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Density, Ultrasonic velocity, viscosity and their excess parameters of the some binary liquid mixtures containing 1,3-Dioxolane with alkanols at 298.15K

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Abstract

Densities, viscosities and speed of sound of binary mixture of 1,3-Dioxolane with Pentanol, Hexanol, Heptanol, Octanol, Nonanol and Decanol have been measured over the entire range of composition at temperature 298.15K. From the experimental densities, viscosities and speed of sound, the excess sound velocity (u^E), excess molar volume (V_m^E), and excess viscosity (η^E) have been investigated have been calculated. The present paper represents the nonlinear variation of ultrasonic velocity lead to dipole –dipole interactions between unlike molecules through hydrogen bonding and positive values indicate that the effect due to breaking up of self-associated structures of the components of the mixtures is dominant over the effect of H-bonding and dipole-dipole interaction between unlike molecules. The deviation has been fitted by a Redlich-Kister polynomial equation and the results are discussed in terms of molecular interactions. The excess properties are found to be eighter negative or positive depending on the molecular interactions and nature of the liquid mixtures. Excess properties provide important information in understanding the solute-solvent interaction in a solution.

Keywords: Alkanols, 1, 3-dioxolane, excess viscosity, density, sound velocity, deviation in viscosity, molecular interaction

Introduction

Studies on thermodynamic and transport properties of binary liquid mixtures provide information on the nature of interactions in the constituent binaries. The sound velocity (u), density (ρ) and viscosity (η) of binary liquid mixtures are used experimentally to understand molecular interaction between the components of the mixtures and find applications in several industries and cosmetics [1-3]. The studies of viscosity, density, and ultrasonic velocities are being increasingly used as tools for investigation of the properties of pure components and the nature of inter-molecular interactions between the liquid mixture constituents. As part of the experimental investigation of the excess thermodynamic properties of industrially significant liquid mixtures, in the present study, measurements of densities, viscosities, and ultrasonic velocities of six binary mixtures of 1, 3-Dioxolane with Pentanol, Hexanol, Heptanol, Octanol, Nonanol and Decanol have also been made at temperatures, 298.15 K. This forms a part of a program to study the properties of *n*-alkanol mixtures with a C_5 or C_{10} aromatic hydrocarbon as one of the components. The variation of sound velocity and other ultrasonic parameters of binary liquid mixtures have been studied by many researchers and thy have shed height upon structural changes associated with liquid mixtures of weakly and strongly components [4-10]. The study of molecular association in binary liquid mixtures having alcohol as one of the components is of particular interest, since alcohols are strongly self-associated liquids having a three-dimensional network of hydrogen bonds and can be associated [11-12].

In present paper we have studied the physico-chemical properties of the mixtures indicated above, in order to explain the strength and nature of the interactions between the components by deriving various thermodynamic parameters from volumetric, viscometric, acoustic properties of binary mixtures study.

The thermodynamic and transport properties of a binary liquid mixture such as sound velocity (u), density (ρ) and viscosity (η) are important from practical and theoretical points of view to understand liquid theory. Their properties are extremely useful for the design of process equipment in chemical industries. The data of the properties associated with the liquids and liquid mixtures likesound velocity (u), density (ρ) and viscosity (η) find extensive application in solution theory and molecular dynamics. Such results are necessary for interpretation of data obtained from thermochemical, electrochemical, biochemical and kinetic studies.

The present paper is a part of our ongoing research program in the measurement of thermodynamic and transport properties of binary liquid mixtures. The liquids were chosen in the present investigation on the basis of their industrial impotence.1, 3-dioxolane (cyclic diether) have played a major role in the pharmaceutical chemistry. Therefore, the applications of these compounds attract us to study their behavior in alcohols. Alcohols are used as hydraulic fluids in pharmaceutical and cosmetics, in medications for animals, in manufacturing of perfumes, paint removers, flavors and dyestuffs, as defrosting and as an antiseptic agent. The experimental results have been used to discuss the nature of interaction between unlike molecules in terms of hydrogen bonding, dipole-dipole interactions and dispersive forces. It is well known that ethers interact with alcohols by dipole-dipole interaction, formation of new hydrogen bonds or hetro-associations and dispersion forces.

