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Partial molar properties of binary liquid mixtures of Propiophenone with 2-AlkoxyEthanols at T=303.15-318.15K

Nanduri Gayatri Devi[1], D.Ramachandran[*1],

[1]Ch.S.D.St.Theresa's (Autonomous) College for Women, Eluru, India.

[*1]Acharya Nagarjuna University, Guntur, India.

(*Corresponding Author - Email: dittakavirc17@gmail.com)

Abstract: **Densities 'ρ', Ultrasonic speeds of sound'u'of binary mixtures of Propiophenone with2-Methoxy Ethanol, 2-Ethoxy Ethanol and 2-Butoxy Ethanol were measured over the entire composition range at T = 303.15 to 318.15K at atmospheric pressure 0.1MPa. Experimental data has been used to calculate the deviation in isentropic compressibility &the excess isentropic compressibility and their results were fitted with the Redlich Kister equation to estimate the binary coefficients and standard deviation between experimental and calculated data. Partial molar volume ($\bar{V}^{o,E}_{m,i}$), Partial molar isentropic compressibility ($\bar{K}^{o,E}_{s\,m,i}$), partial molar excess volumes ($\bar{V}^{o,E,\infty}_{m,i}$) and partial molar excess isentropic compressibility ($\bar{K}^{o,E,\infty}_{s\,m,i}$) at infinite dilution of the binary mixtures were calculated over the whole composition range to understand further the nature of intermolecular interactions between the molecules in the above binary mixtures.**

Keywords: ***Density; Ultrasonic speed of sound; excess isentropic compressibility; Partial molar volume; Partial molar isentropic compressibility; excess partial molar properties.***

I. INTRODUCTION

In liquid mixtures, thermodynamic properties and it's deviation from the ideality gives the important information about the molecular structures and their intermolecular interactions [1]-[3]. Similarly, excess molar volume property indicates inter or intra molecular changes in between the components and partial molar properties of the binary mixtures play a major role to understand more about the changes in the molar composition and the type of inter molecular interactions between the molecules of the mixture at constant temperature and pressure. Excess property study is important and it has been used for the design of equipment in heat transfer, fluid mechanics, process calculation and process control. Present paper is on partial molar properties of Propiophenone with 2-Methoxy Ethanol, 2-Ethoxy Ethanol and 2-Butoxy Ethanol binary mixtures which are having various applications in chemical industries. Propiophenone is widely used component in perfumes industries. Alkoxyethanols are used as additives to gasoline due to their octane enhancing and pollution reducing properties [4]. Literature survey reveals several studies on 2-alkoxy ethanols with other compounds [4]-[11]. Apparently, no studies were made on the Partial molar properties of Propiophenone with 2-Methoxyethanol (2-MOE), 2-Ethoxyethanol (2-EOE) and 2-Butoxyethanol (2-BOE) binary mixtures. On the other hand, the investigation of mixtures involving alkoxyethanols makes possible the study of self-association via inter and intra molecular hydrogen bonds related to the presence of the etheric Oxygen and OH groups in the same molecule. Hence, thermodynamic mixing properties of the current binary mixtures have such importance in theoretical and applied areas of research. Densities ρ, and ultrasonic velocities u of binary liquid mixtures of Propiophenone with 2-Methoxyethanol (2-MOE), 2-Ethoxyethanol (2-EOE) and 2-Butoxyethanol (2-BOE)were measured over the entire composition range at T = 303.15- 318.15K to calculate various thermodynamic properties like deviation in isentropic compressibility (ΔKs), excess Isentropic compressibility (Ks^E), partial molar volume ($\bar{V}^{o,E}_{m,i}$) and partial molar isentropic compressibility ($\bar{K}^{o,E}_{s\,m,i}$), partial molar excess volumes ($\bar{V}^{o,E,\infty}_{m,i}$) and partial molar excess isentropic compressibility ($\bar{K}^{o,E,\infty}_{s\,m,i}$) at infinite dilution of the binary mixtures were calculated over the whole composition range. Partial molar quantities at infinite dilution shows the component's behavior and it's interactions between (solute – solvent) the compounds. Deviation in isentropic compressibility (Δks) & excess isentropic compressibility values were fitted to the Redlich Kister equation [12] to estimate the binary coefficients and standard deviation between the experimental and calculated data.

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II. EXPERIMENTAL SECTION

1.1 Apparatus and Procedures

Propiophenone (PPH), 2-Methoxyethanol (2-MOE), 2-Ethoxyethanol (2-EOE) and 2-Butoxyethanol (2-BOE), these chemicals were procured from S.D. Fine chemicals Ltd, India and used in the present investigation. The mass fraction purities of the liquids were as Propiophenone (>99%), 2-Methoxyethanol (99.3%), 2-Ethoxyethanol (99.7%), and 2-Butoxyethanol (99.4%). and water content found less than 0.003 mass%. Purities of the solvents are shown in Table-01.

Table-01: Provenance and purity of the materials used

CHEMICALS	CAS number	Source	Mass fraction purity(final)
Propiophenone	93-55-0	S.D fine Chemicals, India	> 99%
2-Methoxy ethanol	109-86-4	S.D fine Chemicals, India	0.993
2-Ethoxy ethanol	110-80-5	S.D fine Chemicals, India	0.997
2-Butoxy ethanol	111-76-2	S.D fine Chemicals, India	0.994

Binary mixtures were prepared by mixing weighed amounts of the pure liquids adopting the method of closed system by using Mettler Toledo (ME204) balance with the precision of ± 0.1 mg. Mixtures were allowed to stand for some time before every measurement so as to avoid air bubbles. The purities of the liquids were checked by comparing the values of densities, ultrasonic velocities and Cp with literature data and are given in Table-02, a[13], b[10], c[14], d[15], e[16], f[17], g[18], h[19], i[20], j[21], k[22], l[23],m[24],n[25].o[26].

Table-02: Comparison of experimental and literature values of density and velocity of pure liquids at *T*= (303.15-318.15) K and 0.1MPa

Compound	T(K)	Density (ρ)		Ref	Ultrasonic speed(u)		Ref	Cp	Ref
		Exp.	Lit.		Exp.	Lit.			
		gm/cm^{-3}	gm/cm^{-3}		m. s^{-1}	m. s^{-1}			
Propiophenone	303.15	1.0045	1.0044	j	1446.41	1440	k	246.15	o
	308.15	1.0015	1.0006	j	1427.038	1432	l	248.00	o
			1.0087	a					
	313.15	0.9985			1403.95			250.04	o
	318.15	0.9955			1380			251.95	o
2-Methoxy Ethanol	303.15	0.9525	0.9527	e	1347.52	1352	b	176.30	n
	308.15	0.9492	0.9511	f	1340.12	1342	b	177.24	n
	313.15	0.9456	0.9463	g	1333.79	1332	b	178.22	n
	318.15	0.9421	0.9416	g	1327.36	1320	b	179.22	n
2-Ethoxy Ethanol	303.15	0.9212	0.9205	c	1318.24	1318	b	210.97	m
	308.15	0.9164	0.9165	h	1296.572	1295.5	b	213.71	m
	313.15	0.9123	0.9123	i	1268.646	1275	b	215.67	m
	318.15	0.9078	0.9078	d	1235	1235.1	d	217.62	m
2-Butoxy Ethanol	303.15	0.8924	0.8921	e	1288	1288	c	271.82	n
	308.15	0.8877	0.8887	f	1272	1275	d	273.05	n
	313.15	0.8833	0.8822	b	1259	1259	d	274.32	n
	318.15	0.8794	0.8796	b	1242	1242.1	d	275.60	n

The standard uncertainties for density*u* (ρ) = 0.001kg·cm^{-3}, velocity *u* (u) = 0.01m.s^{-1}, mole fraction *u* (x_1) = *0.0001*,temperature *u* (T) = 0.01 K and for time *u*(t) = 0.01sec.

