Densities, Viscosities, Refractive Indices, and Surface Tensions for the Mixtures of 1,3-Dioxolane + 2-Propanol or + 2,2,4-Trimethylpentane at (288.15, 298.15, and 308.15) K and 1,3-Dioxolane + 2-Propanol + 2,2,4-Trimethylpentane at 298.15 K

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Densities, viscosities, refractive indices, and surface tensions of a ternary system (1,3-dioxolane + 2-propanol + 2,2,4-trimethylpentane) at $T = 298.15$ K and two binary systems (1,3-dioxolane + 2-propanol and 1,3-dioxolane + 2,2,4-trimethylpentane) at $T =$ (288.15, 298.15, and 308.15) K were measured over the extensive composition range at atmospheric pressure. Densities were determined using a vibrating-tube densimeter. Viscosities were measured with an automatic microviscometer based on the rolling-ball principle. Refractive indices were measured using a digital Abbe-type refractometer. Surface tensions were determined by the Wilhelmy-plate method. The excess molar volumes V^E were calculated from the experimental density data. The results are discussed in terms of molecular interactions.

Introduction

The reformulation of gasoline includes certain oxygenated compounds such as alcohols and ethers. These oxygenated compounds are added to improve the octane rating and pollution-reducing capability of gasoline. This work has been carried out as a part of an extensive study to investigate the thermodynamic behavior of liquid mixtures including oxygenated compounds as the basic components in an alkane liquid. The present paper is concerned with the oxygenated compounds of the type {cyclic ether or aliphatic alcohol} and the alkane liquid that generally appears in gasoline. From the viewpoint of association, cyclic ethers can be regarded as an intermediate case between alkanes (inert compounds) and alkanols (highly self-associated compounds).

For these reasons, we measured densities, viscosities, refractive indices, and surface tensions for two binary systems (1,3-dioxolane + 2-propanol and 1,3-dioxolane + 2,2,4-trimethylpentane) at $T =$ (288.15, 298.15, and 308.15) K and a ternary system (1,3-dioxolane + 2-propanol + 2,2,4-trimethylpentane) at $T = 298.15$ K. In the past, experimental densities and surface tensions were measured at $T = 298.15$ K for the 1,3-dioxolane + 2-propanol system by Calvo et al.[1] Experimental densities and refractive indices were reported at $T = 298.15$ K for the 1,3-dioxolane + 2,2,4-trimethylpentane system by Francesconi et al.[2] However, we are not aware of any other data in the literature for the mixtures presented in this study.

Experimental Section

Materials. The mass purities and sources of the chemicals employed are as follows: 1,3-dioxolane (Merck, > 99.5 %), 2-propanol (Tedia, > 99.5 %), and 2,2,4-trimethylpentane (Merck, > 99.7 %). All chemicals were used without further purification after gas chromatography failed to show any significant impurities. Comparison of our measured densities ρ, viscosities η, refractive indices n_D, and surface tensions σ of pure components with the literature values at $T = 298.15$ K was shown in Table 1.

Apparatus and Procedure. Densities ρ were measured with an Anton Paar DMA-5000 vibrating-tube densimeter (Anton-Paar, Graz, Austria). Viscosities η were determined with an automatic microviscometer (Anton Paar type AMVn), which uses the rolling-ball principle. Refractive indices n_D were measured with an automatic Anton Paar RXA-156 refractometer, which runs with the wavelength of 589 nm corresponding to the D-ray of sodium. Surface tensions σ were measured with an automatic tensionmeter model CBVP-A3 (Kyowa, Japan), which works by the Wilhelmy-plate method. The detailed measuring procedures have been described in the previous studies.[3,4]

All samples were prepared by mass using a Precisa 262SMA balance with a precision of 0.1 mg. The uncertainty in the composition is estimated to within $\pm 1 \cdot 10^{-4}$ mole fraction. All liquids were thermostatically controlled to within $\pm$ 0.01 K, $\pm$ 0.05 K, $\pm$ 0.03 K, and $\pm$ 0.05 K for ρ, η, n_D, and σ measurements, respectively. All measurements were performed at least four times under atmospheric pressure (100.8 $\pm$ 0.4) kPa, and the results were averaged to give the final values. The uncertainties of ρ, η, n_D, and σ were estimated to be $\pm 3 \cdot 10^{-5}$ g·cm^{-3}, $\pm$ 0.004 mPa·s, $\pm$ 0.00005, and $\pm$ 0.05 mN·m^{-1}, respectively.

