

Thermodynamic Properties of Binary Mixtures of Methyl Benzoate with Chlorobenzene and Benzaldehyde at 308.15 and 318.15K

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Densities, viscosities and ultrasonic velocities of binary liquid mixtures of methyl benzoate with chlorobenzene and benzaldehyde have been measured at 308.15K and 318.15 K. By these experimental data excess volume (V^E), deviation in isentropic compressibility (ΔK_s), deviation in viscosity ($\Delta\eta$) intermolecular free length (ΔL_i), intermolecular free volume (ΔV_i) and deviation in acoustic impedance (ΔZ) were calculated. These results have been correlated with the Redlich and Kister type polynomial equation to derive the coefficients and standard errors. Significance of the calculated excess quantities were analyzed for mixtures of methyl benzoate with chlorobenzene and benzaldehyde, through which intermolecular interactions have been investigated.

Keywords: Density, Viscosity, Ultrasonic velocity, Excess properties, Binary mixture, Molecular interaction.

INTRODUCTION

Analysis of thermodynamic properties is most significant method that can expose the types of intermolecular interactions between two liquids. The experimental values of thermodynamic parameters can be explained to decide in terms of specific and non-specific interactions taking place between the molecules of the mixtures. The results of excellent interaction between the molecules can be considered as the appropriate solvent for the particular solute by this way. Methyl benzoate used as a flavours and fragrances in chemical industry. But methyl benzoate can also be used as the solvents of synthetic resins, cellulose esters and rubbers. Molecular interaction of methyl benzoate with ethanol at various temperatures have been investigated by Sheu and Tu [1]. Density, viscosity and speed of sound of methyl benzoate with cyclohexane, *n*-hexane, heptane and octane have been studied by Rathnam *et al.* [2]. Density and viscosity studies of *N,N*-dimethylformamide with methyl benzoate have been performed by Nikam and Kharat [3]. Thermophysical properties of methyl benzoate with *o*-xylene, *m*-xylene, *p*-xylene have been studied by Rathnam *et al.* [4]. Acoustic properties for the binary mixtures of methyl benzoate with 1-propanol and 1-butanol and 1-pentanol have been investigated by Sastry *et al.* [5]. Excess enthalpies and excess volumes for alkyl acetates and alkyl benzoates with aliphatic and aromatic hydrocarbon have been discussed by Grolier *et al.* [6]. Thermodynamic, dielectric, conformational studies of methyl benzoate with propane-1-ol have been reported by Mohan *et al.* [7]. Studies on densities and viscosities

of binary mixtures of methyl benzoate in *n*-heptane is reported by Blanco *et al.* [8]. Study of molecular interaction of binary mixture of methyl benzoate by using viscometric and ultrasonic study has been reported by Rathnam *et al.* [9]. This work is to study the excess properties of binary mixture of methyl benzoate with chlorobenzene and benzaldehyde at different temperatures and molecular interactions have been discussed.

EXPERIMENTAL

Chlorobenzene (Merck Chemicals, Mumbai) with purity of > 99 % (Merck Chemicals, Mumbai) with purity of > 99 % was dried over anhydrous calcium chloride and distilled twice. Benzaldehyde (Merck Chemicals, Mumbai, purity > 99 %) was purified by double distillation and methyl benzoate (Merck Chemicals, Mumbai, purity > 99 %) single distilled.

The solvents purity is established by comparing experimental values of densities, viscosities and ultrasonic velocities with reported in the literature values. Present experimental values of densities, viscosities and ultrasonic velocities matched well with the reported values and are presented in Table-1.

A set of nine compositions was prepared for each mixture, and their physical properties were measured at the respective compositions in the mole fraction scale from 0.1 to 0.9 in steps of 0.1. Binary liquid mixtures of various compositions were prepared by mixing fixed amount of pure liquids in air tight stoppered bottles of 50 mL capacity. Densities of pure liquids and liquid mixtures were measured by relative density method

TABLE-1
COMPARISON OF EXPERIMENTAL DENSITY (ρ), VISCOSITY (η), ULTRASONIC VELOCITY (U) OF PURE LIQUIDS WITH LITERATURE VALUES AT 308.15 K and 318.15 K