Experimental Procedure

The liquids mixtures of various concentrations in mole fraction were prepared by taking AR grade chemicals. All six binary liquid mixtures were prepared by weighing appropriate amounts of pure liquids on a digital electronic balance (Citizen Scale (I) PVT. LTD. Mumbai, India.) With a precision ± 0.1. The experimental uncertainty in mole fractions did not exceed ± 0.0005. All the solutions were prepared by mass ratios and stored in the air-tight stopper measuring flasks.

Table 1: Experimental density (ρ), sound velocity (u) and viscosity (η) of pure Components Values at T = 298.15K.

Compound	ρ (g.cm^{-3})	u (m.s^{-1})	η (mPa s)
1,3-Dioxolane	1.0616	1340	0.5885
Pentanol	0.8124	1198	3.3978
Hexanol	0.8176	1306	4.6091
Heptanol	0.8196	1325	5.9066
Octanol	0.8236	1350	7.1508
Nonanol	0.8248	1366	8.9258
Decanol	0.8292	1378	11.8027

Measurements

Density: Densities of pure components and liquid-liquid mixtures were measured with a 25-ml specific gravity bottle by relative measurement method with an accuracy of ± 0.01 kg.m^{-3}. The specific gravity bottle with the experimental mixture was immersed in the temperature-controlled water bath (MSI Goyal scientific, Meerut, U.P. India.), operating in the temperature range of -10^{0}C to 85^{0}C with an accuracy ± 0.1^{0}C. Double distilled water used for the calibration of the specific gravity bottle. At least three times for each composition in experimental were generally repeated and the results were treatment.

Sound velocity

The speed of sound (u) was measured at a frequency 3 MHz in these solutions using the interferometric method with a (Model F-80D, Mittal Enterprise, New Delhi, India) at 298.15K. The interferometer cell was filled with the test liquid, and water was circulated around the measuring cell from a water bath. The uncertainty was estimated to be ±0.1%. The measured values of ultrasonic velocities of pure1, 3-dioxolane with pentanol. Hexanol, heptanol, octanol, nonanol and decanol compare well with the corresponding literature values.

Viscosity

The viscosities of pure liquids and their binary mixtures were measured by using a Ostawald’s viscometer. The viscometer was calibrated with doubly distilled water and benzene, liquid was allowed to stand for about 30 minutes in a thermostatic water bath so that the thermal fluctuations in viscometer were minimized. The accuracy in viscosity data was ± 0.0005 mPa.s. The flow time of pure liquids and liquid mixtures were repeated for five times. The efflux Time was measured with an electronic stopwatch (Racer) with a time resolution (± 0.015), and an average of at least five flow time readings was taken. Glass stopper was placed at the opening of the viscometer to prevent the loss due to evaporation during measurements. The measured values of viscosities of pure 1, 3-dioxolane with Pentanol, Hexanol, Heptanol, Octanol, Nonanol and Decanol compare well with the corresponding literature values.

Theoretical

The experimentally measured ultrasonic velocity (u), density (ρ) and viscosity (η) are used to evaluate derived parameters like molar volume (V_m), using well established relations.

The molar volume (V_m) of binary liquid mixtures were calculated by using a following equation

$$V_m = \frac{(X_1 M_1 + X_2 M_2)}{\rho} \qquad (1)$$

The excess value of ultrasonic related parameters has been calculated by using the following relation

$$A^E = A_{exp.} - (X_1 A_1 + X_2 A_2) \qquad (2)$$

Where A represents the parameter such as intermolecular free length, molar volume, isentropic compressibility, viscosity and internal pressure and X_1 and X_1 is the mole fractions of components whose parameters.

Result and Discussion

The experimentally determined values of density (ρ), sound velocity (u) and viscosity (η) and derived parameters molar volume (V_m) at 298.15K for the binary liquid system 1,3-Dioxolane with Pentanol, Hexanol, Heptanol, Octanol, Nonanol and Decanol are listed in table-2. The same excess values for the binary liquid mixtures 1, 3-Dioxolane with Pentanol, Hexanol, Heptanol, Octanol, Nonanol and Decanol are presented in table-3. The data related to excess sound velocity, excess viscosity and excess molar volume for the binary liquid system 1, 3-Dioxolane with Pentanol, Hexanol, Heptanol, Octanol, Nonanol and Decanol were graphically represented in figures 1 to 3 at 298.15K respectively.