Results and Discussion

The experimental densities ρ, viscosities η, refractive indices n_D, and surface tensions σ for two binary systems (1,3-dioxolane + 2-propanol and 1,3-dioxolane + 2,2,4-trimethylpentane) at $T =$ (288.15, 298.15, and 308.15) K are presented in Tables 2

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and 3, respectively. Increasing temperatures from (288.15 to 308.15) K decreases the values of ρ, η, n_D, and σ for these two binary systems. Figure 1 contains a comparison of our experimental surface tensions with those from ref 1 at $T = 298.15$ K for 1,3-dioxolane + 2-propanol. Figure 2 shows our experimental refractive indices along with those from ref 2 at $T = 298.15$ K for 1,3-dioxolane + 2,2,4-trimethylpentane. The experimental data of ρ, η, n_D, and σ for the ternary system of 1,3-dioxolane + 2-propanol + 2,2,4-trimethylpentane at $T = 298.15$ K were shown in Table 4.

Tables 5 to 7 list the derived data of excess molar volumes V^E for these mixtures. The excess molar volumes were calculated from density data according to the following equation

$$V^E = \sum_{i=1}^{N} x_i M_i \left(\frac{1}{\rho} - \frac{1}{\rho_i}\right) \quad (1)$$

where x_i, M_i, and ρ_i are the mole fraction, molar mass, and density of the pure component i, respectively. ρ is the density of the mixture, and N is the number of components. The uncertainty of excess molar volumes was estimated to be less than $\pm 5 \cdot 10^{-3}$ cm^3·mol^{-1}.

As shown in the tables, values of excess molar volume V^E for these two binary systems are positive. The maximum V^E values for 1,3-dioxolane (1) + 2-propanol (2) and 1,3-dioxolane (1) + 2,2,4-trimethylpentane (2) occurred at $x_1 = 0.50$ and $x_1 = 0.45$ with the values being 0.204 cm^3·mol^{-1} and 0.507

Table 1. Comparison of Measured Densities ρ, Viscosities η, Refractive Indices n_D, and Surface Tensions σ of Pure Components with Literature Values at $T = 298.15$ K

	(ρ)/(g·cm^{-3})		(η)/(mPa·s)		n_D		(σ)/(mN·m^{-1})	
component	expt	lit.	expt	lit.	expt	lit.	expt	lit.
1,3-dioxolane	1.05929	1.05879[a]	0.596	0.5886[d]	1.39795	1.3980[e]	32.55	32.61[a]
		1.058593[b]						
		1.0591[c]						
		1.05862[d]						
2-propanol	0.78116	0.78089[a]	2.043	2.0436[f]	1.37515	1.3752[f]	20.90	20.85[a]
		0.78126[f]		2.0776[g]				20.95[h]
		0.781024[g]						20.93[i]
2,2,4-trimethyl-pentane	0.68795	0.68781[f]	0.481	0.4804[k]	1.38916	1.3890[b]	18.33	18.60[l]
		0.68885[j]		0.4784[l]		1.38898[f]		18.32[m]
		0.68762[k]				1.3892[j]		
		0.6860[l]				1.38858[l]		

[a] Calvo et al., 2004.[1] [b] Francesconi et al., 1993.[2] [c] Grolier et al., 1982.[5] [d] Gascón et al., 2000.[6] [e] Wisniak et al., 1997.[7] [f] Riddick et al., 1986.[8] [g] Haraschta et al., 1999.[9] [h] Azizian and Bashavard, 2005.[10] [i] Ouyang et al., 2003.[11] [j] Aralaguppi et al., 1999.[12] [k] Bouzas et al., 2000.[13] [l] Gómez-Díaz, et al., 2002.[14] [m] Vargaftik, 1975.[15]