Liquid	Temp. (K)	Density (g cm^{-3})		Viscosity (mPa s^{-1})		Ultrasonic velocity (m s^{-1})	
		Expt.	Lit.	Expt.	Lit.	Expt.	Lit.
Methyl benzoate	308	1.0777	1.0743 [1]	1.5203	1.5310 [1]	1359.5	1364.0 [2]
	318	1.0648	1.0646 [1]	1.2960	1.2970 [1]	1335.5	
Chlorobenzene	308	1.0941	1.0904 [11]	0.7040	0.6830 [14]	1228.0	1224.0 [12]
	318	1.0793	1.0790 [11]	0.6944		1208.5	1194.0 [10]
Benzaldehyde	308	1.0381	1.0313 [12]	1.2483	1.2490 [12]	1417.5	1421.2 [13]
	318	1.0233	1.0229 [13]	1.0508		1395.0	1384.7 [13]

[15-18] using 10 mL relative density bottle and weighed with an accuracy of $\pm 0.001 \text{ kg m}^{-3}$. Viscosities were determined using an Oswald viscometer of 10 mL capacity with an accuracy of $\pm 0.001 \text{ mPa}$ [15-19]. From the measured values of density (ρ) and flow time (t), viscosity (η) was calculated using the following relation [14-17]:

$$\eta = (A \times t - B/t) \times \rho \quad (1)$$

where A and B are viscometer constants. The values of constants were obtained by measuring the flow time with distilled water and pure nitrobenzene as standard liquids. The flow time were measured with electronic stop clock. Ultrasonic velocities of pure and liquid mixtures were measured by a single crystal variable path interferometer (Pico Chennai, Model BL-02) [18] at a frequency of 2 MHz with an accuracy of $\pm 0.02\%$. All the measurements were made at 308.15 and 318.15 K with the help of a digital thermostat with a temperature accuracy of $\pm 0.01 \text{ K}$.

The excess volume V^E was calculated by the relation [13-17]:

$$V^E = [X_A M_A + X_B M_B] / \rho_{AB} - [X_A M_A / \rho_A + X_B M_B / \rho_B] \quad (2)$$

where X_A , X_B are mole fraction of components A and B, M_A , M_B are the molecular mass of components A & B. ρ_A and ρ_B are the density of component A and B, respectively and ρ_{AB} is the density of mixture.

Values of ultrasonic velocity (u) and density of mixture (ρ_{AB}) were used to calculate isentropic compressibility (K_S) by using following relation recommended by Benson and Kiyohara [20-24]:

$$K_S = 1/U^2 \rho \quad (3)$$

where, U is the ultrasonic velocity of pure and mixture, and ρ is the density of pure and mixture.

The deviation in isentropic compressibility was obtained from the relation:

$$\Delta K_S = K_S - (\Phi_1 K_{S1} + \Phi_2 K_{S2}) \quad (4)$$

where Φ_1 and Φ_2 are the volume fraction of component 1 and 2, K_{S1} and K_{S2} are the isentropic compressibility of component 1 and 2. K_S is the experimental value of isentropic compressibility of the mixture.

Deviation in acoustic impedance ΔZ and deviation in intermolecular free length (ΔL_f) has been calculated from the following relation [24,25]:

$$L_f = k/U\rho^{1/2} \quad (5)$$

$$Z = U\rho \quad (6)$$

where, U is the ultrasonic velocity of pure and mixture, and ρ is the density of pure and mixture, k is the Jacobson's constant

which is temperature dependent but independent of the nature of the liquids, whose value is $(91.368 + 0.3565 T) 9 \times 10^{-8}$ and is obtained from the literature [26].

$$V_f = [M_{\text{eff}} U / k \eta]^{3/2} \quad (7)$$

where k is a constant equal to 4.28×10^9 in MKS system [27], independent of temperature for all liquids, M_{eff} is the effective molecular weight. $M_{\text{eff}} = \sum x_i m_i$ where, x is the mole fraction and m is the molecular weight of i th component.

$$\Delta Y = Y_{\text{mix}} - x_1 Y_1 + x_2 Y_2 \quad (8)$$

where ΔY is $\Delta \eta$ or ΔV_f or ΔL_f or ΔZ and x represent mole fraction of the component and subscript 1 and 2 for components 1 and 2.