From the table-2, it was observed that the density and ultrasonic velocity increase with increasing mole fraction of 1, 3-Dioxolane while the viscosity decrease. This may be due to association of a very strong dipole- induced dipole interaction between the component molecules.

Excess Sound Velocity (u^E)

In order to understand the nature of molecular interactions between the components of the liquid mixtures, it is of interest to discuss the same in terms of excess parameters rather than actual values. Non-ideal liquid mixtures show considerable deviation from linearity in their concentrations and this can be interpreted as the presence of strong or weak interactions.

The extent of deviation depends upon the nature of the constituents and composition of the mixtures. The thermodynamic excess properties are found to be more sensitive towards intermolecular interaction among the component molecules of liquid mixtures. The sign and extent of deviation of excess parameters depend on the strength of interaction between unlike molecules [13]. So various excess acoustic and thermodynamic parameters have been evaluated and corresponding graphs are also given.

The sign and magnitude of excess ultrasonic velocity (u^E) play an important role in describing molecular rearrangement as a result of the molecular interaction between the component molecules in the mixtures. The excess ultrasonic velocity (u^E) curves at 298.15 K varying with mole fraction of 1, 3-Dioxolane are represented in Figure-1 for the six binary systems. The excess ultrasonic velocity values exhibiting positive in all six binary systems. Generally, the value of the excess function (u^E) depend upon several physical and chemical contributions [14-15]. The physical contribution depends mainly on two factors, namely

1. The dispersion forces or weak dipole-dipole interaction that leads to positive values.

2. The geometrical effect allowing the fitting of molecules of two different sizes in to each other's structure resulting in negative values.

The chemical contributions include breaking up of the associates present in pure liquids, resulting in positive u^E. In the present mixture the graphical representation of excess sound velocity (u^E) are positive, presented in Figure-1. The positive values reveal that there are present weak interactions in the mixture.

The observed positive trends in excess sound velocity indicate that the effect due to the breaking up of self-associated structure of the components of the mixtures is dominant over the effect of hydrogen bonding and dipole-dipole interaction between unlike molecule. The excess sound velocity values in the sequence

Pentanol < Hexanol < Heptanol < Octanol < Nonanol < Decanol

Which also reflects the decreasing strength of interaction unlike molecule in the mixture

