_{ad}): $\beta_{ad} = 1 / \rho\, U^2$
- Deviation in adiabatic compressibility ($\Delta\beta_{ad}$): $= \beta_{ad} - (\beta_{ad1}\, X_1 + \beta_{ad2}\, X_2)$
- Intermolecular free length (L_f): $L_f = K\,(\beta_{ad})\,^{\frac{1}{2}}$
- Excess intermolecular free length (L_f^E): $L_f^E = L_f - (L_{f1} X_1 + L_{f2} X_2)$

Where, L_{f1} and L_{f2} are the individual intermolecular free length values of pure liquids in the binary mixtures.

Redlich-Kister equation: $Y^E = Y^M_{real} - Y^M_{ideal}$

The standard deviations σ (Y^E) were calculated by using the relation σ $(Y^E) = \Sigma[(Y_{exp}{}^E - Y_{cal}{}^E)^2/(m-n)]^{1/2}$ Where, m is the number of experimental data points and n is the number of coefficients considered and (n=5 in the present calculation).

$Y_{cal}{}^E$ has been obtained from the above equation using the best - fit values of Ai.

Table-1: Comparison of Experimental Values with Literatures Data [11,16] at 303.15K

Liquid	Density Kg/m³		Ultrasonic Velocity m/s	
	Exptl	Lit	Exptl	Lit
1-OCP	1.1423	1.2550[a]	1365.2	1381.4[a]
1-Hexanol	0.8136	0.8119 [b]	1289.7	1287.12[b]
Heptanol	0.8157	0.8157 [b]	1313.2	1310.7 [b]
1-Octanol	0.8199	0.8187 [b]	1333.1	1330.4[b]

The experimentally measured values of ultrasonic velocities (U), densities (ρ) are presented in the table 2. From the table it is clear that experimental values are in good agreement with the literature values.

In order to substantiate the presence of interaction between the molecules, it is essential to study the excess parameters. Excess parameters, associated with a liquid mixture, are a quantitative measure of deviation in the behaviour of the liquid mixture from ideality. The nature and excess functions' sign can be explained in terms of the molecular interactions considering both the positive and negative contributions. The excess values of molar volume (VE) and inter molecular free length ($L_f{}^E$) and deviation in adiabatic compressibility ($\Delta\beta_d$) are showed in table 3. Redlich-Kister coefficients are along with the standard deviations for all the excess and deviation properties at all the experimental temperatures are presented in Table 4. The non-rectilinear behaviour of ultrasonic velocity, compressibility and other thermo-dynamical parameters of liquid mixtures with changing mole fractions are attributed to the difference in the size of the molecules and strength of interactions.

The variations of excess molar volume, intermolecular free length and deviation in adiabatic compressibility with the mole fraction of OCP for the studied systems are given in figures 1.1 to 3.3 respectively.

Discussion
Various types of interactions are possible, which can operate in the binary liquid mixtures. Negative deviations in excess molar volumes, deviation in adiabatic

compressibilities and excess intermolecular free length have been observed in the studied systems, which may indicate some sort of strong interactions between component molecules.

Excess Molar Volume(V_m)
If the contractive factors dominate the expansive factors, then VE becomes negative [17]. The negative VE arises due to dominance of the following factors:

(1) Chemical interaction between constituent molecules such as heteromolecular association through the formation of H-bond, often termed as strong specific interaction.

(2) Association through weaker physical forces such as dipolar force or any other forces of this kind.

(3) Difference in molecular volumes and free volumes between liquid components which favours fitting of the component molecules with each other.

Self-association of alkanols decreases with increasing chain length in their pure state. When alkanols are mixed with OCP there is an interaction between their individual functional groups (—OH and —CO). The presence of electron withdrawing group on benzene ring decreases its electron densities. The polarity of alkanol is less hence, there degree of self- association is less as compared to OCP.

The algebraic VE values decrease (become more negative as the temperature is increased from 303.15 to 318.15K) for all the three systems. This indicates a gradual decreasing trend in the degree of the inter molecular hydrogen bonding in associated alkanol molecules as the temperature increases and hydrogen bonding broken hetero molecules are increased leading to greater contraction in the mix-up volumes. The expansion in volume due to increase in temperature of the systems seems to be dominated by more favourable fitting of small molecules into the larger voids created by bigger molecules at high temperatures leading to a contraction in volume, hence resulting in those higher negative values with rise in temperature.