RESULTS AND DISCUSSION

Experimental values of density (ρ), viscosity (η) and ultrasonic velocity (u) were measured from which, calculated values of excess volume V^E , deviation in isentropic compressibility (ΔK_S) of all the five binary mixtures are presented in Tables 2 and 3. The excess properties of V^E , ΔK_S , $\Delta \eta$, L_f^E and ΔZ were fitted to Redlich-Kister [28] type polynomial equation:

$$\Delta A = x_1 x_2 [a + b(x_1 - x_2) + c(x_1 - x_2)^2] \quad (9)$$

By the method of least squares to derive the adjustable parameters a , b and c .

The standard deviations (σ) presented in this work were computed using the following relation:

$$\sigma = \sum \left(\frac{(X_{\text{exp}} - X_{\text{cal}})^2}{N - n} \right)^{1/2} \quad (10)$$

where N is the number of data points and n is the number of coefficients.

The excess volumes (V^E), deviation in isentropic compressibility (ΔK_S), deviation in viscosity ($\Delta \eta$), deviation in intermolecular free length (ΔL_f), deviation in intermolecular free volume (ΔV_f) and deviation in acoustic impedance (ΔZ) for all six liquid mixtures at two temperatures are presented in Figs. 1-6.

The excess volume provide good information about the intermolecular behaviour. The factors that are dependable for increase in volume are as follows: (i) loss of dipolar association, (ii) the geometry of molecular structure, which does not allow fitting of one component into other component, (iii) steric hindrance, which opposes the proximity of constituent molecules [29]. In the present work, benzaldehyde and chlorobenzene shows positive values of V^E with methyl benzoate (Fig. 1). But benzaldehyde mixture seems to be low positive chlorobenzene mixture that revealed methyl benzoate + benzaldehyde mixture interact more than methyl benzoate + chlorobenzene mixture.

TABLE-2
PHYSICAL AND THERMODYNAMIC PROPERTIES OF METHYL BENZOATE WITH CHLOROBENZENE AND BENZALDEHYDE AT 308.15 K

x_1	ρ (g cm ⁻³)	V^E (cm ³ mol ⁻¹)	η (mPa s)	U (m s ⁻¹)	ΔK_s (Tpa ⁻¹)	$\Delta\eta$ (mPa s)	ΔL_f (10 ⁻¹⁰ m)	ΔZ (10 ⁻⁶ Kg m ² s ⁻¹)	ΔV_f (10 ⁻¹⁵ m ³ mol ⁻¹)
Methyl benzoate + Chlorobenzene									
0.0000	1.0931	0.0000	0.7033	1228.00	0.0000	0.0000	0.0000	0.0000	0.0000
0.0992	1.0908	0.0398	0.7644	1236.5	5.3732	-0.0200	0.1044	-5.6699	-3.80 × 10 ⁻¹⁵
0.2154	1.0884	0.0842	0.8432	1244.0	13.4221	-0.0361	0.2840	-14.8478	-7.10 × 10 ⁻¹⁵
0.2985	1.0867	0.1126	0.9024	1249.5	18.6279	-0.0448	0.4071	-21.1441	-8.40 × 10 ⁻¹⁵
0.4077	1.0847	0.1425	0.9829	1258.0	23.7905	-0.0534	0.5361	-27.8680	-8.90 × 10 ⁻¹⁵
0.5025	1.0831	0.1552	1.0574	1267.0	26.3690	-0.0564	0.6070	-31.7280	-8.70 × 10 ⁻¹⁵
0.6055	1.0817	0.1427	1.1456	1282.5	23.7038	-0.0523	0.5486	-29.3682	-7.80 × 10 ⁻¹⁵
0.6997	1.0807	0.1131	1.2299	1299.0	19.2294	-0.0450	0.4451	-24.4659	-6.40 × 10 ⁻¹⁵
0.7999	1.0797	0.0765	1.3231	1319.0	12.6309	-0.0337	0.2895	-16.5270	-4.50 × 10 ⁻¹⁵
0.9004	1.0787	0.0367	1.4192	1340.0	5.6119	-0.0198	0.1247	-7.5101	-2.30 × 10 ⁻¹⁵
1.0000	1.0777	0.0000	1.5203	1359.50	0.0000	0.0000	0.0000	0.0000	0.0000
Methyl benzoate + Benzaldehyde									
0.0000	1.0381	0.0000	1.2483	1417.50	0.0000	0.0000	0.0000	0.0000	0.0000
0.0962	1.0425	0.0256	1.2710	1416.00	-3.6193	-0.0034	-0.0966	5.2155	2.20 × 10 ⁻¹⁶
0.2019	1.0470	0.0539	1.2967	1417.00	-9.1316	-0.0065	-0.2468	13.3875	5.10 × 10 ⁻¹⁶
0.3014	1.0511	0.0828	1.3219	1417.50	-13.7878	-0.0084	-0.3731	20.3165	7.40 × 10 ⁻¹⁶
0.3972	1.0549	0.1062	1.3465	1414.50	-15.7726	-0.0098	-0.4245	23.1389	8.60 × 10 ⁻¹⁶
0.4885	1.0585	0.1176	1.3706	1410.00	-16.4494	-0.0106	-0.4407	24.0173	9.06 × 10 ⁻¹⁶
0.5921	1.0626	0.1047	1.3991	1402.00	-15.1536	-0.0102	-0.4044	21.9897	8.37 × 10 ⁻¹⁶
0.6995	1.0668	0.0781	1.4298	1391.00	-11.7358	-0.0087	-0.3112	16.8498	6.59 × 10 ⁻¹⁶
0.7990	1.0706	0.0493	1.4593	1379.00	-7.0197	-0.0063	-0.1839	9.8988	4.15 × 10 ⁻¹⁶
0.9035	1.0744	0.0195	1.4912	1367.00	-2.1598	-0.0029	-0.0548	2.9310	1.48 × 10 ⁻¹⁶
1.0000	1.0777	0.0000	1.5203	1359.50	0.0000	0.0000	0.0000	0.0000	0.0000

