Excess Molar Volumes and Surface Tensions of Trimethylbenzene + Ethylene Glycol Ester at 298.15 K and 313.15 K

Jianhong Deng,[†] Yangyi Yang,*[,†] Peizi Wang,[‡] Gangfeng Ouyang,[†] and Zhongqi Huang[†]

School of Chemistry and Chemical Engineering, Sun Yat-sen University, Guangzhou 510275, China, and R&D Centre, Guangzhou Branch, China Petroleum & Chemical Corporation, Huangpu, Guangzhou 510726, China

Densities for binary systems of [1,2,4-trimethylbenzene or 1,3,5-trimethylbenzene + ethylene glycol monomethyl ether (2-methoxyethanol) or ethylene glycol dimethyl ether (1,2-dimethoxyethane)] have been determined under normal atmospheric pressure at 298.15 K and 313.15 K over the entire mole fraction range. The excess molar volumes were calculated. Surface tensions of these binary systems have been measured at 298.15 K and 313.15 K by the pendant drop method, and the values of the surface tension deviation were also derived. The excess molar volumes and the values of the surface tension deviation are fitted to the Redlich−Kister polynomial equation. The excess molar volumes for all the binary systems are positive over the whole composition range, and their surface tension deviations are negative.

Introduction

The surface tension and density of liquids and liquids mixtures are important physical properties because they play an important role in the mass and heat transfer of interface such as liquid−liquid extraction, gas absorption, distillation, and condensation. In the course of separating mixed xylene and trimethylbenzene, our group has invented a high-performance separation method named urging rectification[1] that involves adding some special solvent (named urging solvent) to the rectification system to aid light component separation. The determination of excess functions of the mixtures involved is vital for selecting the urging solvent. In previous papers, the excess molar volumes and surface tensions at 298.15 K were presented for xylene + alkone (acetone or 2-butanone), xylene + ether (isopropyl ether or methyl *tert*-butyl ether), trimethylbenzene + alkanol (1-butanol, or 2-methyl-1-propanol, 2-butanol, 2-methyl-2-propanol), trimethylbenzene + tetrahydrofuran, or tetrachloromethane, dimethyl sulfoxide.[2−5] In this paper, excess molar volumes and surface tensions for 1,2,4-trimethylbenzene or 1,3,5-trimethylbenzene + ethylene glycol monomethyl ether or ethylene glycol dimethyl ether at 298.15 K and 313.15 K are determined.

Experimental Section

Ethylene glycol monomethyl ether, ethylene glycol dimethyl ether, 1,2,4-trimethylbenzene, and 1,3,5-trimethylbenzene were commercially available (Acros Organics). All the chemicals were stored over molecular sieve before use. The mass fraction of the substances, determined by PE auto system XL gas chromatograph, were as follows: ethylene glycol monomethyl ether (99.68 %), ethylene glycol dimethyl ether (99.79 %), 1,2,4-trimethylbenzene (99.20 %), and 1,3,5-trimethylbenzene (99.30 %). The mole fraction of each mixture was obtained by the measuring masses of the components using an Ohaus E12140 balance; the uncertainty of the mole fraction is estimated to be less than ± 0.0001.

* Corresponding author. E-mail: cesyyy@mail.sysu.edu.cn or cesyyy@zsu.edu.cn.
[†] Sun Yat-sen University.
[‡] China Petroleum & Chemical Corporation.

Table 1. Physical Properties of the Pure Components

substance	ρ/g·cm^{-3} exptl	ρ/g·cm^{-3} lit	σ/mN·m^{-1} exptl	σ/mN·m^{-1} lit
T = 298.15 K				
ethylene glycol monomethyl ether	0.96002	0.96002[10]	30.88	30.82[20]
		0.96002[11]		30.82[21]
		0.96014[12]		
		0.96024[13]		
		0.96029[14]		
ethylene glycol dimethyl ether	0.86127	0.86130[12]	23.93	23.79[21]
		0.86124[15]		
		0.86132[16]		
		0.86135[17]		
1,2,4-trimethylbenzene	0.87164	0.87174[18]	29.29	29.25[5]
		0.87164[5]		29.19[20]
1,3,5-trimethylbenzene	0.86104	0.86109[19]	28.09	28.09[5]
		0.86103[5]		27.54[20]
T = 313.15 K				
ethylene glycol monomethyl ether	0.94617	0.94622[12]	29.42	29.36[20]
ethylene glycol dimethyl ether	0.84531		22.51	*a*
1,2,4-trimethylbenzene	0.85954		27.67	27.66[20]
1,3,5-trimethylbenzene	0.84874		26.82	26.20[20]