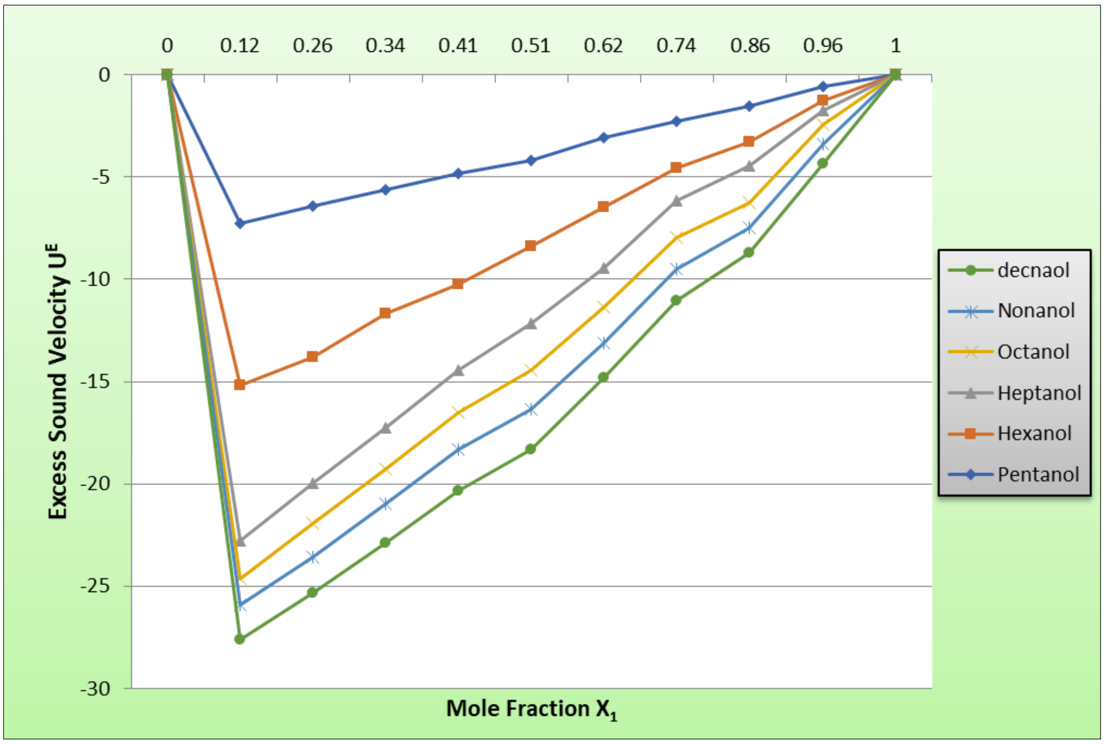

Fig 1: Curves of excess sound velocity (u^E) against the mole fraction of 1, 3-dioxolane x_1, for the binary mixture (1, 3-dioxolane (1) + Alkanols (2) at 298.15K. The solid lines represent the values calculated from the Redlich−Kister equation

Excess Molar Volume (V_m^E)

The excess molar volume (V_m^E) data of all the binary mixtures of 1, 3-Dioxolane with Pentanol, Hexanol, Heptanol, Octanol, Nonanol and Decanol are presented in table-3 at 298.15K.

A perusal of table-3 indicates that the values of excess molar volume (V_m^E) data for the binary mixtures of 1, 3-Dioxolane with Pentanol, Hexanol, Heptanol, Octanol, Nonanol and Decanol are positive. On other hand, an inversion in sign for the binary mixtures containing 1, 3-Dioxolane with Pentanol, Hexanol, Heptanol, Octanol, Nonanol and Decanol was observed. Further, it is observed the magnitude of positive excess molar volume (V_m^E) values decrease with increase in composition of 1, 3-Dioxolane. According to Marcus [16], the molecules of alkanols are associated through hydrogen bonding in pure state. Mixing these alcohol molecules with polar molecule like 1,3-Dioxolane would induce mutual dissociation of the hydrogen-bonded structure present in pure alcohols with subsequent formation of inter molecular hydrogen bonds (O-----OH) between the oxygen atom of ether group of 1, 3-Dioxolane molecule and hydrogen atom of hydroxyl group of alcohols. The positive excess molar volume (V_m^E) values suggest that the higher alcohols less proton donating ability than the lower alcohols. Hence hetro association affects decrees in the binary liquid mixtures with an increase of chain length of linear alcohols. The algebraic values of excess molar volume (V_m^E) for the mixtures of 1, 3-Dioxolane with Pentanol, Hexanol, Heptanol, Octanol, Nonanol and Decanol fall in the order,

Pentanol < Hexanol < Heptanol < Octanol < Nonanol < Decanol

The order suggests that dipole-dipole interaction between unlike molecules decrease with increasing in chain length of alcohols as consequences of these decreases the degree of polymerization in the pure state. These experimental results suggest that the positive excess molar volume (V_m^E) indicate that, the breaking up off self-associated structure of the components of the mixtures is dominant over the effect of H-bonding and dipole-dipole interaction between unlike molecules.