TABLE-3
PHYSICAL AND THERMODYNAMIC PROPERTIES OF METHYL BENZOATE WITH CHLOROBENZENE AND BENZALDEHYDE AT 318.15 K

x_1	ρ (g cm ⁻³)	V^E (cm ³ mol ⁻¹)	η (mPa s)	U (m s ⁻¹)	ΔK_s (Tpa ⁻¹)	$\Delta\eta$ (mPa s)	ΔL_f (10 ⁻¹⁰ m)	ΔZ (10 ⁻⁶ Kg m ² s ⁻¹)	ΔV_f (10 ⁻¹⁵ m ³ mol ⁻¹)
Methyl benzoate + Chlorobenzene									
0.0000	1.0792	0.0000	0.6944	1208.50	0.0000	0.0000	0.0000	0.0000	0.0000
0.0992	1.0770	0.0530	0.7307	1213.0	9.4544	-0.0234	0.2070	-9.5627	-6.7 × 10 ⁻¹⁶
0.2154	1.0746	0.1063	0.7789	1219.0	19.0032	-0.0451	0.4254	-19.7465	-1.6 × 10 ⁻¹⁵
0.2985	1.0729	0.1418	0.8182	1223.5	25.1666	-0.0557	0.5740	-26.6954	-2.4 × 10 ⁻¹⁵
0.4077	1.0710	0.1703	0.8732	1231.0	31.0775	-0.0665	0.7227	-33.8392	-2.9 × 10 ⁻¹⁵
0.5025	1.0696	0.1828	0.9258	1239.5	33.7953	-0.0708	0.7983	-37.7113	-3.2 × 10 ⁻¹⁵
0.6055	1.0683	0.1709	0.9925	1254.5	30.8107	-0.0662	0.7339	-35.4248	-3.2 × 10 ⁻¹⁵
0.6997	1.0673	0.1451	1.0571	1271.5	25.0255	-0.0582	0.5988	-29.6457	-2.8 × 10 ⁻¹⁵
0.7999	1.0664	0.1029	1.1305	1290.0	18.6926	-0.0450	0.4519	-22.8730	-2.1 × 10 ⁻¹⁵
0.9004	1.0656	0.0521	1.2095	1311.5	10.1378	-0.0265	0.2474	-12.8432	-1.1 × 10 ⁻¹⁵
1.0000	1.0648	0.0000	1.2960	1335.50	0.0000	0.0000	0.0000	0.0000	0.0000
Methyl benzoate + Benzaldehyde									
0.0000	1.0233	0.0000	1.0508	1395.00	0.0000	0.0000	0.0000	0.0000	0.0000
0.0962	1.0278	0.0346	1.0698	1392.00	-2.8614	-0.0046	-0.0741	3.6915	3.88 × 10 ⁻¹⁶
0.2019	1.0325	0.0749	1.0920	1389.50	-6.3036	-0.0083	-0.1641	8.1954	7.60 × 10 ⁻¹⁶
0.3014	1.0367	0.1084	1.1140	1388.50	-10.3071	-0.0107	-0.2715	13.5986	1.10 × 10 ⁻¹⁵
0.3972	1.0407	0.1335	1.1357	1386.00	-12.8815	-0.0125	-0.3396	17.0412	1.32 × 10 ⁻¹⁵
0.4885	1.0445	0.1434	1.1570	1382.00	-14.0557	-0.0136	-0.3703	18.5889	1.43 × 10 ⁻¹⁵
0.5921	1.0488	0.1306	1.1830	1373.00	-12.0082	-0.0129	-0.3132	15.6795	1.25 × 10 ⁻¹⁵
0.6995	1.0532	0.1038	1.2112	1363.00	-9.1479	-0.0110	-0.2363	11.7867	9.90 × 10 ⁻¹⁶
0.7990	1.0572	0.0700	1.2384	1352.50	-5.3134	-0.0083	-0.1345	6.6779	6.44 × 10 ⁻¹⁶
0.9035	1.0612	0.0316	1.2679	1342.50	-1.7769	-0.0044	-0.0430	2.1259	2.75 × 10 ⁻¹⁶
1.0000	1.0648	0.0000	1.2960	1335.50	0.0000	0.0000	0.0000	0.0000	0.0000