Table 2. Experimental Densities ρ, Viscosities η, Refractive Indices n_D, and Surface Tensions σ for 1,3-Dioxolane (1) + 2-Propanol (2) Mixtures

x_1	(ρ)/(g·cm^{-3})	(η)/(mPa·s)	n_D	(σ)/(mN·m^{-1})	x_1	(ρ)/(g·cm^{-3})	(η)/(mPa·s)	n_D	(σ)/(mN·m^{-1})
				$T = 288.15$ K					
0.0000	0.78953	2.849	1.37933	21.75	0.5500	0.93582	0.779	1.39107	25.85
0.0500	0.80201	2.285	1.38037	21.98	0.6000	0.95011	0.745	1.39227	26.43
0.1000	0.81465	1.846	1.38139	22.23	0.6500	0.96458	0.719	1.39348	27.05
0.1500	0.82745	1.564	1.38242	22.53	0.7001	0.97920	0.697	1.39473	27.75
0.2000	0.84043	1.371	1.38343	22.85	0.7500	0.99401	0.682	1.39600	28.57
0.2500	0.85356	1.221	1.38447	23.20	0.8000	1.00900	0.671	1.39731	29.47
0.3001	0.86686	1.105	1.38550	23.57	0.8500	1.02420	0.657	1.39862	30.50
0.3500	0.88033	1.012	1.38655	23.95	0.9000	1.03961	0.636	1.39993	31.63
0.4000	0.89396	0.934	1.38763	24.38	0.9500	1.05525	0.635	1.40123	32.95
0.4500	0.90775	0.874	1.38875	24.83	1.0000	1.07124	0.667	1.40252	34.37
0.5000	0.92170	0.823	1.38990	25.32					
				$T = 298.15$ K					
0.0000	0.78116	2.043	1.37515	20.90	0.5500	0.92502	0.671	1.38611	24.92
0.0500	0.79333	1.690	1.37601	21.22	0.6000	0.93914	0.645	1.38729	25.48
0.1000	0.80566	1.429	1.37686	21.52	0.6500	0.95343	0.626	1.38850	26.10
0.1500	0.81826	1.237	1.37776	21.80	0.7001	0.96787	0.611	1.38975	26.77
0.2000	0.83103	1.099	1.37869	22.10	0.7500	0.98251	0.599	1.39103	27.53
0.2500	0.84397	0.992	1.37966	22.40	0.8000	0.99736	0.592	1.39234	28.38
0.3001	0.85709	0.908	1.38065	22.75	0.8500	1.01238	0.587	1.39368	29.33
0.3500	0.87034	0.840	1.38168	23.12	0.9000	1.02767	0.585	1.39509	30.37
0.4000	0.88374	0.784	1.38274	23.50	0.9500	1.04329	0.587	1.39653	31.43
0.4500	0.89731	0.740	1.38384	23.93	1.0000	1.05929	0.596	1.39795	32.55
0.5000	0.91108	0.720	1.38496	24.42					
				$T = 308.15$ K					
0.0000	0.77252	1.541	1.37061	20.17	0.5500	0.91373	0.586	1.38121	24.03
0.0500	0.78433	1.299	1.37126	20.48	0.6000	0.92766	0.568	1.38238	24.55
0.1000	0.79638	1.126	1.37207	20.80	0.6500	0.94179	0.555	1.38359	25.15
0.1500	0.80869	0.999	1.37295	21.10	0.7001	0.95609	0.542	1.38483	25.80
0.2000	0.82118	0.895	1.37388	21.42	0.7500	0.97057	0.531	1.38608	26.50
0.2500	0.83389	0.817	1.37483	21.70	0.8000	0.98526	0.525	1.38737	27.28
0.3001	0.84677	0.756	1.37579	22.00	0.8500	1.00013	0.520	1.38872	28.10
0.3500	0.85980	0.706	1.37680	22.33	0.9000	1.01521	0.519	1.39013	28.95
0.4000	0.87301	0.667	1.37785	22.70	0.9500	1.03071	0.523	1.39165	29.82
0.4500	0.88641	0.637	1.37894	23.12	1.0000	1.04685	0.535	1.39322	30.67
0.5000	0.89998	0.609	1.38006	23.55					

Table 3. Experimental Densities ρ, Viscosities η, Refractive Indices n_D, and Surface Tensions σ for 1,3-Dioxolane (1) + 2,2,4-Trimethylpentane (2) Mixtures