2.1 Apparatus and Procedures

Anton Paar (DSA 5000 M) oscillating u-tube densimeter, automatically thermostatic within ±0.01K, used to calculate the densities and speed of sounds of the pure components and the binary mixtures over the whole composition range *T*= 303.15 to 318.15K. The accuracy for densities is ± 1 x 10^{-2} kg.m^{-3} and ± 0.1m.s^{-1} for speed of sound. Corresponding precessions are ± 1 x 10^{-3} kg.m^{-3} and ± 0.01m.s^{-1} for density and speed of sound respectively. It can measure the density in the range of 0 to 3 × 10^{3} kg·m^{-3} and

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speed of sound from (1000 to 2000) $m \cdot s^{-1}$. At regular intervals calibration was done at the required temperature using dry air and ultrapure water (millipore). Averages of three consecutive measurements were taken between the temperatures from 303.15to 318.15K with an increment of 5K under atmospheric pressure. The standard uncertainties associated with the measurement of density are ±0.001 $kg.m^{-3}$ and ±0.01ms^{-1} for speed of sound.

III. THEORY AND CALCULATIONS

Deviation in isentropic compressibility (ΔKs), excess isentropic compressibility (K_S^E) and other excess partial molar properties were calculated from the experimental data by using the following relations.

a) The isentropic compressibility(Ks) was calculated using the Laplace relation

$$K_s = U^{-2}\,\rho^{-1} \quad \ldots\ldots (1)$$

Where u is the ultrasonic velocity and ρ the density.

b) The deviation in isentropic compressibility, ΔK_S obtained using the relation,

$$\Delta K_S(\mathrm{TPa}^{-1}) = K_S 12 - \varphi 1 K_S 1 - \varphi 2 K_S 2 \quad \ldots\ldots (2)$$

WhereK_S12 is the experimental isentropic compressibility of the mixture, and $\varphi 1$, $\varphi 2$ andK_S1, K_S2 are the volume fractions and isentropic compressibility, respectively, of the pure components.

Where ϕ_i is the ideal state volume fraction and is defined by the relation:

$$\phi_i = \frac{x_i V_i}{\sum_{i=1}^{2} x_i V_i} \quad \ldots\ldots (3)$$

c) Excess isentropic compressibility (K_S^E) calculated by the relation

$$K_S^E = K_S - K_S^{iD} \quad \ldots\ldots (4)$$

$$K_S^{iD} = \sum_{i=1}^{2} \phi_i \left(K_{si} + \frac{T V_i \alpha_i^2}{C_{pi}} \right) - \frac{T\left(\sum_{i=1}^{2} x_i V_i\right)\left(\sum_{i=1}^{2} \phi_i \alpha_i\right)}{\sum_{i=1}^{2} x_i C_{pi}} \quad \ldots\ldots (5)$$

2.2 Deviation in isentropic compressibility (ΔKs)

K_S^{iD} is the isentropic compressibility of the ideal mixture. Its values are calculated as per Benson and Kiyohara [27] and Acree [28]

where φ_i is the volume fraction of component i in the mixture, x_i is the corresponding mole fraction of i, T is the absolute temperature, and Ks, V, α_i and C_{pi} are the isentropic compressibility, molar volume, cubic expansion coefficient, and molar heat capacity of the pure component i, respectively.

d) The values of Δks,&K_s^E,with mole fraction were fitted to the Redlich–Kister Equation of the type:

$$Y^E = x_i x_2 \{a0 + a1(x_1 - x_2) + a2(x_1 - x_2)^2 + \cdots + a4(x_1 - x_2)^4\} \quad \ldots.. (6)$$

Where Y^E is for V^E, ΔKs, and K_s^E, in the polynomial degree. The values of a0, a1 and a2, a3, and a4 are the coefficients of the polynomial equation and were obtained by the method of least-squares. The standard deviation values are calculated by using the equation:

$$\sigma(Y^E) = \frac{\{\sum_{i=1}^{n}(Y_{obs}^E - Y_{cal}^E)\wedge 2\}^{1/2}}{n-m} \quad \ldots\ldots (7)$$

Where n is the total number of experimental points and m is the number of coefficients.

IV. RESULTS AND DISCUSSIONS

The non-linear variation is a deviation from ideal behavior which suggests the presence of intermolecular interactions between the component molecules of the mixtures, however the strength of interaction is well reflected in the excess parameters like deviation in isentropic compressibility, excess isentropic compressibility (Ks^E), partial molar volume (PMV) and partial molar compressibility (PMC) as these parameters are found to be more sensitive towards intermolecular interactions in the liquid mixtures[29].These parameters are strongly affected by the changes of concentration, volume and temperature, besides the type of bonding present between the molecules of the constituent liquids. In the current study, Ks^E values are negative for all the three binary systems over the entire mole fraction range and their magnitude decreases with increase in temperatures from 303.15 to 318.15K.

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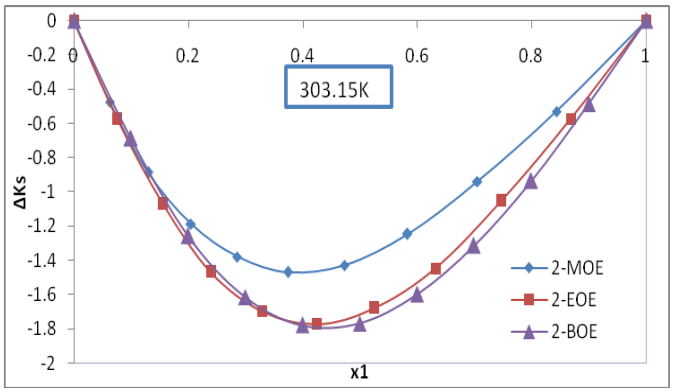

Figure-01: Graph for deviation in isentropic compressibility values of Propiophenone with 2-Methoxyethanol (2-MOE), 2-Ethoxyethanol (2-EOE) and 2-Butoxyethanol (2-BOE) binary mixtures at *T*= 303.15K

Figure-01shows, ΔKs values are negative for all the binary mixtures and they are decreasing with increase in temperature. Values are tabulated in Table -03. Peak negative ΔKs values -1.4697, -1.7712, &-1.7799 are observed at mole fractions 0.3744, 0.4239, and 0.3990 for the binary mixtures of PPH+2-MOE, PPH+2-EOE, & PPH+2-BOE respectively at *T*=303.15K.

Table-03: Deviation in isentropic compressibility of binary mixtures Propiophenone with2-MOE, 2-EOE & 2-BOE at *T*= (303.15-318.15) K

X1	303.15K	308.15K	313.15K	318.15K
	Δks	*Δks*	*Δks*	*Δks*
	PPH+2-MOE			
0.0000	0.0000	0.0000	0.0000	0.0000
0.0624	-0.4766	-0.3955	-0.3347	-0.3004
0.1302	-0.8882	-0.7226	-0.6307	-0.5743
0.2041	-1.1884	-1.0086	-0.9095	-0.8296
0.2852	-1.3779	-1.2454	-1.1190	-0.9858
0.3744	-1.4698	-1.3544	-1.2042	-1.0386
0.4731	-1.4278	-1.3365	-1.1894	-1.0033
0.5827	-1.2454	-1.1788	-1.0481	-0.8679
0.7054	-0.9410	-0.8944	-0.7955	-0.6376
0.8434	-0.5300	-0.4592	-0.4360	-0.3429
1.0000	0.0000	0.0000	0.0000	0.0000
	PPH+2-EOE			
0.0000	0.0000	0.0000	0.0000	0.0000
0.0756	-0.5786	-0.5878	-0.5517	-0.5923
0.1554	-1.0720	-1.1066	-1.1121	-1.1765
0.2397	-1.4683	-1.5101	-1.5093	-1.6147
0.3291	-1.6968	-1.7231	-1.7428	-1.8833
0.4239	-1.7712	-1.7871	-1.8138	-1.9737
0.5246	-1.6796	-1.6966	-1.7298	-1.8935
0.6319	-1.4472	-1.4335	-1.4965	-1.6429
0.7464	-1.0547	-1.0668	-1.0862	-1.1996
0.8688	-0.5753	-0.6020	-0.5944	-0.6479
1.0000	0.0000	0.0000	0.0000	0.0000
	PPH+2-BOE			
0.0000	0.0000	0.0000	0.0000	0.0000
0.0996	-0.6898	-0.6828	-0.6319	-0.5886
0.1994	-1.2599	-1.1706	-1.1158	-1.0612