[a] The surface tensions of ethylene glycol dimethyl ether are 22.91 mN·m^{-1} at 308.15 K and 21.89 mN·m^{-1} at 318.15 K.[21]

Densities of the pure liquids and their mixture were measured with an Anton Paar DMA 4500 vibrating tube densimeter, thermostated at (298.15 ± 0.01) K and (313.15 ± 0.01) K. The uncertainty of the density is about 0.00005 g·cm^{-3}. The surface tensions of the pure liquids and their mixtures were determined by the pendant drop method, using a Dataphysics OCA20 contact angle and surface tension measuring device. This instrument provides a computer controlled display video camera (CCD) to take pictures and an electronic syringe unit to inject samples, so the surface tension of the sample can be determined rapidly. The surface tension was given by[6]

$$\sigma = \frac{g\Delta\rho d_e^2}{H} \quad (1)$$

In eq 1, g is the gravitational acceleration, $\Delta\rho$ is the density

10.1021/je050484k CCC: $33.50
Published on Web 02/22/2006

Table 2. Experimental Excess Molar Volumes V^E

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}
			$T = 298.15$ K				
			$CH_3OCH_2CH_2OH$ (x) + 1,2,4-$C_6H_3(CH_3)_3$ (1 − x)				
0.0507	0.177	0.3021	0.425	0.5513	0.423	0.7974	0.262
0.0976	0.263	0.3482	0.438	0.6035	0.400	0.8455	0.205
0.1540	0.334	0.3999	0.443	0.6526	0.375	0.9014	0.142
0.2031	0.377	0.4530	0.442	0.7033	0.341	0.9507	0.069
0.2556	0.405	0.5015	0.440	0.7534	0.302		
			$CH_3OCH_2CH_2OH$ (x) + 1,3,5-$C_6H_3(CH_3)_3$ (1 − x)				
0.0486	0.186	0.3015	0.481	0.5508	0.496	0.8008	0.318
0.0993	0.288	0.3469	0.498	0.6004	0.477	0.8501	0.259
0.1546	0.368	0.4011	0.510	0.6509	0.446	0.9001	0.182
0.2021	0.413	0.4500	0.511	0.7003	0.416	0.9502	0.095
0.2469	0.454	0.5010	0.507	0.7483	0.377		
			$CH_3OCH_2CH_2OCH_3$ (x) + 1,2,4-$C_6H_3(CH_3)_3$ (1 − x)				
0.0488	0.010	0.3006	0.037	0.5491	0.040	0.7977	0.023
0.1030	0.019	0.3515	0.039	0.6010	0.038	0.8501	0.017
0.1497	0.025	0.3980	0.041	0.6490	0.036	0.9018	0.010
0.2050	0.029	0.4492	0.041	0.6979	0.031	0.9463	0.004
0.2496	0.033	0.5005	0.041	0.7506	0.027		
			$CH_3OCH_2CH_2OCH_3$ (x) + 1,3,5-$C_6H_3(CH_3)_3$ (1 − x)				
0.0487	0.049	0.2978	0.217	0.5498	0.265	0.7999	0.180
0.0997	0.091	0.3484	0.234	0.5977	0.264	0.8474	0.136
0.1518	0.133	0.3973	0.255	0.6494	0.247	0.9008	0.100
0.2010	0.165	0.4510	0.262	0.7011	0.232	0.9484	0.051
0.2499	0.192	0.4991	0.269	0.7499	0.209		
			$T = 313.15$ K				
			$CH_3OCH_2CH_2OH$ (x) + 1,2,4-$C_6H_3(CH_3)_3$ (1 − x)				
0.0494	0.187	0.3004	0.524	0.5513	0.513	0.7999	0.315
0.1019	0.299	0.3507	0.540	0.6006	0.484	0.8496	0.245
0.1500	0.395	0.4007	0.548	0.6530	0.451	0.9007	0.179
0.2002	0.449	0.4502	0.545	0.7002	0.409	0.9504	0.109
0.2486	0.495	0.4991	0.535	0.7504	0.368		
			$CH_3OCH_2CH_2OH$ (x) + 1,3,5-$C_6H_3(CH_3)_3$ (1 − x)				
0.0518	0.226	0.3009	0.585	0.5497	0.592	0.8001	0.367
0.0979	0.348	0.3490	0.604	0.6003	0.567	0.8374	0.312
0.1489	0.440	0.3988	0.617	0.6491	0.535	0.9006	0.202
0.1980	0.505	0.4527	0.618	0.6995	0.488	0.9491	0.101
0.2497	0.552	0.5005	0.610	0.7498	0.431		
			$CH_3OCH_2CH_2OCH_3$ (x) + 1,2,4-$C_6H_3(CH_3)_3$ (1−x)				
0.0482	0.021	0.2999	0.084	0.5499	0.098	0.8000	0.059
0.1004	0.040	0.3530	0.093	0.5989	0.095	0.8503	0.043
0.1494	0.055	0.4015	0.098	0.6513	0.090	0.9008	0.031
0.1999	0.069	0.4557	0.100	0.7005	0.084	0.9493	0.011
0.2495	0.077	0.4996	0.103	0.7508	0.068		
			$CH_3OCH_2CH_2OCH_3$ (x) + 1,3,5-$C_6H_3(CH_3)_3$ (1 − x)				
0.0504	0.052	0.3000	0.229	0.5502	0.275	0.8000	0.187
0.0988	0.096	0.3495	0.245	0.5998	0.272	0.8505	0.150
0.1505	0.137	0.4000	0.262	0.6509	0.263	0.8991	0.105
0.1996	0.172	0.4498	0.270	0.6989	0.243	0.9502	0.052
0.2474	0.200	0.5002	0.281	0.7494	0.219		