Compressibility of a liquid is the vital physical quantities in liquid mechanics. It depends on the structure of the liquid [30]. Intermolecular free length (L_f) is the distance between the surfaces of two molecules, which establish the properties of fluids consists of attractive and repulsive forces. According to Fort and Moore [31] a negative value of deviation in compressibility (ΔK_s) and deviation in intermolecular free length (ΔL_f) are the suggestion of strong heteromolecular

interaction in the liquid mixtures, while a positive sign specify weak interaction and is accredited to dispersion forces.

The ΔK_s and ΔL_f values of chlorobenzene is positive and benzaldehyde is negative with methyl benzoate (Fig. 2), it ascribed that benzaldehyde is attracted towards methyl benzoate molecules and chlorobenzene dispersed methyl benzoate molecules (Table-4). The physical contribution consists of dispersion forces or weak interaction that leads to positive values of ΔK_s and ΔL_f [32,33].

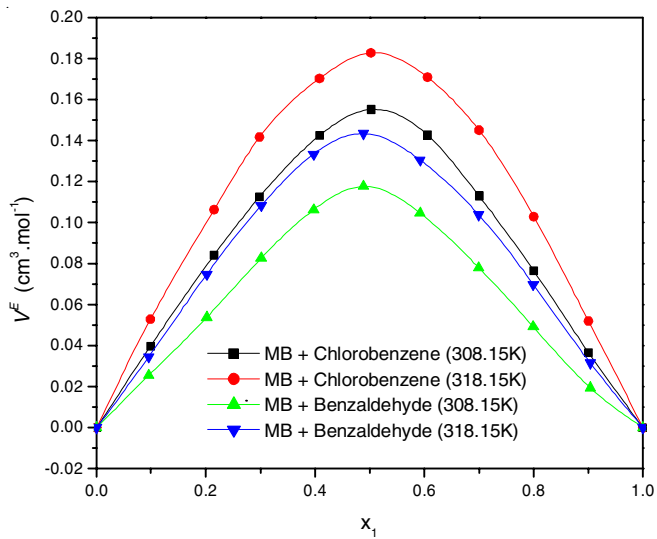


Fig. 1. Excess volume (V^E) for methyl benzoate (MB) with chlorobenzene and benzaldehyde at 308.15 K and 318.15 K