x_1	(ρ) / (g·cm^{-3})	(η) / (mPa·s)	n_D	(σ) / (mN·m^{-1})	x_1	(ρ) / (g·cm^{-3})	(η) / (mPa·s)	n_D	(σ) / (mN·m^{-1})
				$T = 288.15$ K					
0.0000	0.69610	0.537	1.39408	19.18	0.5500	0.82088	0.561	1.39558	21.02
0.0501	0.70403	0.529	1.39395	19.37	0.6000	0.83870	0.568	1.39610	21.32
0.1000	0.71238	0.528	1.39385	19.55	0.6500	0.85832	0.576	1.39668	21.63
0.1500	0.72122	0.527	1.39377	19.70	0.7000	0.87984	0.585	1.39734	22.00
0.2000	0.73061	0.527	1.39374	19.83	0.7500	0.90363	0.595	1.39807	22.43
0.2500	0.74066	0.528	1.39378	19.97	0.8000	0.92995	0.605	1.39883	23.00
0.3000	0.75151	0.532	1.39389	20.08	0.8500	0.95926	0.617	1.39966	23.85
0.3500	0.76325	0.536	1.39411	20.22	0.9000	0.99211	0.632	1.40055	25.35
0.4000	0.77592	0.541	1.39440	20.38	0.9500	1.02919	0.651	1.40152	28.33
0.4500	0.78966	0.547	1.39473	20.57	1.0000	1.07124	0.667	1.40252	34.37
0.5000	0.80459	0.554	1.39512	20.78					
				$T = 298.15$ K					
0.0000	0.68795	0.481	1.38916	18.33	0.5500	0.81069	0.504	1.39068	20.30
0.0501	0.69541	0.480	1.38898	18.57	0.6000	0.82825	0.511	1.39120	20.60
0.1000	0.70347	0.478	1.38885	18.75	0.6500	0.84756	0.519	1.39178	20.93
0.1500	0.71211	0.478	1.38876	18.92	0.7000	0.86887	0.527	1.39243	21.32
0.2000	0.72142	0.479	1.38876	19.07	0.7500	0.89242	0.536	1.39318	21.80
0.2500	0.73137	0.479	1.38883	19.20	0.8000	0.91853	0.546	1.39399	22.40
0.3000	0.74215	0.480	1.38897	19.33	0.8500	0.94766	0.557	1.39487	23.32
0.3500	0.75376	0.483	1.38920	19.47	0.9000	0.98035	0.571	1.39581	24.90
0.4000	0.76631	0.487	1.38948	19.63	0.9500	1.01739	0.584	1.39683	27.60
0.4500	0.77989	0.492	1.38982	19.82	1.0000	1.05929	0.596	1.39795	32.55
0.5000	0.79463	0.498	1.39022	20.03					
				$T = 308.15$ K					
0.0000	0.67962	0.434	1.38497	17.35	0.5500	0.80050	0.453	1.38563	19.42
0.0501	0.68672	0.431	1.38381	17.58	0.6000	0.81780	0.460	1.38614	19.72
0.1000	0.69459	0.432	1.38367	17.78	0.6500	0.83680	0.467	1.38672	20.05
0.1500	0.70308	0.432	1.38361	17.93	0.7000	0.85772	0.475	1.38739	20.47
0.2000	0.71228	0.433	1.38360	18.08	0.7500	0.88096	0.484	1.38814	20.95
0.2500	0.72216	0.433	1.38370	18.23	0.8000	0.90676	0.494	1.38895	21.57
0.3000	0.73281	0.433	1.38387	18.37	0.8500	0.93570	0.505	1.38987	22.60
0.3500	0.74431	0.434	1.38410	18.53	0.9000	0.96803	0.515	1.39090	24.22
0.4000	0.75672	0.438	1.38440	18.72	0.9500	1.00478	0.526	1.39199	26.78
0.4500	0.77011	0.442	1.38476	18.93	1.0000	1.04685	0.535	1.39322	30.67
0.5000	0.78466	0.447	1.38517	19.15					

cm^3·mol^{-1}, respectively. Figure 3 contains a comparison of our V^E values at $T = 298.15$ K with those from ref 1 for 1,3-dioxolane + 2-propanol and those from ref 2 for 1,3-dioxolane + 2,2,4-trimethylpentane. As expected from the behavior of binary mixtures, the V^E values shown in Table 7 for the ternary mixtures of 1,3-dioxolane (1) + 2-propanol (2) + 2,2,4-trimethylpentane (3) are positive. The maximum V^E with a value of 0.748 cm^3·mol^{-1} was found at $x_1 = 0.20$, $x_2 = 0.25$, and $x_3 = 0.55$.