Table 3. Least-Squares Parameters and Standard Deviations for Excess Molar Volumes

	A_0	A_1	A_2	A_3	A_4	σ / cm^3·mol^{-1}
			$T = 298.15$ K			
ethylene glycol monomethyl ether + 1,2,4-trimethylbenzene	1.7507	0.3293	0.3375	0.8609	0.7801	0.0046
ethylene glycol monomethyl ether + 1,3,5-trimethylbenzene	2.0337	0.2477	0.4591	0.7780	0.7783	0.0056
ethylene glycol dimethyl ether + 1,2,4-trimethylbenzene	0.1641	0.0195	−0.0074	0.0554	−0.0023	0.0007
ethylene glycol dimethyl ether + 1,3,5-trimethylbenzene	1.0757	−0.1034	−0.0042	0.1092	−0.0551	0.0028
			$T = 313.15$ K			
ethylene glycol monomethyl ether + 1,2,4-trimethylbenzene	2.1373	0.5938	0.3695	0.3826	0.8356	0.0053
ethylene glycol monomethyl ether + 1,3,5-trimethylbenzene	2.4422	0.4056	0.5606	0.9928	0.6889	0.0044
ethylene glycol dimethyl ether + 1,2,4-trimethylbenzene	0.4034	0.0068	−0.0244	0.1155	−0.0163	0.0018
ethylene glycol dimethyl ether + 1,3,5-trimethylbenzene	1.1092	−0.1174	0.0861	0.1073	−0.1201	0.0017

difference between the droplet and the surroundings, d_e is the largest diameter of the drop, and H is a correction factor, which depends on the sharp of the drop. The sharpness correction factor H is calculated by the Young−Laplace equation and is performed via the computer. The software needs only the density and a picture of the drop of liquid to calculate the surface tension. The uncertainty of the surface tension measured here is about ± 0.05 mN·m^{-1}. The densities and surface tensions of