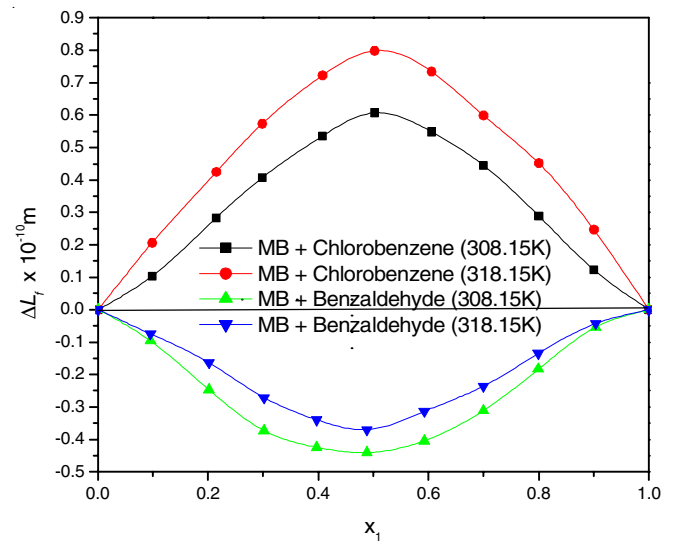


Fig. 4. ΔL_f for methyl benzoate (MB) with chlorobenzene and benzaldehyde at 308.15 and 318.15 K

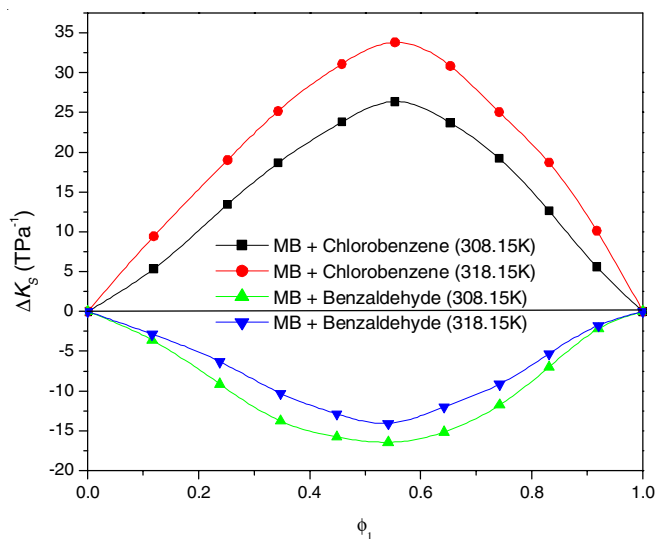


Fig. 2. ΔK_S for methyl benzoate (MB) with chlorobenzene and benzaldehyde at 308.15 K and 318.15 K

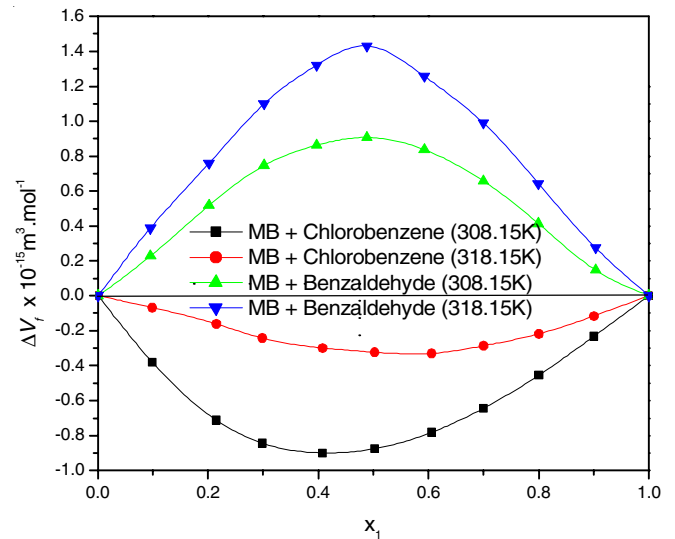


Fig. 5. ΔV_f for methyl benzoate (MB) chlorobenzene and benzaldehyde at 308.15 and 318.15 K