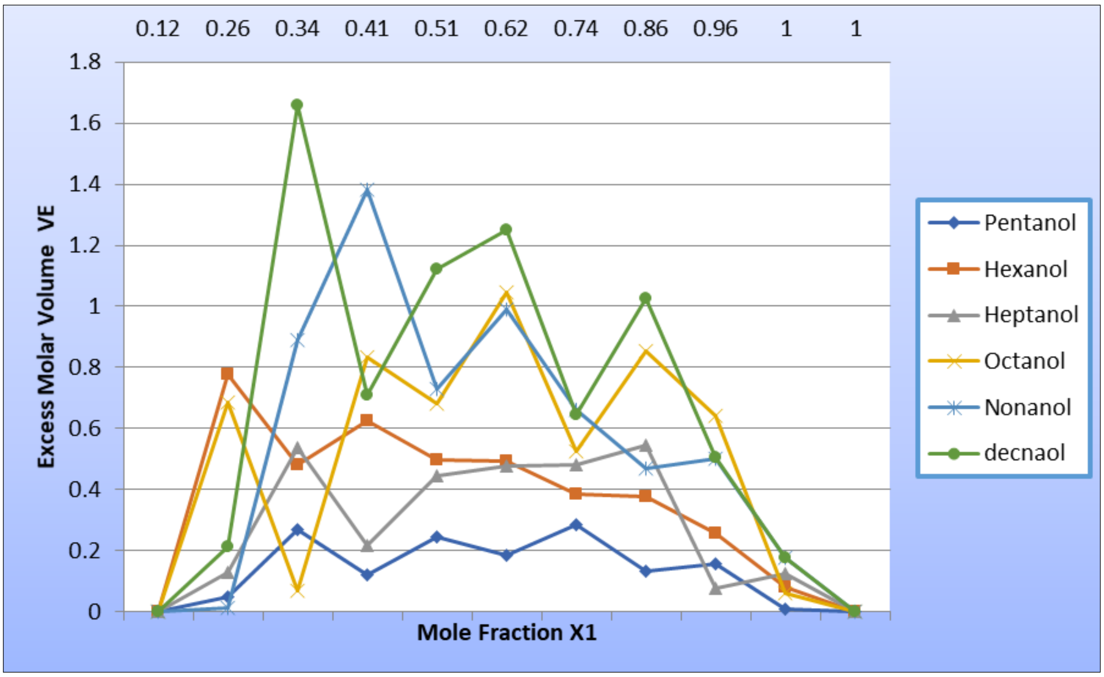

Fig 2: Curves of excess molar volume (V_m^E) against the mole fraction of 1, 3-dioxolane x_1, for the binary mixture (1,3-dioxolane (1) + Alkanols (2) at 298.15K. The solid lines represent the values calculated from the Redlich−Kister equation.

Excess Viscosity (η^E)

The excess viscosity (η^E) data of all the binary mixtures of 1, 3-Dioxolane with Pentanol, Hexanol, Heptanol, Octanol, Nonanol and Decanol are graphically presented Figures 3 at 298.15 K. An examination of curves in Figure 3 shows that the values of excess viscosity (η^E) data for 1, 3-Dioxolane with Pentanol, Hexanol, Heptanol, Octanol, Nonanol and Decanol are negative over the entire composition range at 298.15 K**.**

The measurement of viscosity in binary liquid mixture provides some reliable information in the study of molecular interaction. Table- 2 shows that the viscosity decrease with increase in concentration of 1, 3-Dioxolane molecule. More insight about molecular interaction can be obtained by excess viscosity (η^E) values.

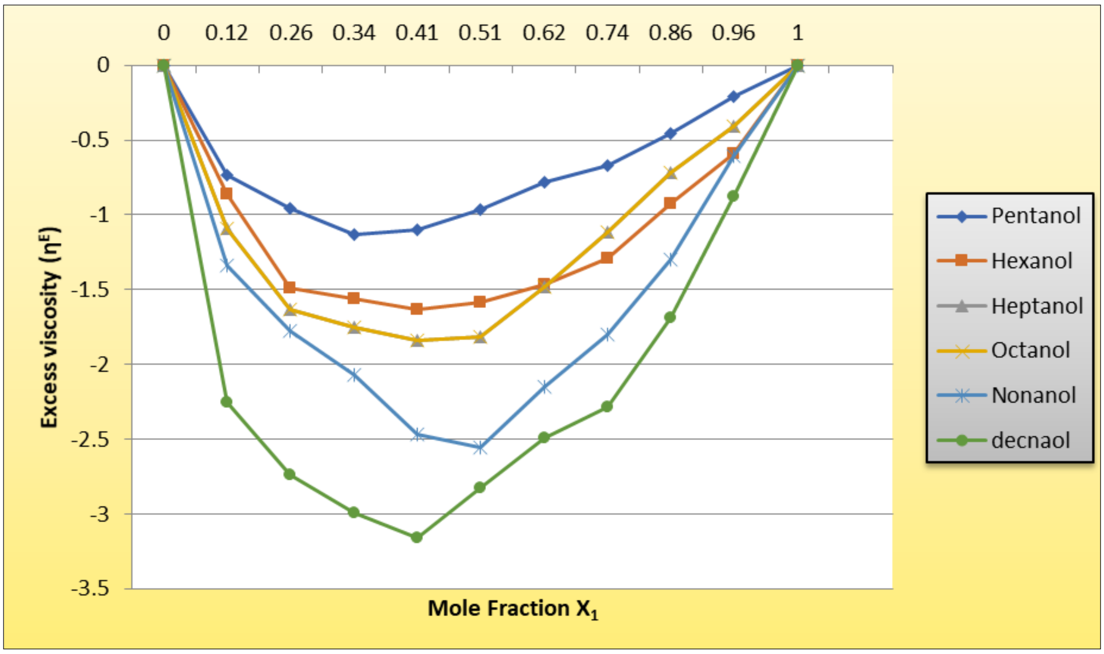

Fig 3: Curves of excess viscosity η^E against the mole fraction of 1, 3-dioxolane x_1, for the binary mixture (1, 3-dioxolane (1) + Alkanols (2) at 298.15K. The solid lines represent the values calculated from the Redlich−Kister equation.