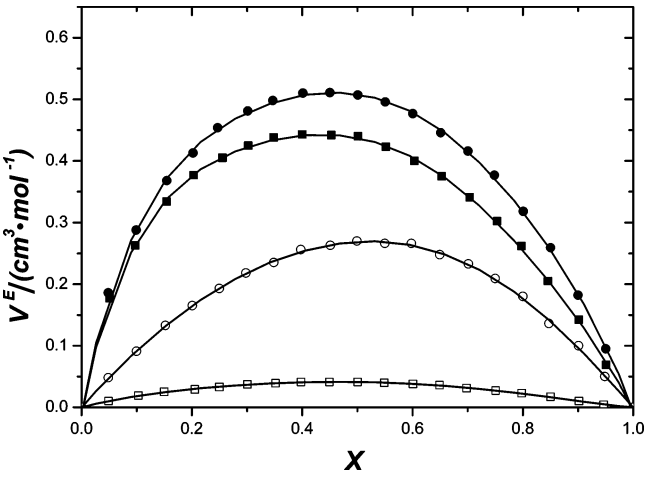

Figure 1. Excess molar volumes V^E for ethylene glycol monomethyl ether (x) + ●, 1,3,5-trimethylbenzene ($1 - x$); + ■, 1,2,4-trimethylbenzene ($1 - x$) or for ethylene glycol dimethyl ether (x) + ○, 1,3,5-trimethylbenzene ($1 - x$); + □, 1,2,4-trimethylbenzene ($1 - x$) at 298.15 K.

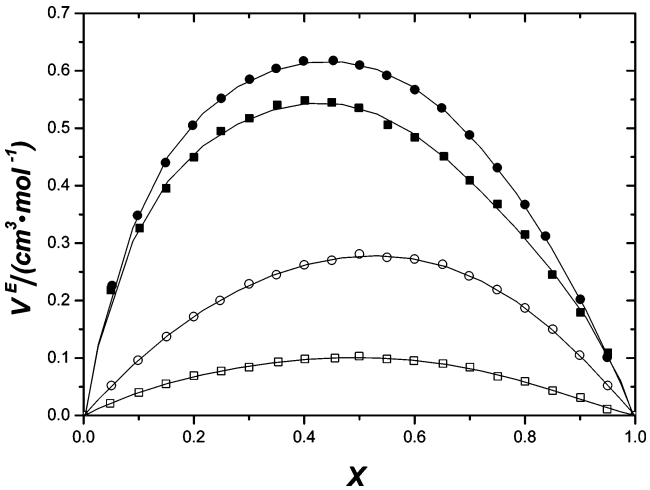

Figure 2. Excess molar volumes V^E for ethylene glycol monomethyl ether (x) + ●, 1,3,5-trimethylbenzene ($1 - x$); + ■, 1,2,4-trimethylbenzene ($1 - x$) or for ethylene glycol dimethyl ether (x) + ○, 1,3,5-trimethylbenzene ($1 - x$); + □, 1,2,4-trimethylbenzene ($1 - x$) at 313.15 K.

the pure compounds are given in Table 1 and compared with the literature values.

Result and Discussion

Excess molar volumes were determined from the density data:[7]

$$V^E = \frac{x_1 M_1 + x_2 M_2}{\rho} - x_1 \frac{M_1}{\rho_1} - x_2 \frac{M_2}{\rho_2} \quad (2)$$

where M_i is the molar mass of component i, ρ and ρ_i are the densities of the mixture and component i, and x_i is the molar fraction of component i. Experimental excess molar volumes V^E for four binary mixtures (ethylene glycol monomethyl ether + 1,2,4-trimethylbenzene, ethylene glycol monomethyl ether + 1,3,5-trimethylbenzene, ethylene glycol dimethyl ether + 1,2,4-trimethylbenzene, and ethylene glycol dimethyl ether + 1,3,5-trimethylbenzene) at 298.15 K are listed in Table 2 and graphically presented in Figure 1. The values of V^E for these mixtures at 313.15 K are listed in Table 2 and graphically presented in Figure 2. The experimental results were fitted by the method of least squares with all points weighted equally to the smoothing equation:[8]

$$V^E = x(1-x)\sum_{i=0}^{k} A_i (1-2x)^i \quad (3)$$

The parameters A_0, A_1, A_2, A_3, and A_4 and the standard deviations are given in Table 3.