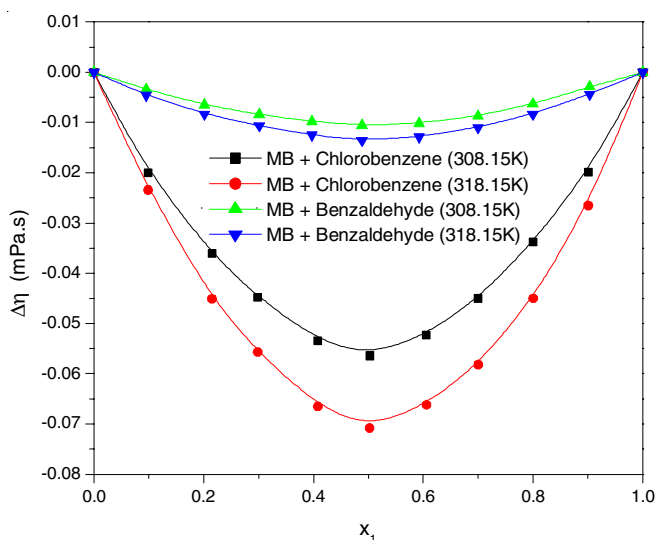


Fig. 3. $\Delta \eta$ for methyl benzoate (MB) with chlorobenzene and benzaldehyde at 308.15 and 318.15 K

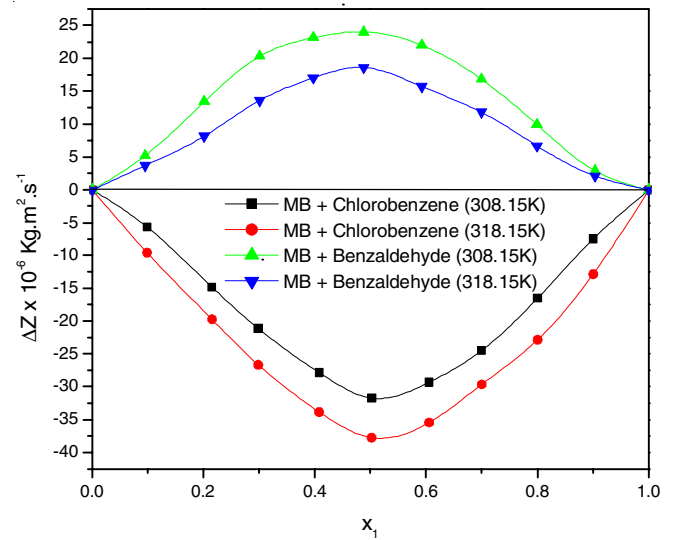


Fig. 6. ΔZ for methyl benzoate (MB) with chlorobenzene and benzaldehyde at 308.15 and 318.15 K

TABLE-4
VALUES OF THE CO-EFFICIENT OF THE REDLICH-KISTER TYPE POLYNOMIAL EQUATION
(eqn. 9) AND STANDARD DEVIATION (eqn. 10) AT THE DIFFERENT TEMPERATURE