The strength of the interactions follows the order:
OCP+1-hexanol > OCP+1-heptanol > OCP+1-octanol

Deviation in Adiabatic Compressibility($\Delta\beta_{ad}$)
The sign and magnitude of $\Delta\beta$ad play a vital role in assessing the molecular rearrangement as a result of molecular interaction between the component molecules in the liquid mixtures. The negative $\Delta\beta$ad in the studied mixtures can be explained on the basis of

complex formation between O - chlorophenol and alkanol molecules through hydrogen bonding between o-chlorophenol and the alkanol molecules. This is in accordance with the view proposed by Fort and Moore [18] according to which liquids of different molecular size usually mix with decrease in volume yielding negative $\Delta\beta$ad values. It can be seen that the deviation in adiabatic compressibility is negative over the composition range of o- chlorophenol for all the studied mixtures. Same results were reported by earlier [19,20]. The negative values of $\Delta\beta$ad suggest that the mixture is less compressible than the corresponding ideal mixtures and the positive values indicate an opposite behaviour. The values of $\Delta\beta$ad for these mixtures can be explained as accumulative manifestation of the various types of intermolecular interactions between the components. In general, $\Delta\beta$ad values depend on two factors (i) increase in free length, defined by Jacobson [21] due to loss of dipolar association, breaking up of hydrogen bonding [22] and difference in size and shapes of the molecules and

(ii) decrease in free length as a result of dipole-dipole interactions, hydrogen bonding association and complex formation between the component molecules [23]. The first factor constitutes to the increase in inter space between molecules in mixtures, consequently sound waves cause smaller distances in mixtures than in pure components. This would result in negative deviation in ultrasonic velocity and positive deviation in adiabatic compressibilities while the second factor constitutes to the decrease in inert space between molecules in mixtures consequently sound waves causes larger distances in mixtures than in pure components. This would result in positive deviation in ultrasonic velocity and negative deviation in adiabatic compressibility. The actual value of $\Delta\beta$ad would depend on the balance between the two opposing effects. The deviations in adiabatic compressibility for all the three systems are negative over the entire composition range at all the four temperatures and atmospheric pressure. The negative values of $\Delta\beta$ad are attributed due to formation of hydrogen bonding between OCP and alkanols. Negative trends in $\Delta\beta$ad were also reported by earlier workers [24].

Intermolecular Free Length($L_f{}^E$)
The intermolecular free length is the distance between the surfaces of the neighbouring molecules. According to Jacobson [25,26] the adiabatic compressibility can be studied more through intermolecular free length. Increase in free length due to the process of mixing results in lowering of sound velocity. This indicates free length is the predominant factor in determination of nature of ultrasonic velocity variation in the liquid mixture. The structural changes are also found to affect the variation of intermolecular free length. Similar trends as compared to adiabatic compressibility are found in $L_f{}^E$ in all three systems under study at all temperatures. According to Ramamurthy and Sastry [27] the negative $L_f{}^E$ values indicate that sound wave has to travel a longer distance. This may be attributed to dominant nature of interactions between unlike molecules. The $\Delta\beta$ad and $L_f{}^E$ minima occur at the same concentrations further strengthens the occurrence of molecular associations [28]. The sign and magnitude of the observed values $L_f{}^E$ were found to depend on several contributions which are physical or/and chemical nature. The physical contributions comprise the dispersion forces and non-specific physical weak interactions that lead to positive values in $L_f{}^E$ values, hence in order in the system. Chemical contributions involve breaking up of hydrogen bonded structure if any resulting in positive $L_f{}^E$ values and specific interactions such as formation of new hydrogen bonds, charge transfer complex formation and strong dipole-dipole interaction between component

molecules result in negative L_f^E values, making the system more ordered due to increased- inter molecular interaction. The negative L_f^E values for all the systems clearly indicate the existence of strong molecular interaction between the components.

Conclusions

The three binary systems studied viz., o-chlorophenol + 1- Hexanol, o-chlorophenol + 1- Heptanol and o-chlorophenol + 1- Octanol experimental data of ultrasonic velocity (U), density (ρ), along with related acoustic parameters like adiabatic compressibility (βad), molar volume (V), intermolecular free length (Lf) and their excess parameters are reported in this paper.

1. For all the three systems ultrasonic velocity values increase with increase in the concentration of o-chlorophenol. It is also observed that velocity decreases with increase in temperature at any concentration.

2. As density and viscosity are directly related, they show similar trends in all the systems under study, viscosity decreases with increase in temperature at any particular concentration.

3. The adiabatic compressibility (βad) and intermolecular free length (L_f) both have an inverse relationship with ultrasonic velocity (U).