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0.2992	-1.6150	-1.5262	-1.4519	-1.4115
0.3990	-1.7800	-1.7117	-1.6430	-1.5830
0.4990	-1.7683	-1.7386	-1.6727	-1.6024
0.5990	-1.6000	-1.6026	-1.5277	-1.4744
0.6992	-1.3155	-1.3197	-1.2635	-1.2074
0.7994	-0.9379	-0.9377	-0.8901	-0.8483
0.8996	-0.4867	-0.4806	-0.4363	-0.4136
1.0000	0.0000	0.0000	0.0000	0.0000

2.3 Excess isentropic compressibility (Ks^E)

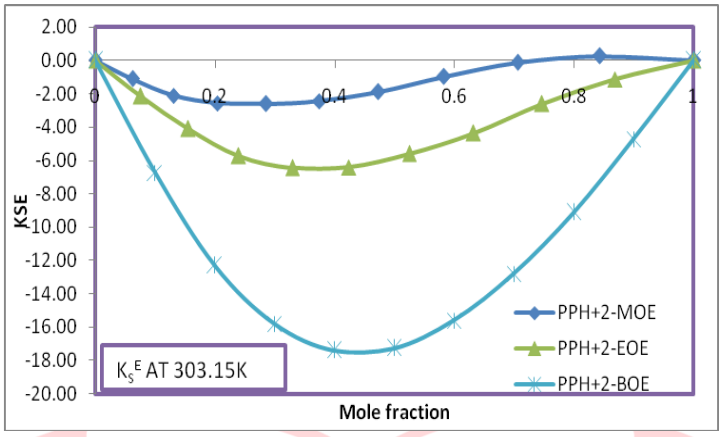

Figure-02: Graph for excess isentropic compressibility values of Propiophenone with 2-Methoxyethanol (2-MOE), 2-Ethoxyethanol (2-EOE) and 2-Butoxyethanol (2-BOE) binary mixtures at *T*= 303.15K

The values of Ks^E for all the three binary mixtures are tabulated in Table-04.

Table-04: The values of Excess isentropic compressibility of the components Propiophenone with 2-MOE, 2-EOE & 2-BOE at temperatures *T*= (303.15-318.15) K

X1	*KsE = Ks - KsiD*			
	303.15K	308.15K	313.15K	318.15K
	PPH+2-MOE			
0.0000	0.0000	0.0000	0.0000	0.0000
0.0624	-1.1150	-0.5287	-0.2939	-0.3773
0.1302	-2.0981	-0.8601	-0.6325	-0.8588
0.2041	-2.5610	-1.3361	-1.2939	-1.5795
0.2852	-2.5982	-1.9590	-1.8318	-1.7980
0.3744	-2.4472	-2.0442	-1.7845	-1.5492
0.4731	-1.8759	-1.7217	-1.5060	-1.0813
0.5827	-0.9773	-1.0120	-0.8649	-0.3896
0.7054	-0.1332	-0.2323	-0.1789	0.3292
0.8434	0.2567	0.6261	0.2990	0.5898
1.0000	0.0000	0.0000	0.0000	0.0000
	PPH+2-EOE			
0.0000	0.0000	0.0000	0.0000	0.0000
0.0756	-2.1558	-1.5700	-1.3524	-1.2574
0.1554	-4.0884	-3.4187	-3.5092	-3.2375
0.2397	-5.7309	-4.8932	-4.8147	-4.6301
0.3291	-6.4368	-5.3118	-5.3328	-5.2769
0.4239	-6.4103	-5.2680	-5.1523	-5.1822
0.5246	-5.6072	-4.3779	-4.4384	-4.5187

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0.6319	-4.3668	-3.0167	-3.3458	-3.4016
0.7464	-2.5908	-1.6295	-1.7112	-1.7341
0.8688	-1.1236	-0.6155	-0.6174	-0.5041
1.0000	0.0000	0.0000	0.0000	0.0000
	PPH+2-BOE			
0.0000	0.0000	0.0000	0.0000	0.0000
0.0996	-6.7440	-6.7128	-6.2439	-5.8393
0.1994	-12.3248	-11.5007	-11.0257	-10.5290
0.2992	-15.7894	-14.9931	-14.3450	-14.0070
0.3990	-17.3882	-16.8098	-16.2310	-15.7060
0.4990	-17.2547	-17.0659	-16.5202	-15.8952
0.5990	-15.5882	-15.7191	-15.0789	-14.6208
0.6992	-12.7949	-12.9280	-12.4615	-11.9658
0.7994	-9.1049	-9.1719	-8.7686	-8.4015
0.8996	-4.7127	-4.6913	-4.2885	-4.0903
1.0000	0.0000	0.0000	0.0000	0.0000

Figure-02 shows the negative values of Ks^E for all the three binary mixtures indicates that the mixture is less compressible than the ideal mixture and suggests specific interactions between the components of analysed binary mixture. The negative values of Ks^E decreases with increase in temperature. The magnitude of the various contributions depends mainly on the relative molecular size of the components.

Observed K_S^E values -2.5982, -6.4368, &-17.3882 are maximum at mole fractions 0.2852, 0.3291, &0.3990for the binary mixtures of PPH+2-MOE, PPH+2-EOE, & PPH+2-BOErespectively. The negative values of Ks^E under the current study indicates that the values of K_s^E become more negative as the number of –CH2– units in the alkoxyethanol molecules increases.

2.4 Partial Molar volume (PMV)

The partial molar volumes, $\bar{V}^o_{m,1}$ of component 1(Propiophenone) and $\bar{V}^o_{m,2}$ of component (2-Methoxyethanol (2-MOE), 2-Ethoxyethanol (2-EOE) and 2-Butoxyethanol (2-BOE).*)* in the mixture over entire composition range are calculated by using the following relations.

$$\bar{V}^o_{m,1} = V_m^E + V^*_{m,1} + x_2\left(\frac{\partial V_m^E}{\partial x_1}\right)_{T,P} \quad \text{..... (8)}$$

$$\bar{V}^o_{m,2} = V_m^E + V^*_{m,2} - x_1\left(\frac{\partial V_m^E}{\partial x_1}\right)_{T,P} \quad \text{..... (9)}$$

Where$V^*_{m,1}$, $V^*_{m,2}$ are molar volumes of pure components Propiophenone with 2-Methoxyethanol (2-MOE), 2-Ethoxyethanol (2-EOE) and 2-Butoxyethanol (2-BOE). The derivative of $\left(\frac{\partial V_m^E}{\partial x_1}\right)$ obtained by using below equations.

$$\bar{V}^o_{m,2} = V^*_{m,2} + x_1^2 \sum_{i=0}^{n} A_i(1-2x_1)^i + 2x_1x_2^2 \sum_{i=1}^{n} A_i\,(1-2x_1)^{i-1} \quad \text{..... (10)}$$

$$\bar{V}^o_{m,1} = V^*_{m,1} + x_2^2 \sum_{i=0}^{n} A_i(1-2x_1)^i - 2x_1x_2^2 \sum_{i=1}^{n} A_i\,(1-2x_1)^{i-1} \quad \text{..... (11)}$$

The Excess Partial Molar Volumes$\bar{V}^{o,E}_{m,1}$, $\bar{V}^{o,E}_{m,2}$ over the whole composition range are calculated by using the below relation [30].

$$\bar{V}^{o,E}_{m,1} = \bar{V}^o_{m,1} - V^*_{m,1} \quad \text{..... (12)}$$

$$\bar{V}^{o,E}_{m,2} = \bar{V}^o_{m,2} - V^*_{m,2} \quad \text{..... (13)}$$

The values of excess partial molar volumes are given in Table-05.The negative excess partial molar volumes may be indicative of solute–solvent[31,32] interactions between unlike molecules, whereas positive values indicate the presence of strong self-

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association between like molecules. Positive values of $\bar{V}^{o,E}_{m,i}$ indicate the presence of weak interactions between the studied binary mixtures.