Temp. (K)	Methyl benzoate + Chlorobenzene				Methyl benzoate + Benzaldehyde			
	a	b	c	σ	a	b	c	σ
	V^E ($\text{cm}^3 \text{mol}^{-1}$)				V^E ($\text{cm}^3 \text{mol}^{-1}$)			
308	-0.0880	0.3790	0.1768	0.0449	0.8275	-0.3475	0.2571	0.0367
318	-0.0755	0.4457	0.0275	0.0051	0.3566	-0.1396	0.1242	0.0092
	$\Delta\eta$ (mPa s)				$\Delta\eta$ (mPa s)			
308	1.6342	-6.1865	5.3876	0.2141	-0.0402	0.0005	0.0068	0.0001
318	2.2362	-5.3336	6.0809	0.2738	-0.1107	-0.0039	0.0107	0.0042
	ΔK_s (Tpa $^{-1}$)				ΔK_s (Tpa $^{-1}$)			
308	100.81	27.7362	-62.6938	0.0499	-62.0592	-27.1197	33.0251	0.1456
318	128.817	32.2414	-38.9171	0.0298	-53.9367	-7.9224	46.3779	0.1023
	$\Delta L_f \times 10^{-10}$ m				$\Delta L_f \times 10^{-10}$ m			
308	-5.81×10^{-10}	-2.52×10^{-10}	-3.36×10^{-10}	6.3701×10^{-11}	-2.04×10^{-10}	-7.33×10^{-12}	9.92×10^{-11}	2.3121×10^{-12}
318	-4.81×10^{-10}	-4.12×10^{-10}	-5.58×10^{-10}	4.5174×10^{-11}	2.68×10^{-12}	8.77×10^{-12}	-2.94×10^{-11}	1.1516×10^{-13}
	$\Delta Z \times 10^{-6}$ Kg m 2 s $^{-1}$				$\Delta Z \times 10^{-6}$ Kg m 2 s $^{-1}$			
308	-123.297	-16.5277	81.5453	0.0078	97.1631	-18.0452	-71.0522	0.0114
318	-145.693	-21.2663	44.1346	0.0222	71.2854	-10.2706	-65.1788	0.0117
	$\Delta V_f \times 10^{-15}$ m 3 mol $^{-1}$				$\Delta V_f \times 10^{-15}$ m 3 mol $^{-1}$			
308	1.43×10^{-6}	2.78×10^{-7}	4.27×10^{-6}	1.7441×10^{-7}	3.85×10^{-15}	7.96×10^{-18}	-1.52×10^{-15}	2.2208×10^{-17}
318	1.39×10^{-6}	8.80×10^{-8}	3.96×10^{-6}	1.6115×10^{-7}	5.27×10^{-14}	8.60×10^{-15}	-3.09×10^{-13}	4.6195×10^{-16}

Viscosity deviation is linked to the struggle of a mixture to flow, positive deviations of viscosity values for the mixtures are the effect of a higher resistance to flow than the pure compounds. Rowlinson and Swinton [34] stated that the positive deviation of the viscosities on mole fraction is the incidence of maxima where the component molecules interact more strongly. Negative deviations occurred where London forces or dispersion forces are responsible for the interactions [35]. In the present work, both chlorobenzene and benzaldehyde got negative sign over the entire range, but benzaldehyde gets lower negative sign than chlorobenzene, this suggests that benzaldehyde attract more than chlorobenzene with methyl benzoate.

ΔZ described how much resistance an ultrasound beam encounters as it passes through a liquid. Positive and negative deviations in these functions of the mixtures specify the extent of association or dissociation between the mixing components [36,37]. According to Kondaiah and Rao [38], the nature of the positive values of ΔZ is attributed to specific interaction between the unlike molecules ΔZ and ΔV_f values are positive over the entire range for benzaldehyde (Figs. 5 and 6) and negative over the whole array for chlorobenzene mixture.

From the above data, we can interpreted that benzaldehyde interact more with methyl benzoate than chlorobenzene, because benzaldehyde has more dipole moment (2.89 D) and dielectric constant (17.80) than chlorobenzene which has 1.54 D and 5.62, respectively (Table-4). Benzaldehyde contains carbonyl group, since carbonyl carbon gets partially positive charge due to inductive effect, the positive carbon may be approached by oxygen atom of the methylbenzoate. Although chlorobenzene has more electronegative chlorine atom, its polarity suppressed by the benzene ring, hence chlorobenzene is less polar molecule than benzaldehyde. Methyl benzoate interacts with benzaldehyde through dipole-dipole interaction. Both the two mixture molecules decreasing interaction with increasing temperature because of the thermal vibration they move away from each other.

Conclusion

This work has determined V^E , ΔK_s , ΔL_f , $\Delta\eta$, ΔV_f and ΔZ for mixtures of methyl benzoate with chlorobenzene and benzaldehyde. The importances of V^E and ΔK_s , ΔL_f , $\Delta\eta$, ΔV_f and ΔZ have been interpreted in terms of different molecular interaction between those molecules. The magnitudes of excess properties have shown that methyl benzoate + benzaldehyde mixtures get strong specific interaction which is explained by dipole-dipole interaction between them. Interaction between methyl benzoate + chlorobenzene is described as dispersion force. Interaction decreases with increasing temperature because of thermal action.

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