The dependence of V^E on both composition and temperature for the present mixtures may be explained as a balance between

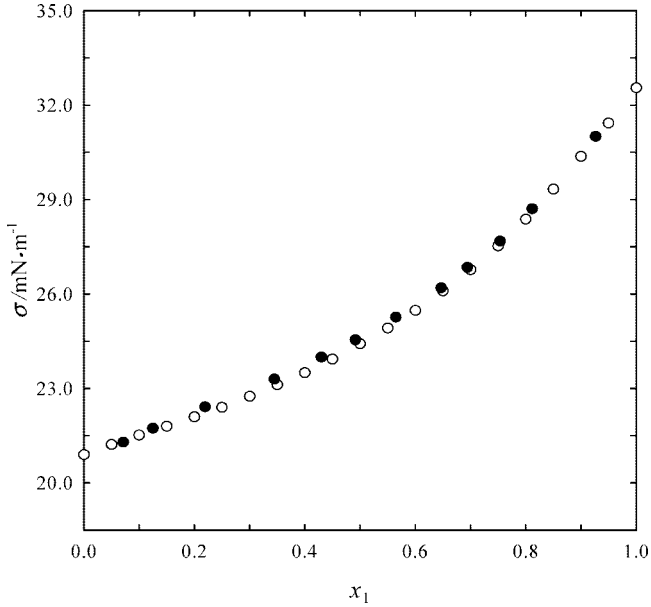

Figure 1. Comparison of surface tension data between this work and the literature at $T = 298.15$ K: ○, 1,3-dioxolane (1) + 2-propanol (2); ●, 1,3-dioxolane (1) + 2-propanol (2) from Calvo et al.[1]

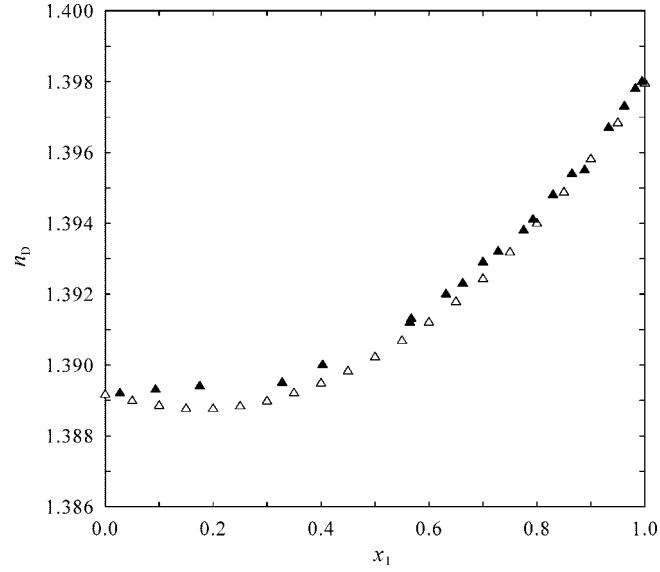

Figure 2. Comparison of refractive index data between this work and the literature at $T = 298.15$ K: Δ, 1,3-dioxolane (1) + 2,2,4-trimethylpentane (2); ▲, 1,3-dioxolane (1) + 2,2,4-trimethylpentane (2) from Francesconi et al.[2]

Table 4. Experimental Densities ρ, Viscosities η, Refractive Indices n_D, and Surface Tensions σ for 1,3-Dioxolane (1) + 2-Propanol (2) + 2,2,4-Trimethylpentane (3) Mixtures