4. The V^E values are negative over the entire mole fraction range and at all temperatures investigated for all binary systems under study. The negative V^E values are attributed to strong dipole-dipole interactions and hydrogen bonding between unlike molecules in the mixtures. The V^E values are more negative for o-chlorophenol + 2-methoxyethanol system than those for other two systems. 5. Deviation in adiabatic compressibilities and L_f^E are found to be negative over the mole fraction of o-chlorophenol indicating the presence of strong interactions between the molecules. The $\Delta\beta_{ad}$ and L_f^E minima occur at the same concentrations further strengthens the occurrence of molecular associations and strength of interactions between the component molecules. The results are in good agreement with those derived from data based on V^E and $(\Delta\beta_{ad})$. These results are in qualitative agreement with observations made by earlier investigators.

Table 1: Experimentally determined values of ultrasonic velocity (U), densty(ρ) for the binary systems OCP + 1- Hexanol, OCp + 1- Heptanol and OCP+1- Heptanol

Molefraction X1	Velocity U m/s	Density ρ gm/cm³	Velocity U m/s	Density ρ gm/cm³	Velocity U m/s	Density ρ gm/cm³	Velocity U m/s	Density ρ gm/cm³
	303.15K		308.15K		313.15K		318.15K	
OCP + 1- Hexanol								
0.0000	1289.5	0.8135	1280.0	0.8080	1256.5	0.8042	1236.5	0.8001
0.1199	1294.9	0.8586	1284.4	0.8534	1261.9	0.8495	1242.2	0.8453
0.2346	1300.7	0.9042	1289.6	0.8988	1267.9	0.8947	1248.0	0.8901
0.3445	1308.1	0.9495	1296.2	0.9439	1275.2	0.9396	1255.3	0.9345
0.4498	1317.0	0.9946	1304.1	0.9889	1283.8	0.9843	1264.0	0.9789
0.5508	1327.0	1.0394	1313.1	1.0334	1293.4	1.0285	1273.1	1.0227
0.6478	1336.5	1.0835	1321.7	1.0776	1302.8	1.0723	1282.5	1.0660
0.7410	1346.6	1.1270	1330.5	1.1210	1312.4	1.1156	1292.0	1.1091
0.8306	1357.5	1.1702	1340.0	1.1641	1322.5	1.1584	1302.0	1.1516
0.9169	1369.6	1.2124	1350.5	1.2061	1333.9	1.2001	1313.0	1.1928
1.0000	1382.0	1.2551	1361.2	1.2481	1345.2	1.2413	1324.1	1.2330
OCP + 1- Hexanol								
0.0000	1313.2	0.8157	1297.0	0.8114	1278.0	0.8077	1276.0	0.7859
0.1233	1320.4	0.8567	1303.8	0.8525	1285.1	0.8489	1285.9	0.8276
0.2403	1326.9	0.8991	1310.1	0.8946	1291.9	0.8908	1294.8	0.8705
0.3516	1333.9	0.9419	1316.9	0.9372	1299.0	0.9331	1304.5	0.9135
0.4576	1341.3	0.9855	1324.1	0.9805	1306.5	0.9762	1314.6	0.9576
0.5586	1349.3	1.0295	1331.5	1.0243	1314.1	1.0197	1324.7	1.0022
0.6550	1355.7	1.0738	1337.6	1.0684	1320.6	1.0635	1333.9	1.0474
0.7470	1361.9	1.1184	1343.2	1.1129	1326.5	1.1077	1342.4	1.0934
0.8350	1368.3	1.1635	1348.9	1.1578	1332.5	1.1521	1350.9	1.1399
0.9193	1375.2	1.2085	1354.9	1.2024	1338.9	1.1965	1360.0	1.1863
1.0000	1382	1.2551	1361.2	1.2481	1345.2	1.2413	1369.0	1.2330
OCP + 1- Hexanol								
0.0000	1313.2	0.8157	1297.0	0.8114	1278.0	0.8077	1276.0	0.7859
0.1233	1320.4	0.8567	1303.8	0.8525	1285.1	0.8489	1285.9	0.8276
0.2403	1326.9	0.8991	1310.1	0.8946	1291.9	0.8908	1294.8	0.8705
0.3516	1333.9	0.9419	1316.9	0.9372	1299.0	0.9331	1304.5	0.9135
0.4576	1341.3	0.9855	1324.1	0.9805	1306.5	0.9762	1314.6	0.9576
0.5586	1349.3	1.0295	1331.5	1.0243	1314.1	1.0197	1324.7	1.0022