According to Fort and Moore, [17-18] the excess viscosity gives the strength of the molecular interaction between the interacting molecules. The excess value of viscosity at the six binary mixtures 1,3-Dioxolane + Pentanol, 1,3-Dioxolane + Hexanol, 1,3-Dioxolane + Heptanol, 1,3-Dioxolane + Octanol, 1,3-Dioxolane + Nonanol and 1,3-Dioxolane + Decanol at the 298.15 K are reported in Table-3. The Figure -3 represents the variation of excess viscosity (η^E) is found to be negative for all six binary liquid mixtures over the entire composition range at the 298.15 K. Which suggest the presence of weak intermolecular interactions. For systems where dispersion, induction and dipolar forces are operating, the values of excess viscosity are found to be negative, whereas the existence of specific interaction leading to the formation of complexes in mixtures tends to make positive. The excess viscosity is negative through the whole range of concentration in all the studied systems. The large negative values of excess viscosity for all systems can be attributed to the presence of dispersion, induction and dipolar forces between the components

The negative excess viscosity (η^E) for all the six binary liquid mixtures (1,3-Dioxolane + Pentanol, 1,3-Dioxolane + Hexanol, 1,3-Dioxolane + Heptanol, 1,3-Dioxolane + Octanol, 1,3-Dioxolane + Nonanol and 1,3-Dioxolane + Decanol) studied are indicative of the predominance of dispersion forces and further their magnitudes increase from pentanol to decanol (C_5-C_{10}), hence suggesting an increase in dispersion forces in the same order . Alcohols are good solvent that can dissolve both the polar and non-polar components. The hydrophilic –OH group of alcohols can dissolve the polar whereas the short hydrophobic hydrocarbon group can dissolve the non-polar. Alcohols are strongly self-associated liquids with a three dimensional network of hydrogen bonds and can be associated with any other group having some degree of polar attraction. The associative alcohols molecule act as proton donor enabling hydrogen bonding with 1,3-Dioxolane molecule. In the system studied, the complex formation is likely to occur between $H^{\delta+}$ of alcohol and $O^{\delta-}$ of ether group of 1,3-Dioxolane. Hence in the present study there is existence of solute-solvent interactions. The algebraic values of excess viscosity for binary mixtures of 1, 3-Dioxolane with Pentanol, Hexanol, Heptanol, Octanol, Nonanol and Decanol fall in the order

Decanol < Nonanol < Octanol < Heptanol < Hexanol < Pentanol

In the alkanol mixture, the 1,3-Dioxolane is completely dissolved and so no changes of hydrogen bond raptures and only the interaction with the 1,3-Dioxolane ring and the active group of alkanols, which are mostly dispersive in nature. The increase in mole fraction of 1,3-Dioxolane increase the net dispersive interaction and hence the velocity continuously increases as observed. As the mole fraction of 1,3-Dioxolane increases, the hydrogen bond repture of the boat form is of considerable extent and they leads to additional dipole type interaction. 1,3-Dioxolane being non-polar the predominant dispersive type interactions with temporary dipolar type are existing as a net result of intermolecular forces in all systems.

Conclusions

From experimental results, negative excess molar volume (V_m^E) values can be attributed to the dipole –dipole interactions between unlike molecules through hydrogen bonding and positive values indicate that the effect due to breaking up of self-associated structures of the components of the mixtures is dominant over the effect of H-bonding and dipole-dipole interaction between unlike molecules The positive values of Excess molar volume (V_m^E) may be attributed to the formation of hydrogen bonding (O-H….O) resulting in the formation of complexes between the component molecules and negatives values suggesting breaking of the self-associated alcohols and weak interactions between unlike molecules. From these data, several thermodynamic excess functions have been calculated and correlated using the Redlich–Kister type polynomial equation. The sign and magnitude of these quantities have been discussed in terms of hydrogen bond, electron-transfer complexes and dipole-dipole interactions between the component molecules.