Table-05: Values of Partial molar volumes of Propiophenone with 2-MOE, 2-EOE & 2-BOE at *T*= (303.15-318.15) K

	303.15 K		308.15 K		313.15 K		318.15 K	
x1	$\bar{V}^{E}_{m,1}$	$\bar{V}^{E}_{m,2}$	$\bar{V}^{E}_{m,1}$	$\bar{V}^{E}_{m,2}$	$\bar{V}^{E}_{m,1}$	$\bar{V}^{E}_{m,2}$	$\bar{V}^{E}_{m,1}$	$\bar{V}^{E}_{m,2}$
				Propiophenone+2-MOE				
0.0000	0.4018	0.0000	0.2334	0.0000	0.1746	0.0000	0.0692	0.0000
0.0624	0.3861	0.0005	0.2572	0.0002	0.1830	-0.0113	0.1076	-0.0187
0.1302	0.3643	0.0031	0.2554	0.0026	0.1823	-0.0168	0.1331	-0.0295
0.2041	0.3335	0.0101	0.2337	0.0097	0.1728	-0.0153	0.1437	-0.0303
0.2852	0.2918	0.0250	0.1984	0.0237	0.1549	-0.0054	0.1382	-0.0194
0.3744	0.2389	0.0529	0.1557	0.0466	0.1292	0.0147	0.1177	0.0042
0.4731	0.1772	0.0999	0.1113	0.0800	0.0971	0.0469	0.0855	0.0398
0.5827	0.1122	0.1720	0.0698	0.1263	0.0616	0.0917	0.0487	0.0831
0.7054	0.0536	0.2718	0.0347	0.1889	0.0283	0.1462	0.0171	0.1235
0.8434	0.0133	0.3919	0.0097	0.2730	0.0058	0.1966	0.0009	0.1390
1.0000	0.0000	0.5022	0.0000	0.3779	0.0000	0.2023	0.0000	0.0886
				Propiophenone+2-EOE				
0.0000	0.7348	0.0000	0.3349	0.0000	0.4021	0.0000	0.1912	0.0000
0.0756	0.5970	0.0046	0.3803	0.0006	0.3350	0.0014	0.2313	-0.0141
0.1554	0.4820	0.0180	0.3705	0.0069	0.2803	0.0074	0.2331	-0.0089
0.2397	0.3835	0.0405	0.3239	0.0244	0.2290	0.0218	0.2043	0.0132
0.3291	0.2970	0.0734	0.2573	0.0562	0.1770	0.0461	0.1556	0.0477
0.4239	0.2201	0.1189	0.1848	0.1034	0.1252	0.0796	0.0994	0.0881
0.5246	0.1522	0.1799	0.1178	0.1644	0.0780	0.1195	0.0485	0.1260
0.6319	0.0942	0.2606	0.0639	0.2363	0.0408	0.1624	0.0131	0.1527
0.7464	0.0473	0.3688	0.0265	0.3144	0.0168	0.2086	-0.0026	0.1620
0.8688	0.0140	0.5221	0.0060	0.3940	0.0045	0.2705	-0.0029	0.1568
1.0000	0.0000	0.7621	0.0000	0.4700	0.0000	0.3894	0.0000	0.1603
				Propiophenone+2-BOE				
0.0000	0.8778	0.0000	0.4693	0.0000	0.4666	0.0000	0.2439	0.0000
0.0996	0.6385	0.0086	0.4286	0.0028	0.3552	0.0081	0.2594	-0.0136
0.1994	0.4872	0.0288	0.3722	0.0139	0.2732	0.0195	0.2355	-0.0044
0.2992	0.3812	0.0581	0.3072	0.0366	0.2085	0.0376	0.1913	0.0209
0.3990	0.2974	0.0991	0.2405	0.0730	0.1555	0.0642	0.1407	0.0564
0.4990	0.2250	0.1568	0.1777	0.1244	0.1119	0.1003	0.0932	0.0976
0.5990	0.1601	0.2380	0.1222	0.1926	0.0764	0.1479	0.0543	0.1407
0.6992	0.1022	0.3531	0.0754	0.2826	0.0477	0.2113	0.0265	0.1831
0.7994	0.0527	0.5193	0.0379	0.4055	0.0248	0.2989	0.0096	0.2230
0.8996	0.0157	0.7660	0.0111	0.5821	0.0076	0.4240	0.0018	0.2599
1.0000	0.0000	1.1428	0.0000	0.8483	0.0000	0.6068	0.0000	0.2939

The excess Partial molar volume of Propiophenone with 2-Methoxyethanol (2-MOE), 2-Ethoxyethanol (2-EOE) and 2-Butoxyethanol (2-BOE).at infinite dilution are calculated by using the relation

$$\bar{V}^{o,E,\infty}{}_{m,2} = \bar{V}^{o,\infty}{}_{m,2} - V^{*}_{m,2} \quad \text{..... (14)}$$

$$\bar{V}^{o,E,\infty}{}_{m,1} = \bar{V}^{o,\infty}{}_{m,1} - V^{*}_{m,1} \quad \text{..... (15)}$$

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The values of excess partial molar volume of at infinite dilution $\bar{V}^{o,E,\infty}{}_{m,1}$, $\bar{V}^{o,E,\infty}{}_{m,2}$ for the selected binary systems at different temperatures are presented in Table-06. Figure: 03show positive values of $\bar{V}^{o,E,\infty}{}_{m,1}$, $\bar{V}^{o,E,\infty}{}_{m,2}$of current binary mixtures at *T*= 303.15K which indicates weak solute–solvent interactions at infinite dilution. .The action of propiophenone over three oxyethanols is in the order of MOE > EOE > BOE, thus the order of O-H bond occurs. The same trend is supported by Begum *et.al* [33].

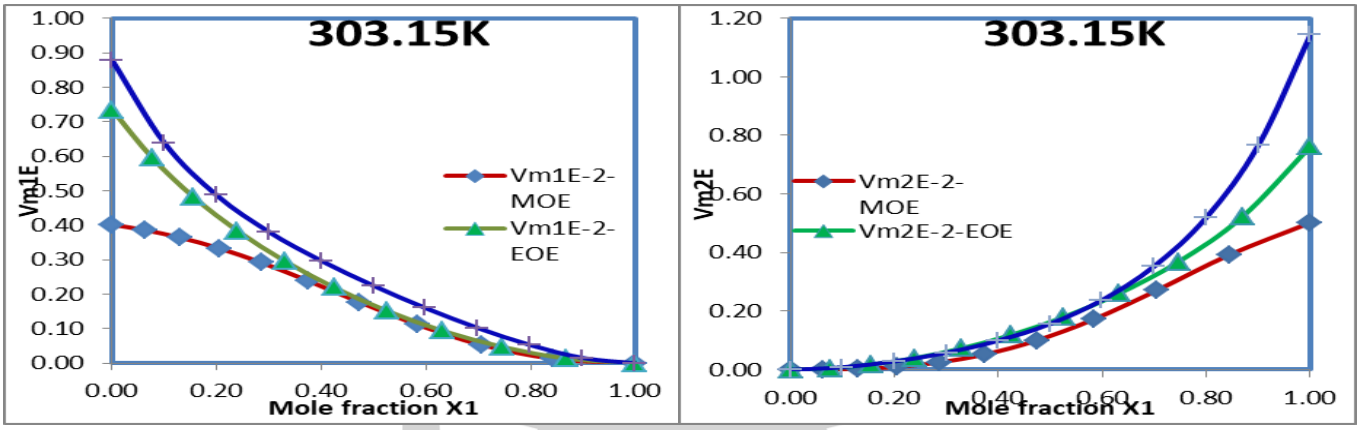

Figure-03: Excess partial molar volume values of Propiophenone with 2-Methoxyethanol (2-MOE), 2-Ethoxyethanol (2-EOE) and 2-Butoxyethanol (2-BOE).binary mixtures at T= 303.15 K.