x_1	x_2	(ρ) / (g·cm^{-3})	(η) / (mPa·s)	n_D	(σ) / (mN·m^{-1})	x_1	x_2	(ρ) / (g·cm^{-3})	(η) / (mPa·s)	n_D	(σ) / (mN·m^{-1})
0.0500	0.8999	0.78229	1.146	1.37685	20.75	0.3000	0.5500	0.81680	0.707	1.38195	21.35
0.0500	0.8000	0.76350	1.106	1.37813	20.15	0.3000	0.4500	0.79666	0.624	1.38214	20.50
0.0500	0.7000	0.74862	0.894	1.37941	19.67	0.3000	0.3500	0.78020	0.565	1.38393	19.90
0.0500	0.6000	0.73648	0.750	1.38111	19.33	0.3000	0.2500	0.76651	0.524	1.38513	19.45
0.0500	0.5000	0.72598	0.647	1.38223	19.05	0.3000	0.1500	0.75513	0.498	1.38624	19.25
0.0500	0.4000	0.71745	0.579	1.38341	18.89	0.3000	0.0500	0.74610	0.480	1.38786	19.15
0.0500	0.3000	0.71010	0.534	1.38475	18.75	0.4000	0.5500	0.86710	0.732	1.38232	22.75
0.0500	0.2000	0.70413	0.504	1.38608	18.67	0.4000	0.4500	0.83913	0.642	1.38346	21.63
0.0500	0.1000	0.69920	0.486	1.38729	18.60	0.4001	0.3500	0.81687	0.580	1.38459	20.70
0.0500	0.0500	0.69720	0.480	1.38811	18.55	0.4000	0.2500	0.79872	0.536	1.38574	20.15
0.1000	0.8500	0.79380	1.229	1.37716	21.30	0.4000	0.1500	0.78387	0.505	1.38685	19.85
0.1000	0.7500	0.77381	0.983	1.37847	20.20	0.4000	0.0501	0.77130	0.486	1.38911	19.75
0.1000	0.6500	0.75780	0.813	1.37991	19.60	0.5000	0.4500	0.89280	0.664	1.38457	23.55
0.1000	0.5500	0.74473	0.693	1.38125	19.33	0.5000	0.3500	0.86220	0.596	1.38563	22.20
0.1000	0.4501	0.73378	0.611	1.38247	19.12	0.5000	0.2500	0.83768	0.549	1.38665	21.20
0.1000	0.3500	0.72461	0.556	1.38365	18.97	0.5000	0.1501	0.81784	0.518	1.38772	20.45
0.1000	0.2501	0.71696	0.518	1.38481	18.85	0.5000	0.0500	0.80159	0.496	1.38884	20.10
0.1000	0.1500	0.71062	0.494	1.38635	18.75	0.6000	0.3500	0.91920	0.617	1.38691	24.40
0.1000	0.0500	0.70550	0.479	1.38791	18.65	0.6000	0.2500	0.88574	0.567	1.38785	22.65
0.2000	0.7500	0.81762	0.988	1.37896	21.75	0.6000	0.1500	0.85920	0.531	1.38885	21.25
0.2000	0.6500	0.79495	0.817	1.38002	20.75	0.6000	0.0500	0.83772	0.509	1.38991	20.70
0.2000	0.5500	0.77654	0.695	1.38137	20.05	0.7000	0.2500	0.94608	0.588	1.38936	25.35
0.2000	0.4500	0.76211	0.615	1.38236	19.70	0.7000	0.1500	0.91004	0.549	1.39024	22.85
0.2000	0.3500	0.74992	0.556	1.38358	19.45	0.7000	0.0500	0.88126	0.527	1.39123	21.45
0.2000	0.2500	0.73966	0.558	1.38493	19.25	0.8000	0.1500	0.97400	0.574	1.39287	26.65
0.2000	0.1500	0.73108	0.491	1.38642	19.05	0.7999	0.0501	0.93509	0.547	1.39285	23.25
0.2000	0.0500	0.72430	0.475	1.38753	18.87	0.8999	0.0500	1.00250	0.573	1.39523	27.85
0.3000	0.6500	0.84181	0.826	1.38071	22.25						

Table 5. Excess Molar Volumes V^E for 1,3-Dioxolane (1) + 2-Propanol (2) Mixtures

x_1	(V^E) / (cm^3·mol^{-1})	x_1	(V^E) / (cm^3·mol^{-1})	x_1	(V^E) / (cm^3·mol^{-1})	x_1	(V^E) / (cm^3·mol^{-1})
			T = 288.15 K				
0.0500	0.035	0.3001	0.139	0.5500	0.149	0.8000	0.102
0.1000	0.066	0.3500	0.145	0.6000	0.144	0.8500	0.083
0.1500	0.092	0.4000	0.150	0.6500	0.135	0.9000	0.063
0.2000	0.111	0.4500	0.152	0.7001	0.128	0.9500	0.036
0.2500	0.125	0.5000	0.153	0.7500	0.116		
			T = 298.15 K				
0.0500	0.051	0.3001	0.180	0.5500	0.199	0.8000	0.140
0.1000	0.096	0.3500	0.190	0.6000	0.191	0.8500	0.118
0.1500	0.126	0.4000	0.198	0.6500	0.181	0.9000	0.092
0.2000	0.150	0.4500	0.203	0.7001	0.173	0.9500	0.052
0.2500	0.165	0.5000	0.204	0.7500	0.158		
			T = 308.15 K				
0.0500	0.071	0.3001	0.242	0.5500	0.260	0.8000	0.180
0.1000	0.129	0.3500	0.254	0.6000	0.251	0.8500	0.153
0.1500	0.170	0.4000	0.263	0.6500	0.236	0.9000	0.126
0.2000	0.203	0.4500	0.266	0.7001	0.223	0.9500	0.078
0.2500	0.223	0.5000	0.266	0.7500	0.203		