Table 4. Surface Tensions σ

x_1	σ / mN·m^{-1}	$\delta\sigma$ / mN·m^{-1}	x_1	σ / mN·m^{-1}	$\delta\sigma$ / mN·m^{-1}	x_1	σ / mN·m^{-1}	$\delta\sigma$ / mN·m^{-1}	x_1	σ / mN·m^{-1}	$\delta\sigma$ / mN·m^{-1}
					$T = 298.15$ K						
	$CH_3OCH_2CH_2OH$ (x) + 1,2,4-$C_6H_3(CH_3)_3$ ($1 - x$)						$CH_3OCH_2CH_2OH$ (x) + 1,3,5-$C_6H_3(CH_3)_3$ ($1 - x$)				
0	29.29	0	0.6035	29.78	−0.474	0	28.09	0	0.6004	29.03	−0.734
0.0976	29.36	−0.089	0.7033	30.03	−0.383	0.0993	28.19	−0.179	0.7003	29.35	−0.693
0.2031	29.36	−0.248	0.7974	30.34	−0.222	0.2021	28.23	−0.428	0.8008	29.72	−0.602
0.3021	29.35	−0.417	0.9014	30.61	−0.111	0.3015	28.34	−0.587	0.9001	30.20	−0.401
0.3999	29.44	−0.486	1	30.88	0	0.4011	28.51	−0.696	1	30.88	0
0.5015	29.57	−0.515				0.5010	28.73	−0.755			
	$CH_3OCH_2CH_2OCH_3$ (x) + 1,2,4- $C_6H_3(CH_3)_3$ ($1 - x$)						$CH_3OCH_2CH_2OCH_3$ (x) + 1,3,5-$C_6H_3(CH_3)_3$ ($1 - x$)				
0	29.29	0	0.6010	25.90	−0.168	0	28.09	0	0.5977	25.35	−0.252
0.1030	28.71	−0.023	0.6979	25.42	−0.131	0.0997	27.60	−0.075	0.7011	25.00	−0.175
0.2050	28.11	−0.086	0.7977	24.92	−0.094	0.2010	27.07	−0.180	0.7999	24.67	−0.096
0.3006	27.54	−0.139	0.9018	24.41	−0.047	0.2978	26.59	−0.265	0.9008	24.30	−0.045
0.3980	26.97	−0.182	1	23.93	0	0.3973	26.14	−0.300	1	23.93	0
0.5005	26.43	−0.175				0.4991	25.71	−0.305			
					$T = 313.15$ K						
	$CH_3OCH_2CH_2OH$ (x) + 1,2,4-$C_6H_3(CH_3)_3$ ($1 - x$)						$CH_3OCH_2CH_2OH$ (x) + 1,3,5-$C_6H_3(CH_3)_3$ ($1 - x$)				
0	27.67	0	0.6006	28.03	−0.696	0	26.82	0	0.6003	27.36	−1.016
0.1019	27.78	−0.071	0.7002	28.29	−0.607	0.0979	26.93	−0.146	0.6995	27.67	−0.972
0.2002	27.72	−0.302	0.7999	28.59	−0.478	0.1980	26.91	−0.432	0.8001	28.01	−0.888
0.3004	27.72	−0.473	0.9007	28.96	−0.289	0.3009	26.97	−0.628	0.9006	28.55	−0.614
0.4007	27.79	−0.584	1	29.42	0	0.3988	27.02	−0.844	1	29.42	0
0.4991	27.84	−0.705				0.5005	27.13	−0.990			
	$CH_3OCH_2CH_2OCH_3$ (x) + 1,2,4-$C_6H_3(CH_3)_3$ ($1 - x$)						$CH_3OCH_2CH_2OCH_3$ (x) + 1,3,5-$C_6H_3(CH_3)_3$ ($1 - x$)				
0	27.67	0	0.6006	24.23	−0.348	0	26.82	0	0.5998	23.84	−0.394
0.1019	27.02	−0.133	0.7002	23.77	−0.291	0.0988	26.20	−0.189	0.6989	23.49	−0.313
0.2002	26.43	−0.206	0.7999	23.32	−0.224	0.1996	25.69	−0.268	0.8000	23.17	−0.202
0.3004	25.85	−0.269	0.9007	22.94	−0.087	0.3000	25.17	−0.357	0.8991	22.84	−0.101
0.4007	25.26	−0.342	1	22.51	0	0.4000	24.69	−0.406	1	22.51	0
0.4991	24.73	−0.365				0.5002	24.24	−0.425			