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Declarations conflict of interest

The authors have no competing interests to declare that are relevant to the content of this article.

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Data availability statement

All data generated or analyzed during this study are included in this published article.

Table 2: Experimental Values of density (ρ), sound velocity (u) and viscosity (η) and derived parameter molar volume (V_m) for the binary mixtures of 1,3-Dioxolane(1) + Alkanols (2) at 298.15K.

Mole fraction 1,3-Dioxolane (x_1)	Density (ρ) g.cm^{-3}	Sound velocity (u) ms^{-1}	Viscosity (η) mPa.s	molar volume (V_m) × 10^{-3} cm^3.mole^{-1}
1,3-Dioxolane + Pentanol				
0	0.8124	1198	3.3978	0.1085
0.0939	0.8276	1284	2.3973	0.1049
0.1942	0.8436	1290	1.8970	0.1012
0.2941	0.8640	1296	1.4437	0.0972
0.3942	0.8836	1300	1.1866	0.0934
0.4787	0.9068	1304	1.0904	0.0897
0.5999	0.9316	1310	0.9311	0.0855
0.6972	0.9596	1318	0.7717	0.0816
0.7928	0.9876	1324	0.7171	0.0779
0.9035	1.0260	1332	0.6489	0.0735
1.0000	1.0616	1340	0.5885	0.0697
1,3-Dioxolane + Hexanol				
0	0.8176	1306	4.6091	0.1249

0.0912	0.8252	1317	3.3826	0.1207
0.1955	0.8432	1320	2.3306	0.1146
0.2923	0.8584	1322	1.9839	0.1094
0.3982	0.8792	1325	1.5720	0.1034
0.4942	0.8992	1327	1.3059	0.0981
0.6059	0.9264	1330	1.0343	0.0919
0.6976	0.9508	1332	0.9131	0.0868
0.8018	0.9836	1335	0.7680	0.0809
0.8914	1.0168	1337	0.7304	0.0758
1.0000	1.0616	1340	0.5885	0.0697
1,3-Dioxolane + Heptanol				
0	0.8196	1325	5.9066	0.1417
0.0928	0.8304	1334	4.3181	0.1352
0.1905	0.8412	1334	3.2577	0.1286
0.2939	0.8592	1335	2.5895	0.1208
0.3894	0.8740	1335	1.9926	0.1141
0.4818	0.8916	1336	1.5315	0.1075
0.6021	0.9184	1337	1.2190	0.0989
0.6952	0.9420	1337	1.0959	0.0922
0.7892	0.9756	1338	0.9903	0.0850
0.9006	1.0156	1339	0.7057	0.0770
1.0000	1.0616	1340	0.5885	0.0697
1,3-Dioxolane + Octanol				
0	0.8296	1350	7.1508	0.1581
0.0885	0.8296	1350	5.6095	0.1509
0.1967	0.8464	1349	3.9321	0.1408
0.2998	0.8560	1348	3.2616	0.1324
0.3902	0.8712	1348	2.4284	0.1243
0.4963	0.8876	1348	1.9058	0.1153
0.6008	0.9140	1347	1.3631	0.1055
0.6925	0.9340	1348	1.1376	0.0978
0.7975	0.9676	1348	0.9141	0.0883
0.8940	1.0104	1348	0.7652	0.0792
1.0000	1.0616	1340	0.5885	0.0697
1,3-Dioxolane + Nonanol				
0	0.8248	1366	8.9258	0.1749
0.0876	0.8336	1366	6.8601	0.1656
0.1913	0.8404	1363	5.8531	0.1556
0.2942	0.8504	1359	4.4022	0.1453
0.3963	0.8692	1355	3.1558	0.1339
0.4959	0.8844	1352	2.3340	0.1237
0.6050	0.9092	1349	1.7321	0.1119
0.6947	0.9332	1346	1.3334	0.1023
0.7993	0.9648	1343	0.9642	0.0913
0.9013	1.0084	1340	0.8031	0.0803
1	1.0616	1340	0.5885	0.0697
1,3-Dioxolane + Decanol				
0	0.8292	1378	11.8027	0.1908
0.0881	0.8364	1374	8.5615	0.1803
0.191	0.8396	1370	7.8207	0.1693
0.2921	0.8560	1366	5.5340	0.1561
0.3937	0.8672	1362	4.2319	0.1442
0.4956	0.8824	1358	3.4173	0.1320
0.604	0.9076	1353	2.5370	0.1183
0.7129	0.9308	1348	1.5262	0.1055
0.7983	0.9616	1344	1.1637	0.0946
0.8971	1.0040	1340	0.8623	0.0824
1	1.0616	1340	0.5885	0.0697