positive contributions (hydrogen bond rupture or dispersive interactions between unlike molecules) and negative contributions (intermolecular dipolar interactions or geometrical fitting between components). In the present investigation, 1,3-dioxolane is associated through the dipole−dipole interaction, and 2-propanol is associated through the hydrogen bonding of its hydroxyl group. The 2,2,4-trimethylpentane molecules do not exhibit this property because they have no atoms having that ability.

In our binary systems, the values of excess molar volume V^E for 1,3-dioxolane + 2,2,4-trimethylpentane are larger than those for 1,3-dioxolane + 2-propanol. Larger V^E values in the mixtures of 1,3-dioxolane with 2,2,4-trimethylpentane may lead us to believe that the contribution to the V^E values occurred from the cleavage of the O−O interaction between 1,3-dioxolane molecules. Smaller values of V^E observed in the 1,3-dioxolane + 2-propanol mixtures imply that a weak dispersion type interaction likely exists between these two molecules. Despite the non-negligible degree of cyclic diethers−alkanol complexation by a hydrogen bond, such association between unlike molecules, as happens in the 1,3-dioxolane + 2-propanol mixtures, is not significant to offset the positive contribution to V^E.

Conclusion

This paper reports the experimental data of densities ρ, viscosities η, refractive indices n_D, and surface tensions σ for two binary systems (1,3-dioxolane + 2-propanol and 1,3-dioxolane + 2,2,4-trimethylpentane) at T = (288.15, 298.15, and 308.15) K and a ternary system (1,3-dioxolane + 2-propanol + 2,2,4-trimethylpentane) at T = 298.15 K. Increasing temperatures from (288.15 to 308.15) K decreases the values of ρ, η, n_D, and σ for binary mixtures. A good agreement was found between our data and the literature results of excess molar volume V^E at T = 298.15 K for these two binary systems. Increasing temperatures increases the values of V^E. The values

Table 6. Excess Molar Volumes V^E for 1,3-Dioxolane (1) + 2,2,4-Trimethylpentane (2) Mixtures

x_1	(V^E) / (cm^3·mol^{-1})	x_1	(V^E) / (cm^3·mol^{-1})	x_1	(V^E) / (cm^3·mol^{-1})	x_1	(V^E) / (cm^3·mol^{-1})
			T = 288.15 K				
0.0501	0.051	0.3000	0.356	0.5500	0.374	0.8000	0.151
0.1000	0.108	0.3500	0.381	0.6000	0.342	0.8500	0.108
0.1500	0.175	0.4000	0.398	0.6500	0.294	0.9000	0.067
0.2000	0.246	0.4500	0.402	0.7000	0.248	0.9500	0.028
0.2500	0.311	0.5000	0.394	0.7500	0.197		
			T = 298.15 K				
0.0501	0.141	0.3000	0.476	0.5500	0.481	0.8000	0.236
0.1000	0.240	0.3500	0.497	0.6000	0.452	0.8500	0.176
0.1500	0.325	0.4000	0.506	0.6500	0.410	0.9000	0.115
0.2000	0.387	0.4500	0.507	0.7000	0.355	0.9500	0.062
0.2500	0.445	0.5000	0.499	0.7500	0.295		
			T = 308.15 K				
0.0501	0.209	0.3000	0.557	0.5500	0.555	0.8000	0.325
0.1000	0.329	0.3500	0.571	0.6000	0.531	0.8500	0.244
0.1500	0.423	0.4000	0.577	0.6500	0.495	0.9000	0.177
0.2000	0.482	0.4500	0.580	0.7000	0.451	0.9500	0.095
0.2500	0.528	0.5000	0.572	0.7500	0.389		