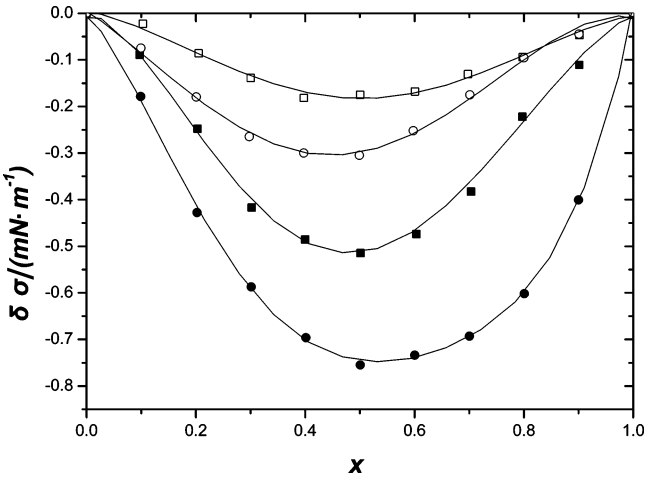

Figure 3. Surface tension deviation $\delta\sigma$ for ethylene glycol monomethyl ether (x) + ●, 1,3,5-trimethylbenzene ($1 - x$); + ■, 1,2,4-trimethylbenzene ($1 - x$) or for ethylene glycol dimethyl ether (x) + ○, 1,3,5-trimethylbenzene ($1 - x$); + □, 1,2,4-trimethylbenzene ($1 - x$) at 298.15 K.

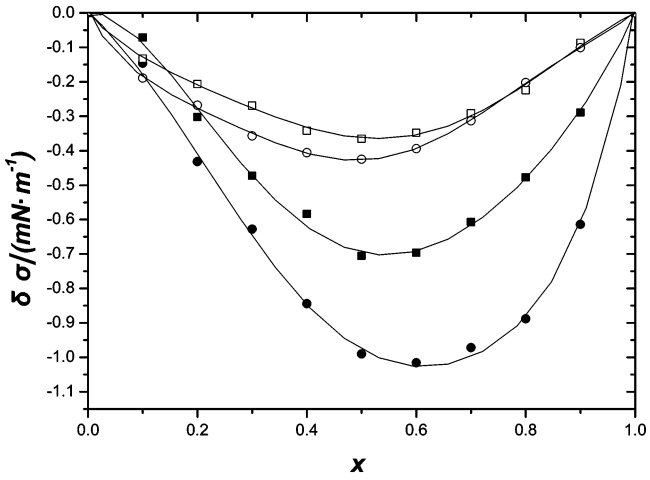

Figure 4. Surface tension deviation $\delta\sigma$ for ethylene glycol monomethyl ether (x) + ●, 1,3,5-trimethylbenzene ($1 - x$); + ■, 1,2,4-trimethylbenzene ($1 - x$) or for ethylene glycol dimethyl ether (x) + ○, 1,3,5-trimethylbenzene ($1 - x$); + □, 1,2,4-trimethylbenzene ($1 - x$) at 313.15 K.

The surface tensions σ and surface tension deviations $\delta\sigma$ for four binary mixtures (ethylene glycol monomethyl ether + 1,2,4-trimethylbenzene, ethylene glycol monomethyl ether + 1,3,5-trimethylbenzene, ethylene glycol dimethyl ether + 1,2,4-trimethylbenzene, and ethylene glycol dimethyl ether + 1,3,5-trimethylbenzene) at 298.15 K and 313.15 K are listed in Table 4. The values of surface tension deviations for these mixtures at 298.15 K and 313.15 K are graphically presented in Figure 3 and Figure 4. The surface tension deviations $\delta\sigma$ are defined by:[7]

$$\delta\sigma = \sigma - x_1\sigma_1 - x_2\sigma_2 \tag{4}$$

The surface tensions data were fitted by the method of least squares with all points weighted equally to the smoothing equation:[9]

$$\delta\sigma = x(1-x)\sum_{i=0}^{k} A_i(1-2x)^i \tag{5}$$

The parameters A_0, A_1, A_2, A_3, and A_4 and the standard deviations are given in Table 5.

Figure 1 and Figure 2 show that the V^E values are all positive for these binary mixtures at 298.15 K and 313.15 K. The maximum values of V^E for them also follow the order: ethylene glycol dimethyl ether + 1,2,4-trimethylbenzene < ethylene glycol dimethyl ether + 1,3,5-trimethylbenzene < ethylene glycol monomethyl ether + 1,2,4-trimethylbenzene < ethylene glycol monomethyl ether + 1,3,5-trimethylbenzene. At the same time, it can be seen that V^E curves are shifted in a regular way with increasing temperature (i.e., V^E becomes more positive at higher temperature).