Table-06: Values of Partial molar volumes of Propiophenone with 2-MOE, 2-EOE & 2-BOE at infinite dilution at temperatures 303.15 to 318.15K

T/K	$\bar{V}^{\circ}_{m,1}$	$V^{*}_{m,1}$	$\bar{V}^{\circ E}_{m,1}$	$\bar{V}^{\circ}_{m,2}$	$V^{*}_{m,2}$	$\bar{V}^{\circ E}_{m,2}$
			($cm^3 \cdot mol^{-1}$)			
			Propiophenone+2-MOE			
303.1500	133.9807	133.5789	0.4018	80.3972	79.8950	0.5022
308.1500	134.2124	133.9790	0.2334	80.5506	80.1728	0.3779
313.1500	134.5562	134.3816	0.1746	80.6803	80.4780	0.2023
318.1500	134.8558	134.7865	0.0692	80.8656	80.7770	0.0886
			Propiophenone+2-EOE			
303.1500	134.3137	133.5789	0.7348	98.5942	97.8321	0.7621
308.1500	134.3139	133.9790	0.3349	98.8081	98.3381	0.4700
313.1500	134.7837	134.3816	0.4021	99.1760	98.7865	0.3894
318.1500	134.9778	134.7865	0.1912	99.4289	99.2686	0.1603
			Propiophenone+2-BOE			
303.1500	134.4566	133.5789	0.8778	133.5655	132.4226	1.1428
308.1500	134.4483	133.9790	0.4693	133.9661	133.1178	0.8483
313.1500	134.8481	134.3816	0.4666	134.3953	133.7885	0.6068
318.1500	135.0305	134.7865	0.2439	134.6711	134.3772	0.2939

2.5 Partial molar isentropic compressibility (PMC)

The partial molar isentropic compressibility$\bar{K}^{o}{}_{s\,m,1}$ of component 1(Propiophenone) and $\bar{K}^{o}{}_{s\,m,2}$ of component 2 (2-Methoxyethanol (2-MOE), 2-Ethoxyethanol (2-EOE) and 2-Butoxyethanol (2-BOE)) in the mixture over entire composition range are calculated using the following relations.

$$\bar{K}^{o}{}_{s\,m,1} = K_s^E + K^{*}_{s\,m,1} + x_2\left(\frac{\partial K_S^E}{\partial x_1}\right)_{T,P} \quad \text{..... (16)}$$

$$\bar{K}^{o}{}_{s\,m,2} = K_s^E + K^{*}_{s\,m,2} - x_1\left(\frac{\partial K_S^E}{\partial x_1}\right)_{T,P} \quad \text{..... (17)}$$

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Where $K^*_{s\,m,1}$, $K^*_{s\,m,2}$ are molar isentropic compressibility of pure components Propiophenone with 2-MOE, 2-EOE & 2-BOE. The derivative of $\left(\frac{\partial K_s^E}{\partial x_1}\right)$ obtained by using below equations.

$$\bar{K}^o{}_{s\,m,2} = K^*_{s\,m,2} + x_1^2 \sum_{i=0}^{n} A_i (1-2x_1)^i + 2x_1 x_2^2 \sum_{i=1}^{n} A_i (1-2x_1)^{i-1} \quad \ldots\ldots\ldots\ldots (18)$$

$$\bar{K}^o{}_{s\,m,1} = K^*_{s\,m,1} + x_2^2 \sum_{i=0}^{n} A_i (1-2x_1)^i - 2x_1 x_2^2 \sum_{i=1}^{n} A_i (1-2x_1)^{i-1} \quad \ldots\ldots\ldots\ldots (19)$$

The excess partial molar isentropic compressibility $\bar{K}^{o,E}{}_{s\,m,1}$, $\bar{K}^{o,E}{}_{s\,m,2}$ over the whole composition range are calculated by using the below relation

$$\bar{K}^{o,E}{}_{s\,m,1} = \bar{K}^o{}_{s\,m,1} - K^*_{s\,m,1} \quad \ldots\ldots\ldots\ldots (20)$$

$$\bar{K}^{o,E}{}_{s\,m,2} = \bar{K}^o{}_{s\,m,2} - K^*_{s\,m,2} \quad \ldots\ldots\ldots\ldots (21)$$

The values of excess partial molar isentropic compressibility $\bar{K}^{o,E}{}_{s\,m,1}$, $\bar{K}^{o,E}{}_{s\,m,2}$ of Propiophenone with 2-MOE, 2-EOE & 2-BOEare given in Table-07. Figure: 04 show the variation of excess partial molar isentropic compressibility $\bar{K}^{o,E}{}_{s\,m,1}$, $K^{o,E}{}_{s\,m,2}$ with composition at temperature 303.15K. Negative values are observed in case of PPH in oxyethanols whereas oxyethanols in PPH shown mixed results except with 2-BOE. It is the indication that molar isentropic compressions of each component are less than their respective molar isentropic compression in the pure state.

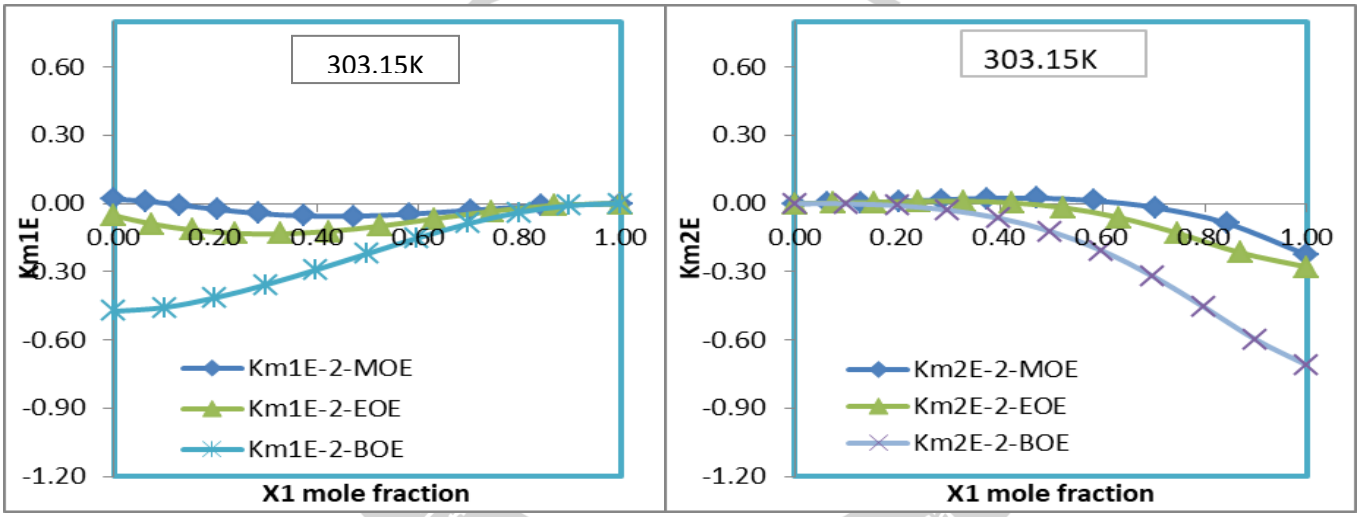

Figure-04: Excess partial molar isentropic compressibility values of Propiophenone with 2-Methoxyethanol (2-MOE), 2-Ethoxyethanol (2-EOE) and 2-Butoxyethanol (2-BOE).at T= 303.15 K.