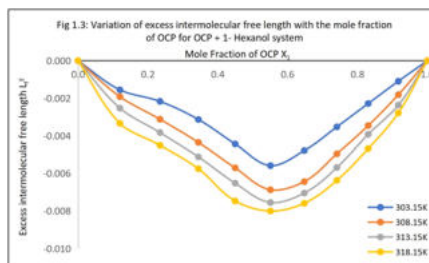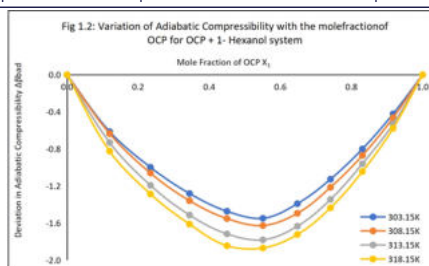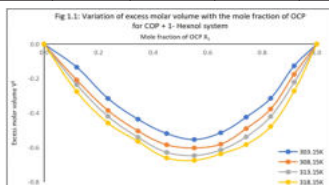## Table 2: Deviation in adiabatic compressibiltiy (Δβad), excess molar volume(VE) and excess intermolecular freelength(Lf E) for the binary systems OCP + 1- Hexanol, OCp + 1- Heptanol and OCP+1- Heptanol

Mole Fraction X1	$\Delta\beta_{ad}\times10^{-12}$ m^2N^{-1}	V^E $cm^3 mol^{-1}$	L_f^E Å	Mole Fraction X1	$\Delta\beta_{ad}\times10^{-12}$ m^2N^{-1}	V^E $cm^3 mol^{-1}$	L_f^E Å	Mole Fraction X1	$\Delta\beta_{ad}\times10^{-12}$ m^2N^{-1}	V^E $cm^3 mol^{-1}$	L_f^E Å
303.15K											
OCP + 1-			OCP + 1- Heptanol			OCP + 1- Octanol					
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.1199	-0.5989	-0.1352	-0.0014	0.1233	-0.5172	-0.1037	-0.0012	0.1356	-0.4296	-0.1040	-0.0006
0.2346	-0.9991	-0.3170	-0.0022	0.2403	-0.8587	-0.2872	-0.0018	0.2608	-0.7415	-0.2368	-0.0013
0.3445	-1.2821	-0.4376	-0.0031	0.3516	-1.0930	-0.3983	-0.0026	0.3768	-0.9608	-0.3855	-0.0020
0.4498	-1.4740	-0.5203	-0.0044	0.4576	-1.2449	-0.4838	-0.0037	0.4848	-1.1041	-0.4743	-0.0028
0.5508	-1.5502	-0.5551	-0.0056	0.5586	-1.3264	-0.5118	-0.0050	0.5853	-1.2152	-0.4976	-0.0037
0.6478	-1.3921	-0.5158	-0.0048	0.6550	-1.1788	-0.4793	-0.0042	0.6792	-1.0659	-0.4529	-0.0032
0.7410	-1.1277	-0.4254	-0.0035	0.7470	-0.9399	-0.3995	-0.0029	0.7671	-0.7989	-0.3780	-0.0021
0.8306	-0.8009	-0.3155	-0.0023	0.8350	-0.6555	-0.2894	-0.0017	0.8496	-0.5267	-0.2686	-0.0012
0.9169	-0.4221	-0.1270	-0.0011	0.9193	-0.3327	-0.1055	-0.0007	0.9270	-0.2408	-0.0803	-0.0003
1.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000
308.15K											
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.1199	-0.6355	-0.2089	-0.0019	0.1233	-0.5533	-0.1529	-0.0015	0.1356	-0.5323	-0.1346	-0.0012
0.2346	-1.0615	-0.3866	-0.0031	0.2403	-0.9205	-0.3335	-0.0025	0.2608	-0.8859	-0.2762	-0.0021
0.3445	-1.3599	-0.5056	-0.0044	0.3516	-1.1797	-0.4452	-0.0036	0.3768	-1.1488	-0.4130	-0.0031