Table 3: Excess sound velocity, Excess viscosity (η^E), excess molar volume (V_m^E) for the binary mixtures of 1,3-Dioxolane (1) + Alkanols (2) at 298.15K.

1,3-Dioxolane + Pentanol			
Mole fraction 1,3-Dioxolane (x_1)	**Excee Sound Velocity (u^E) m.s^{-1}**	**excess viscosity (η^E) mPa.s**	**Excess molar volume (V_m^E) × 10^{-3} cm^3.mole^{-1}**
0	-	-	-
0.0939	72.6662	-0.7367	0.0469
0.1942	64.4236	-0.9552	0.2682

0.2941	56.2378	-1.1280	0.1192
0.3942	48.0236	-1.1038	0.2446
0.4787	42.0246	-0.9627	0.1860
0.5999	30.8142	-0.7815	0.2867
0.6972	22.9976	-0.6675	0.1314
0.7928	15.4224	-0.4535	0.1568
0.9035	5.7030	-0.2108	0.0076
1.0000	-	-	-
1,3-Dioxolane + Hexanol			
0			
0.0912	7.8978	-0.8597	0.7779
0.1955	7.3530	-1.4925	0.4810
0.2923	6.0618	-1.4500	0.6245
0.3982	5.4612	-1.4361	0.4952
0.4942	4.1972	-1.3162	0.4919
0.6059	3.3994	-1.1387	0.3860
0.6976	2.2816	-0.8912	0.3783
0.8018	1.7388	-0.6174	0.2564
0.8914	0.6924	-0.2947	0.0816
1.0000	-	-	-
1,3-Dioxolane + Heptanol			
0	-	-	-
0.0928	7.6084	-1.0951	0.1293
0.1905	6.1425	-1.6358	0.5357
0.2939	5.5915	-1.7541	0.2168
0.3894	4.1590	-1.8431	0.4437
0.4818	3.7730	-1.8128	0.4770
0.6021	2.9685	-1.4856	0.4818
0.6952	1.5720	-1.1136	0.5437
0.7892	1.1620	-0.7193	0.0752
0.9006	0.4910	-0.4114	0.1264
1.0000	-	-	-
1,3-Dioxolane + Octanol			
0	-	-	-
0.0885	0.8850	-1.0951	0.6846
0.1967	0.9670	-1.6358	0.0682
0.2998	0.9980	-1.7541	0.8340
0.3902	1.9020	-1.8431	0.6824
0.4963	2.9630	-1.8128	1.0462
0.6008	3.0080	-1.4856	0.5270
0.6925	4.9250	-1.1136	0.8545
0.7975	5.9750	-0.7193	0.6410
0.8940	6.9400	-0.4114	0.0624
1.0000	-	-	-
1,3-Dioxolane + Nonanol			
0		-	-
0.0876	2.2776	-1.3354	-0.0127
0.1913	1.9738	-1.4778	0.8880
0.2942	0.6492	-2.0708	1.3824
0.3963	-0.6962	-2.4659	0.7277
0.4959	-1.1066	-2.4573	0.9917
0.6050	-1.2700	-2.1496	0.6632
0.6947	-1.9378	-1.8005	0.4673
0.7993	-2.2182	-1.2976	0.5023
0.9013	-2.5662	-0.6083	0.1749
1	-	-	-
1,3-Dioxolane + Decanol			
0	-	-	-
0.0881	-0.6522	-2.2532	0.2115
0.191	-0.7420	-1.8401	1.6598
0.2921	-0.9002	-2.9930	0.7076
0.3937	-1.0394	-3.1558	1.1236
0.4956	-1.1672	-2.8276	1.2487
0.604	-2.0480	-2.4923	0.6457
0.7129	-2.9098	-2.2819	1.0260
0.7983	-3.6646	-1.6867	0.5040
0.8971	-3.9102	-0.8801	0.1778
1	-	-	-

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