Table-07: The Values of the partial molar isentropic compressibility of the components Propiophenone with 2-MOE, 2-EOE & 2-BOE at temperatures *T*= (303.15-318.15) K

x1	303.15 K		308.15 K		313.15 K		318.15 K	
	$\bar{K}^{E}_{s,m,1}$	$\bar{K}^{E}_{s,m,2}$	$\bar{K}^{E}_{s,m,1}$	$\bar{K}^{E}_{s,m,2}$	$\bar{K}^{E}_{s,m,1}$	$\bar{K}^{E}_{s,m,2}$	$\bar{K}^{E}_{s,m,1}$	$\bar{K}^{E}_{s,m,2}$
				Propiophenone+ 2-MOE				
0.0000	0.0188	0.0000	0.1112	0.0000	0.0545	0.0000	0.1012	0.0000
0.0624	0.0103	0.0008	0.0553	0.0016	0.0242	0.0010	0.0514	0.0012
0.1302	-0.0064	0.0039	0.0100	0.0058	-0.0012	0.0037	0.0162	0.0044
0.2041	-0.0262	0.0093	-0.0233	0.0113	-0.0216	0.0080	-0.0090	0.0093
0.2852	-0.0438	0.0162	-0.0435	0.0163	-0.0363	0.0129	-0.0270	0.0154
0.3744	-0.0548	0.0222	-0.0505	0.0180	-0.0438	0.0165	-0.0388	0.0218
0.4731	-0.0560	0.0231	-0.0456	0.0130	-0.0426	0.0152	-0.0430	0.0250
0.5827	-0.0469	0.0125	-0.0320	-0.0018	-0.0325	0.0038	-0.0374	0.0184

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0.7054	-0.0298	-0.0192	-0.0155	-0.0268	-0.0164	-0.0208	-0.0222	-0.0071
0.8434	-0.0105	-0.0874	-0.0033	-0.0540	-0.0028	-0.0456	-0.0054	-0.0461
1.0000	0.0000	-0.2271	0.0000	-0.0532	0.0000	0.0079	0.0000	-0.0131
				Propiophenone+2-EOE				
0.0000	-0.0531	0.0000	-0.0228	0.0000	0.0506	0.0000	0.0680	0.0000
0.0756	-0.0905	0.0015	-0.0555	0.0016	-0.0378	0.0021	-0.0297	0.0023
0.1554	-0.1168	0.0052	-0.0822	0.0060	-0.0829	0.0060	-0.0814	0.0067
0.2397	-0.1316	0.0091	-0.1018	0.0121	-0.1029	0.0098	-0.1047	0.0107
0.3291	-0.1337	0.0100	-0.1119	0.0172	-0.1084	0.0120	-0.1104	0.0122
0.4239	-0.1228	0.0030	-0.1094	0.0159	-0.1036	0.0095	-0.1037	0.0079
0.5246	-0.0997	-0.0184	-0.0930	0.0006	-0.0884	-0.0044	-0.0862	-0.0083
0.6319	-0.0678	-0.0614	-0.0646	-0.0374	-0.0629	-0.0395	-0.0593	-0.0446
0.7464	-0.0341	-0.1300	-0.0319	-0.1013	-0.0316	-0.1019	-0.0285	-0.1040
0.8688	-0.0086	-0.2162	-0.0072	-0.1728	-0.0068	-0.1701	-0.0056	-0.1624
1.0000	0.0000	-0.2793	0.0000	-0.1755	0.0000	-0.1343	0.0000	-0.1107
				Propiophenone+ 2-BOE				
0.0000	-0.4739	0.0000	-0.4797	0.0000	-0.4001	0.0000	-0.3560	0.0000
0.0996	-0.4575	-0.0015	-0.4565	-0.0017	-0.4249	-0.0008	-0.4038	-0.0004
0.1994	-0.4152	-0.0095	-0.4129	-0.0109	-0.3966	-0.0095	-0.3825	-0.0087
0.2992	-0.3580	-0.0289	-0.3508	-0.0341	-0.3385	-0.0326	-0.3274	-0.0309
0.3990	-0.2921	-0.0649	-0.2776	-0.0759	-0.2670	-0.0738	-0.2591	-0.0703
0.4990	-0.2218	-0.1228	-0.2021	-0.1387	-0.1940	-0.1346	-0.1892	-0.1284
0.5990	-0.1520	-0.2075	-0.1327	-0.2222	-0.1272	-0.2151	-0.1246	-0.2062
0.6992	-0.0889	-0.3206	-0.0756	-0.3246	-0.0720	-0.3136	-0.0702	-0.3027
0.7994	-0.0394	-0.4568	-0.0339	-0.4447	-0.0316	-0.4272	-0.0300	-0.4121
0.8996	-0.0092	-0.5989	-0.0086	-0.5846	-0.0076	-0.5508	-0.0067	-0.5197
1.0000	0.0000	-0.7112	0.0000	-0.7544	0.0000	-0.6761	0.0000	-0.5962

The excess partial molar isentropic compressibility of Propiophenone with 2-Methoxyethanol (2-MOE), 2-Ethoxyethanol (2-EOE) and 2-Butoxyethanol (2-BOE) at infinite dilution are calculated by using the relation

$$\bar{K}^{o,E,\infty}{}_{s\,m,2} = \bar{K}^{o,\infty}{}_{s\,m,2} - K^{*}_{s\,m,2} \quad \text{..... (22)}$$

$$\bar{K}^{o,E,\infty}{}_{s\,m,1} = \bar{K}^{o,\infty}{}_{s\,m,1} - K^{*}_{s\,m,1} \quad \text{..... (23)}$$

The values of excess partial molar isentropic compressibility of at infinite dilution $\bar{K}^{o,E,\infty}{}_{s\,m,1}$,$\bar{K}^{o,E,\infty}{}_{s\,m,2}$ for the selected binary systems at different temperatures are presented inTable-08.The values of $\bar{K}^{o,E,\infty}{}_{s\,m,1}$, $\bar{K}^{o,E,\infty}{}_{s\,m,2}$of Propiophenone with 2-Methoxyethanol (2-MOE), 2-Ethoxyethanol (2-EOE) and 2-Butoxyethanol (2-BOE) shows weak solute–solvent interactions at infinite dilution.

Table-08: The Values of the partial molar compressibility at infinite dilution of the components Propiophenone with 2-MOE, 2-EOE & 2-BOE at temperatures *T*= (303.15-318.15) K

T/K	$\bar{K}^{\circ}_{s,m,1}$	$K^{*}_{s,m,1}$	$\bar{K}^{\circ E}_{s,m,1}$	$\bar{K}^{\circ}_{s,m,2}$	$K^{*}_{s,m,2}$	$\bar{K}^{\circ E}_{s,m,2}$
			Propiophenone+ 2-MOE			
303.1500	0.0824	6.3563	0.0188	-0.1809	4.6194	-0.2271
308.1500	0.1769	6.5692	0.1112	-0.0062	4.7031	-0.0532
313.1500	0.1227	6.8279	0.0545	0.0558	4.7840	0.0079
318.1500	0.1723	7.1096	0.1012	0.0356	4.8665	-0.0131

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			Propiophenone+2-EOE			
303.1500	0.0105	6.3563	-0.0531	-0.2182	6.1116	-0.2793
308.1500	0.0429	6.5692	-0.0228	-0.1126	6.2822	-0.1755
313.1500	0.1188	6.8279	0.0506	-0.0670	6.7281	-0.1343
318.1500	0.1391	7.1096	0.0680	-0.0390	7.1692	-0.1107
			Propiophenone+ 2-BOE			
303.1500	-0.4103	6.3563	-0.4739	-0.6218	8.9451	-0.7112
308.1500	-0.4140	6.5692	-0.4797	-0.6617	9.2681	-0.7544
313.1500	-0.3318	6.8279	-0.4001	-0.5805	9.5561	-0.6761
318.1500	-0.2849	7.1096	-0.3560	-0.4972	9.9061	-0.5962

The values of ΔKs&Ks^E are fitted into Redlich-Kister polynomial equations (7) & (8) and are tabulated in Table-09.The obtained results are satisfactory with the experimental criteria.