0.4498	-1.5529	-0.5859	-0.0057	0.4576	-1.3542	-0.5306	-0.0049	0.4848	-1.3540	-0.5028	-0.0043
0.5508	-1.6282	-0.6040	-0.0069	0.5586	-1.4289	-0.5701	-0.0061	0.5853	-1.5138	-0.5171	-0.0057
0.6478	-1.4959	-0.5820	-0.0065	0.6550	-1.2853	-0.5331	-0.0054	0.6792	-1.3010	-0.4759	-0.0047
0.7410	-1.2149	-0.4915	-0.0050	0.7470	-1.0329	-0.4653	-0.0041	0.7671	-1.0179	-0.3951	-0.0036
0.8306	-0.8711	-0.3779	-0.0035	0.8350	-0.7256	-0.3583	-0.0026	0.8496	-0.6303	-0.2873	-0.0018
0.9169	-0.4644	-0.1759	-0.0018	0.9193	-0.3605	-0.1577	-0.0010	0.9270	-0.3044	-0.1112	-0.0008
1.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000
313.15K											
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.1199	-0.6355	-0.2360	-0.0025	0.1233	-0.5533	-0.2185	-0.0020	0.1356	-0.5323	-0.1744	-0.0017
0.2346	-1.0615	-0.4208	-0.0038	0.2403	-0.9205	-0.3992	-0.0032	0.2608	-0.8859	-0.3499	-0.0028
0.3445	-1.3599	-0.5422	-0.0051	0.3516	-1.1797	-0.5077	-0.0043	0.3768	-1.1488	-0.4728	-0.0037
0.4498	-1.5529	-0.6296	-0.0065	0.4576	-1.3542	-0.5934	-0.0057	0.4848	-1.3540	-0.5781	-0.0050
0.5508	-1.6282	-0.6482	-0.0076	0.5586	-1.4289	-0.6274	-0.0068	0.5853	-1.5138	-0.6162	-0.0064
0.6478	-1.4959	-0.6157	-0.0071	0.6550	-1.2853	-0.5955	-0.0062	0.6792	-1.3010	-0.5539	-0.0055
0.7410	-1.2149	-0.5395	-0.0057	0.7470	-1.0329	-0.5207	-0.0048	0.7671	-1.0179	-0.4853	-0.0044
0.8306	-0.8711	-0.4214	-0.0039	0.8350	-0.7256	-0.3999	-0.0032	0.8496	-0.6303	-0.3619	-0.0027
0.9169	-0.4644	-0.2218	-0.0024	0.9193	-0.3605	-0.2076	-0.0017	0.9270	-0.3044	-0.1764	-0.0013
1.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000
318.15K											
0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
0.1199	-0.7314	-0.2762	-0.0033	0.1233	-0.6171	-0.2322	-0.0026	0.1356	-0.8903	-0.1996	-0.0021
0.2346	-1.1936	-0.4595	-0.0045	0.2403	-1.0236	-0.4784	-0.0037	0.2608	-1.4499	-0.3337	-0.0033
0.3445	-1.5148	-0.5663	-0.0058	0.3516	-1.2926	-0.5643	-0.0048	0.3768	-1.8018	-0.5645	-0.0049