Table 7. Excess Molar Volumes V^E for 1,3-Dioxolane (1) + 2-Propanol (2) + 2,2,4-Trimethylpentane (3) Mixtures

x_1	x_2	(V^E) / (cm^3·mol^{-1})	x_1	x_2	(V^E) / (cm^3·mol^{-1})	x_1	x_2	(V^E) / (cm^3·mol^{-1})	x_1	x_2	(V^E) / (cm^3·mol^{-1})
0.0500	0.8999	0.139	0.1000	0.4501	0.677	0.3000	0.5500	0.457	0.5000	0.2500	0.536
0.0500	0.8000	0.319	0.1000	0.3500	0.718	0.3000	0.4500	0.583	0.5000	0.1501	0.579
0.0500	0.7000	0.435	0.1000	0.2501	0.706	0.3000	0.3500	0.671	0.5000	0.0500	0.555
0.0500	0.6000	0.511	0.1000	0.1500	0.613	0.3000	0.2500	0.727	0.6000	0.3500	0.264
0.0500	0.5000	0.623	0.1000	0.0500	0.420	0.3000	0.1500	0.730	0.6000	0.2500	0.390
0.0500	0.4000	0.653	0.2000	0.7500	0.247	0.3000	0.0500	0.584	0.6000	0.1500	0.452
0.0500	0.3000	0.672	0.2000	0.6500	0.435	0.4000	0.5500	0.294	0.6000	0.0500	0.451
0.0500	0.2000	0.594	0.2000	0.5500	0.613	0.4000	0.4500	0.463	0.7000	0.2500	0.240
0.0500	0.1000	0.443	0.2000	0.4500	0.670	0.4001	0.3500	0.579	0.7000	0.1500	0.317
0.0500	0.0500	0.306	0.2000	0.3500	0.725	0.4000	0.2500	0.647	0.7000	0.0500	0.348
0.1000	0.8500	0.195	0.2000	0.2500	0.748	0.4000	0.1500	0.651	0.8000	0.1500	0.178
0.1000	0.7500	0.370	0.2000	0.1500	0.711	0.4000	0.0501	0.632	0.7999	0.0501	0.215
0.1000	0.6500	0.503	0.2000	0.0500	0.531	0.5000	0.4500	0.287	0.8999	0.0500	0.109
0.1000	0.5500	0.600	0.3000	0.6500	0.303	0.5000	0.3500	0.431			

of V^E for 1,3-dioxolane + 2,2,4-trimethylpentane are larger than those for 1,3-dioxolane + 2-propanol. The V^E values are positive at all compositions. The predominant contributions to this excess property are most likely from the breaking of the hydrogen bonding interactions between alcohols and the O−O interaction between 1,3-dioxolane molecules.

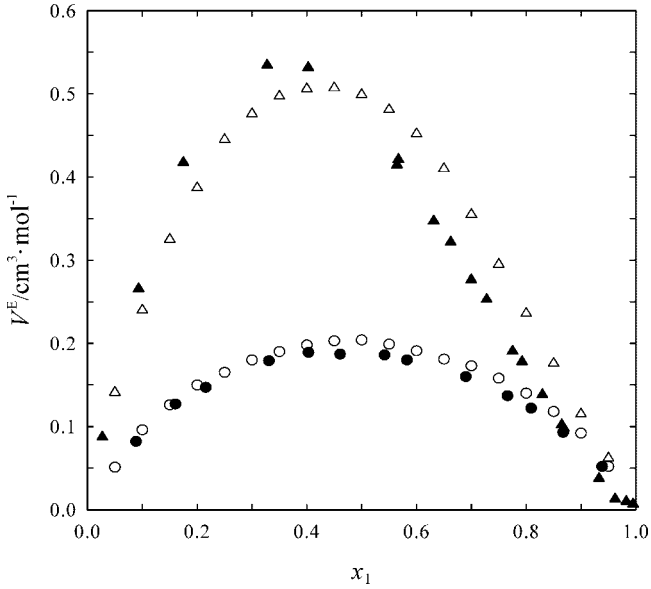

Figure 3. Variation of excess molar volume V^E with mole fraction x_1 for the binary systems at T = 298.15 K: ○, 1,3-dioxolane (1) + 2-propanol (2); ●, 1,3-dioxolane (1) + 2-propanol (2) from Calvo et al.;[1] Δ, 1,3-dioxolane (1) + 2,2,4-trimethylpentane (2); ▲, 1,3-dioxolane (1) + 2,2,4-trimethylpentane (2) from Francesconi et al.[2]

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