TABLE- 09– Coefficients of Redlich-Kister Polynomial Equation & standard deviation of binary systems

Property	Temp(K)	A0	A1	A2	A3	A4	σ
		PPH+2-MOE					
KsE (pa^{-1})	**303.15**	-6.5685	15.2885	-0.5005	-2.9909	-3.3468	0.0536
	308.15	-6.4975	10.5941	9.6054	-2.3755	-0.2074	0.1021
	313.15	-5.4844	10.8566	4.3148	-8.5299	4.2882	0.0692
	318.15	-3.5815	13.4370	-1.5005	-7.7232	9.4852	0.0613
ΔKs	**303.15**	-5.5670	2.7241	-0.3432	-0.2231	-0.3558	0.0054
	308.15	-5.2596	2.1792	0.6865	-0.1667	-0.0404	0.0102
	313.15	-4.6614	2.0803	0.1889	-0.7905	0.4115	0.0069
	318.15	-3.9025	2.1947	-0.3639	-0.7158	0.9479	0.0061
		PPH+2-EOE					
KsE (pa^{-1})	**303.15**	-23.5527	18.9248	3.8059	-7.6132	3.1269	0.0597
	308.15	-18.4164	20.8384	2.4008	-13.2050	6.1040	0.0740
	313.15	-18.5179	18.7017	-1.9213	-9.4592	16.2532	0.1385
	318.15	-18.8607	17.6785	1.8730	-8.7460	14.8539	0.1009
ΔKs	**303.15**	-7.0703	0.8178	1.0516	-0.4075	-0.0050	0.1514
	308.15	-7.1314	1.1655	0.9084	-1.0802	-0.1877	0.1519
	313.15	-7.2412	0.8945	0.4348	-0.7883	1.4225	0.1576
	318.15	-7.8947	0.6636	0.7879	-0.5668	1.2197	0.1716
		PPH+2-BOE					
KsE (pa^{-1})	**303.15**	-68.9048	19.5098	4.0929	-7.6444	5.5558	0.0395
	308.15	-68.1469	12.3856	10.8755	1.3467	-4.4314	0.0624
	313.15	-65.7189	11.5778	10.4641	2.2210	1.4470	0.0658
	318.15	-63.5089	11.8822	9.2418	0.1281	6.6539	0.0511
ΔKs (pa-1)	**303.15**	-6.9769	2.4802	-0.0140	-0.7950	0.8798	0.0482
	308.15	-6.9014	1.7272	1.1462	0.2004	-0.8274	0.0468
	313.15	-6.6130	1.6617	1.0662	0.2074	-0.1565	0.0459
	318.15	-6.3577	1.7218	0.8931	-0.1255	0.4315	0.0446

V. CONCLUSIONS

The values of deviation in isentropic compressibility, excess isentropic compressibility along with partial molar volume and partial molar isentropic compressibility at infinite dilution, over the entire composition range for the binary liquid mixtures of Propiophenone with 2-Methoxyethanol (2-MOE), 2-Ethoxyethanol (2-EOE) and 2-Butoxyethanol (2-BOE) were calculated at T = 303.15-318.15K. The negative values of ΔKs & Ks^E are due to the specific intermolecular interactions between unlike molecules. Partial molar volume and partial molar isentropic compressibility values at infinite dilution indicate weak solute-solvent interactions. Correlated Redlich-kister values are in good agreement with the experimental data.

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REFERENCES

[1] Kinart CM, Kinart WJ, Checinska-Majak D, et al. Volumetric behavior of binary liquid mixtures of 2-methoxyethanol with n-butylamine, sec-butyl amine and tert- butylamine. J Mol Liq. 2004;109:19–22.https://doi.org/10.1016/j.molliq.2003.07.002.

[2] Oswal SL, Desai HS. Studies of viscosity and excess molar volume of binary mixtures.: 1. Propylamine+1-alkanol mixtures at 303.15 and 313.15 K. Fluid Phase Equilib. 1998;149:359–376. https://doi.org/10.1016/S0378-3812(98)00318-5.

[3] García B, Rafael Alcalde JM, Leal, José SM. Formamide-(C1,-C5,) alkan- 1-ols solvent systems. J Chem Soc Faraday Trans. 1996; 92:3347–3352; https://doi.org/10.1039/FT9969203347.

[4] Thermodynamics of mixtures containing alkoxyethanols. Part XXV. Densities, excess molar volumes and speeds of sound at 293.15, 298.15 and 303.15 K, and isothermal compressibilities at 298.15 K for 2-alkoxyethanol + 1-butanol systems Ismael Mozo a , Juan Antonio González a,□, Isaías García de la Fuente a , José Carlos Cobos a , Nicolás Riesco; https://doi.org/10.1016/j.molliq.2008.01.013.

[5] Ultrasonic Studies On Binary Liquid Mixtures Of Methyl Acrylate With 2-Alkoxy Ethanols At 308.15 K ; Dr. K. Vijaya Lakshmi; http://dx.doi.org/10.21474/IJAR01/1405.

[6] Excess Molar Enthalpies and Excess Molar Volumes of Diethyl Carbonate + Some n-Alkoxyethanols at (298.15 and 313.15) K Romolo Francesconi,*,† Carlo Castellari,† and Fabio Comelli; J. Chem. Eng. Data 1999, 44, 1373-1378; http://dx.doi.org/10.1021/je990135o.

[7] Thermodynamics of mixtures containing alkoxyethanols Part XXVII. Predictions on isobaric thermal expansion coefficients, compressibilities and speeds of sound from the Flory theory; Juan Antonio Gonzálezaa,∗ , Ismael Mozoa, Isaías García De La Fuentea,José Carlos Cobosa, Nicolás Riesco; Thermochimica Acta 476 (2008) 20–27; http://dx.doi.org/10.1016/j.tca.2008.07.002.

[8] Thermodynamic and physicochemical properties of binary mixtures of nitromethane with {2-methoxyethanol + 2-butoxyethanol} systems at T = (293.15, 298.15, 303.15, 308.15, and 313.15) K; Aneta C´ wiklin´ ska , Cezary M. Kinart; J. Chem. Thermodynamics 43 (2011) 420–429; http://dx.doi.org/10.1016/j.jct.2010.10.016.

[9] Excess molar volumes, viscosity deviations and speeds of sound for some alkoxyethanols and amines in cyclohexanone at 298.15 K; Biswajit Sinha; Physics and Chemistry of Liquids; Vol. 48, No. 2, April 2010, 183–198; http://dx.doi.org/10.1080/00319100802706691.

[10] FT-IR Spectroscopic study of excess thermodynamic properties of liquid mixtures containing N-methylformamide with 2-alkoxyethanols at various temperatures; R. Balaji a, M. Gowri Sankar b,□, M. Chandra Shekar; Journal of Molecular Liquids 216 (2016) 330–341; http://dx.doi.org/10.1016/j.molliq.2015.12.051.

[11] Studies on the intermolecular interactions in the binary mixtures of nitrobenzene with 2-methoxyethanol, 2-ethoxyethanol, 2-propoxyethanol and 2-butoxyethanol at T^298.15K,Cezary M. Kinarta*, Aneta C´ wiklin´ skaa, Zdzislaw Kinarta, Adam Balda and Wojciech J. Kinartb; Physics and Chemistry of Liquids, Vol. 50, No. 5, September–October 2012, 679–696; http://dx.doi.org/10.1080/00319104.2012.712971.