0.4498	-1.7185	-0.6618	-0.0075	0.4576	-1.4737	-0.6484	-0.0062	0.4848	-2.0469	-0.6259	-0.0061
0.5508	-1.7826	-0.6762	-0.0080	0.5586	-1.5382	-0.6699	-0.0072	0.5853	-2.1785	-0.6808	-0.0070
0.6478	-1.6353	-0.6383	-0.0076	0.6550	-1.3964	-0.6332	-0.0067	0.6792	-1.9038	-0.6457	-0.0060
0.7410	-1.3461	-0.5841	-0.0064	0.7470	-1.1267	-0.5751	-0.0053	0.7671	-1.5434	-0.5705	-0.0050
0.8306	-0.9608	-0.4794	-0.0047	0.8350	-0.7963	-0.4620	-0.0036	0.8495	-1.0376	-0.4525	-0.0029
0.9169	-0.5330	-0.2726	-0.0028	0.9193	-0.4224	-0.2539	-0.0020	0.9270	-0.5371	-0.2449	-0.0014
1.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000

Table 3: Values of coefficients and standard deviation (σ) for for the binary systems OCP + 1- Hexanol, OCp + 1- Heptanol and OCP+1- Heptanol

	A0	A1	A2	A3	A4	σ
OCP + 1-Hexanol						
Deviation in Adiabatic Compressibility(Δβad)						
303.15K	-6.2019	0.9533	3.4358	-2.0006	-4.3203	0.0206
308.15K	-6.5090	0.9651	2.8094	-1.6207	-3.4566	0.0185
313.15K	-7.1373	0.8860	2.4680	-1.5649	-3.5983	0.0144
318.15K	-7.4873	0.8748	1.7307	-1.8967	-3.4608	0.0091
Excess Molar Volume(VE)						
303.15K	-2.1872	0.5879	0.8289	-0.3782	0.4578	0.0148
308.15K	-2.3839	0.5084	-0.0054	-0.3849	0.5891	0.0112
313.15K	-2.5577	0.5511	-0.0254	-0.1977	0.0319	0.0085
318.15K	-2.6609	0.6252	-0.2547	-0.1549	-0.6253	0.0140
Excess Inter Molecular Free Length(Lf)						
303.15K	-0.0215	0.0150	0.0449	-0.0269	-0.0561	0.0003
308.15K	-0.0266	0.0158	0.0357	-0.0215	-0.0443	0.0003
313.15K	-0.0293	0.0150	0.0309	-0.0196	-0.0456	0.0002
318.15K	-0.0311	0.0149	0.0209	-0.0223	-0.0424	0.0001
OCP +1- Heptanol						
Deviation in Adiabatic Compressibility (Δβad)						
303.15K	-5.3078	1.0256	3.3480	-2.1110	-3.8726	0.0279
308.15K	-5.7032	1.1650	3.0306	-2.2322	-3.2890	0.0225
313.15K	-6.1573	1.0512	2.8781	-1.8918	-3.6262	0.0215
318.15K	-7.2526	0.9847	2.3710	-2.0619	-3.5055	0.0157
Excess Molar Volume (VE)						
303.15K	-1.9998	0.7113	0.4808	-0.3860	1.2308	0.0144
308.15K	-2.2199	0.8313	0.3163	-0.4575	0.6053	0.0162
313.15K	-2.4567	0.7728	0.1511	-0.4479	-0.1284	0.0101
318.15K	-2.6395	0.6187	-0.3266	0.2863	0.2728	0.0225
Excess Inter Molecular Free Length (Lf)						
303.15K	-0.0190	0.0157	0.0442	-0.0292	-0.0506	0.0004
308.15K	-0.0233	0.0180	0.0388	-0.0305	-0.0415	0.0003
313.15K	-0.0262	0.0166	0.0365	-0.0249	-0.0461	0.0003
318.15K	-0.0276	0.0163	0.0298	-0.0263	-0.0440	0.0002
OCP + 1-Octanol						
Deviation in Adiabatic Compressibility (Δβad)						
303.15K	-4.5488	1.4876	2.8827	-2.9094	-3.2502	0.0326
308.15K	-4.9207	1.5551	2.8282	-2.7589	-2.7621	0.0297
313.15K	-5.2682	1.3888	2.5730	-2.4806	-2.9857	0.0232
318.15K	-5.5032	1.4018	2.3767	-2.8970	-3.1975	0.0233
Excess Molar Volume (VE)						
303.15K	-1.8171	0.9396	-0.2546	-0.6110	2.5017	0.0103
308.15K	-2.2306	1.0259	-0.1506	-0.5325	1.5359	0.0139
313.15K	-2.4080	1.0941	0.0299	-0.7205	0.4973	0.0091
318.15K	-2.6582	0.8089	-0.2469	0.3210	0.2057	0.0198
Excess Inter Molecular Free Length (Lf)						
303.15K	-0.0165	0.0219	0.0379	-0.0406	-0.0419	0.0004
308.15K	-0.0202	0.0229	0.0361	-0.0383	-0.0345	0.0004
313.15K	-0.0230	0.0208	0.0326	-0.0335	-0.0377	0.0003
318.15K	-0.0244	0.0208	0.0296	-0.0377	-0.0393	0.0003

Fig 1.1: Variation of excess molar volume with the mole fraction of OCP for COP + 1- Hexanol system

Fig 1.2: Variation of Adiabatic Compressibility with the molefraction of OCP for OCP + 1- Hexanol system

Fig 1.3: Variation of excess intermolecular free length with the mole fraction of OCP for OCP + 1- Hexanol system

Fig 2.1 Variation of deviation in adiabtic compressibility with the mole fraction of OCP for OCP + 1- heptanol system

Fig2.2: Variation of excess molar volume with the molefraction of OCP for OCP + 1- Heptanol system

Fig 3.1: Variation of deviation in adiabatic compressibility with the mole fraction of OCP for OCP + 1- Octanol system

Fig 3.2 Variation of excess molar volume with the mole fraction of OCP for OCP + 1- Octanol system

Fig 3.3 Variation of excess intermolecular freelength with the molefraction of OCP for OCP + 1- Octanol System

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