[12] O. Redlich, A.T. Kister, Algebraic representation of thermodynamic properties and the classification of solutions, Industrial and Engineering Chemistry 40 (2) (1948) 345–348

[13] Thermodynamics of amine+ketone mixtures 3. Volumetric, speed of sound data and viscosity at (303.15 and 308.15K) for the binary mixtures of N,N-dimethylaniline+ propiophenone, +p-methylacetophenone, +p-chloroacetophenone M. Gowrisankar a, P. Venkateswarlu b, K. Siva Kumar c, S. Sivarambabu; Journal of Molecular Liquids 173 (2012) 172–179 ; http://dx.doi.org/10.1016/j.molliq.2012.06.010.

[14] Thermodynamics of Mixtures Containing Alkoxyethanols. Part XXVI. Densities, Excess Molar Volumes, Speeds of Sound at (293.15, 298.15, and 303.15) K, and Isentropic or Isothermal Compressibilities at 298.15 K for 2-Methoxyethanol + Alkoxyethanol or 2-Propoxyethanol + Dibutylether Systems." I.Mozo, I.G. de la Fuente, J.A.González, J.C.Cobos and N.Riesco Journal of Chemical and Engineering Data, 53 (6): 1404-1410, 2008; http://dx.doi.org/10.1021/je8000975. .

[15] Densities, speed of sound, and IR studies of Ethyl lactate with 2 - alkoxyethanols at different temperatures; P.Anila, K. Rayapa Reddy, G. Srinivasa Rao, , P.V.S. Sairam, D. Ramachandran, C. Rambabu*; Thermo chemicaActa 620(2015)1-9; http://dx.doi.org/10.1016/j.tca.2015.09.021.

[16] Thermodynamic, ultrasonic and FT-IR studies on binary liquid mixtures of Propiophenone and

 DOI : 10.18231/2454-9150.2018.0187

alkoxyethanols at different temperatures Zareena Begum, P.B. Sandhya Sri, D.B. Karuna Kumar, C. Rambabu Journal of Molecular Liquids 178 (2013) 99–112; http://dx.doi.org/10.1016/j.molliq.2012.11.016.

[17] C.M. Kinart, A. Cwikli ´ nska, ´ W.J. Kinart, A. Bald, Density and relative permittivity of 2-methoxyethanol + dipropylamine mixtures at various temperatures, J. Chem. Eng. Data 49 (2004) 1425–1428; http://dx.doi.org/10.1021/je040006u.

[18] G. Ferrari, G. Foca, M. Manfredini, D. Manzini, A. Marchetti, L. Tassi, A. Ulrici, Density and volume properties of the 2-chloroethanol + 2- methoxyethanol + 1,2-dimethoxyethane ternary solvent system at different temperatures, J. Sol. Chem. 32 (2003) 93–116; https://doi.org/10.1023/A:1022925521397.

[19] Densities, speed of sound, and IR studies of Ethyl lactate with 2 - alkoxyethanols at different temperatures. P.Anilaa , K. Rayapa Reddya , G. Srinivasa Raob , P.V.S. Sairamb , D. Ramachandranc , C. Rambabu ; http://dx.doi.org/doi:10.1016/j.tca.2015.09.021.

[20] D. Venkatesulu, P. Venkatesu, M.V. Prabhakara Rao, Viscosities and densities of trichloroethylene or tetrachloroethylene with 2-alkoxyethanols at 303.15K and 313.15K, J. Chem. Eng. Data 42 (1997) 365–367; http://dx.doi.org/10.1021/je960316f.

[21] Thermo-Physical Properties for the Binary System of Propiophenone–Methyl Acetate at 303.15–313.15 K1; S. K. Bindhania*, G. K. Roya, Y. K. Mohantya, and T. R. Kubendranb; ISSN 0036-0244, Russian Journal of Physical Chemistry A, 2015, Vol. 89, No. 10, pp. 1828–1837. © Pleiades Publishing, Ltd., 2015, https://doi.org/10.1134/S0036024415100040.

[22] Excess Volumes, Isentropic Compressibilities And Viscosities Of Binary Mixtures Of N- Ethylaniline With Phenones At 303.15 K; G. S. Manukonda, P. Venkatalakshami, and K. Rambabu; Int. J. Phys. Res;. Vol. 3, Issue 4, Oct 2013, p-5-16. http://www.tjprc.org/publishpapers/2-44-1377684294-2.%20Excess%20volumes.full.pdf.

[23] S. J. Tangeda, S. Boodida, and S. Nallani, J. Chem; Thermodyn. 38, 1438 (2006); https://doi.org/10.1016/j.jct.2006.01.009.

[24] Thermophysical properties of 1-butyl-3-methylimidazolium bis(trifluoromethylsulfonyl) imide with 2-ethoxyethanol fromT = (298.15 to 323.15) K at atmospheric pressureG. Prasad a,f, K. Muralidhar Reddy b, R. Padamasuvarna c, T. MadhuMohand,□,T. Vijaya Krishna d,□, V. Ramesh Kumar eJournal of Molecular Liquids 251 (2018) 335–344; https://doi.org/10.1016/j.molliq.2017.12.015.

[25] Densities, speed of sound, and IR studies of Ethyl lactate with2-alkoxyethanols at different temperaturesP. Anilaa, K. Rayapa Reddya, G. Srinivasa Raob, P.V.S. Sairamb, D. Ramachandranc,C. Rambabuc,∗ Thermochimica Acta 620 (2015) 1–9http://dx.doi.org/10.1016/j.tca.2015.09.021.

[26] Estimation of the Heat Capacities of Organic Liquids as a Function of Temperature Using Group Additivity: An Amendment Milan Za´bransky´ and Vlastimil Ru˚ z˘ic˘ka, Jr.; J. Phys. Chem. Ref. Data, Vol. 33, No. 4, 2004; https://doi.org/10.1063/1.1797811.

[27] Benson, G.C., Kiyohara, O.K.: Evaluation of excess isentropic compressibilities and isochoric heat capacities. J. Chem. Thermodyn. 11, 1061–1064 (1979); https://doi.org/10.1016/0021-9614(79)90136-8.

[28] Acree, W.E.: Density, speed of sound, and isentropic compressibility of triethanolamine (or Nmethyldiethanolamine) + water + ethanol solutions from t = (15 to 50) °C. J. Chem. Eng. Data 28, 215–216 (1983);https://doi.org/10.1021/je00032a027.

[29] G.V. Rama Rao, A.V. Sarma, C. Rambabu, Excess volumes, deviation in viscosities and compressibilities of binary mixtures consisting of morpholine, peperidine with methanol and pyridine at different temperatures, Indian Journal of Pure and Applied Physics 42 (2004) 820–826

[30] Wang H, Liu W, Huang J. Densities and volumetric properties of a (xylene + dimethyl sulfoxide) at temperature from (293.15 to 353.15) K. J Chem Thermodyn. 2004;36:743–752. https://doi.org/10.1016/j.jct.2004.04.004.

[31] Hawrylak B, Gracie K, Palepu R. Thermodynamic properties of binary mixtures of butanediols with water. J Sol Chem. 1998;27:17–31.https://doi.org/10.1023/A:1022636511542.

[32] Puneet Kumar P, Vrijesh Kumar P, Awasthi A, et al. Study of intermolecular interactions in binary mixtures of 2- (dimethylamino) ethanol and ethanol at various temperatures. Thermochim Acta. 2014;586:58–65. https://doi.org/10.1016/j.tca.2014.03.038.

[33] Partial molar volumes partial molar adiabatic compressibilitiesandmolar Gibbs energies of anisaldehyde with some alkoxyethanols —Insights through plots showing compositional, volumetric andtemperaturedependenceZareena Begum, P.B. Sandhya Sri, D.B. Karuna Kumar, K. Rayapa Reddy, C. Rambabu □Journal of Molecular Liquids 184 (2013) 33–42; http://dx.doi.org/10.1016/j.molliq.2013.04.007.

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