It was suggested that V^E is the result of contributions from several opposing effects, which may be divided into three types: physical, chemical, and structural effect.[22] Figure 1 and Figure 2 show that the V^E values for ethylene glycol monomethyl ether + trimethylbenzene are more positive than those for ethylene glycol dimethyl ether + trimethylbenzene. This is probably because ethylene glycol monomethyl ether contains a hydroxyl group, which may form stronger hydrogen bonds between the ether molecules than that of the ethylene glycol dimethyl ether. After mixing with trimethylbenzene, the hydrogen bonds between ether molecules are weaken more, so the value of V^E for ethylene glycol monomethyl ether + trimethylbenzene should be more positive than that for ethylene glycol dimethyl ether + trimethylbenzene. The V^E values for 1,3,5-trimethylbenzene + ethylene glycol ethers are more positive than for 1,2,4-trimethylbenzene + ethylene glycol ethers; this is similar to our previous result of trimethylbenzene + butanol.[4]

Figure 3 and Figure 4 show that the surface tension deviations $\delta\sigma$ at 298.15 K and 313.15 K are negative for all the binary systems. The minimum values of $\delta\sigma$ follow the order: ethylene glycol monomethyl ether + 1,3,5-trimethylbenzene < ethylene glycol monomethyl ether + 1,2,4-trimethylbenzene < ethylene glycol dimethyl ether + 1,3,5-trimethylbenzene < ethylene glycol dimethyl ether + 1,2,4-trimethylbenzene. The surface tension deviations $\delta\sigma$ can be considered to be the result of two aspects: one is the surface region, and the other is the bulk region. For the surface region, the surface tension deviations indicate different distributions of unlike components between the surface and the bulk region. The negative value of $\delta\sigma$ indicates that the surface concentration of the lower surface

Table 5. Least-Squares Parameters and Standard Deviations for Surface Tensions

	A_0	A_1	A_2	A_3	A_4	$\overline{\sigma}$ / mN·m^{-1}
			$T = 298.15$ K			
ethylene glycol monomethyl ether + 1,2,4-trimethylbenzene	−2.0804	−0.2445	1.5102	0.5094	0.0797	0.0167
ethylene glycol monomethyl ether + 1,3,5-trimethylbenzene	−2.9733	0.3191	−0.6339	1.8408	0.2764	0.0102
ethylene glycol dimethyl ether + 1,2,4-trimethylbenzene	−0.7270	−0.1398	0.4521	0.5178	0.1314	0.0054
ethylene glycol dimethyl ether + 1,3,5-trimethylbenzene	−1.2041	−0.6245	1.0684	0.6065	−0.3584	0.0050
			$T = 313.15$ K			
ethylene glycol monomethyl ether + 1,2,4-trimethylbenzene	−2.7430	0.6892	0.8756	1.0791	0.3554	0.0252
ethylene glycol monomethyl ether + 1,3,5-trimethylbenzene	−3.8903	1.6131	0.1660	2.3796	−1.4021	0.0253
ethylene glycol dimethyl ether + 1,2,4-trimethylbenzene	−1.4510	0.2599	0.5629	−0.7353	−0.3854	0.0127
ethylene glycol dimethyl ether + 1,3,5-trimethylbenzene	−1.7094	−0.1093	1.0943	−0.7512	−1.4412	0.0066

tension component is higher than its bulk concentration. For the bulk region, the surface tension deviations relate to chemical effects, physical effects, and dipolar−dipolar interaction. The physical effects and dipolar−dipolar interaction make negative contribution to the surface tension deviations, and the chemical effects make positive contribution. For these binary systems, the physical effects are more dominant than the chemical effects, which results in a decrease in surface tension.[4] It can also be observed from Figure 3 and Figure 4 that $\delta\sigma$ curves are shifted in a regular way with increasing temperature (i.e., $\delta\sigma$ becomes more negative at higher temperature).

Supporting Information Available:

Density data of 1,2,4-trimethylbenzene or 1,3,5-trimethylbenzene + ethylene glycol monomethyl ether or ethylene glycol dimethyl ether at 298.15 K and 313.15 K. This material is available free of charge via the Internet at http://pubs.acs.org.

Literature Cited

(1) Zou, Y.; Li, Y.; Feng, M.; Che, G. Separating mixed xylene by urging rectification. Chinese Patent 1105898-A, CN1053386-C, 1997.

(2) Ouyang, G.; Yang, Y.; Lu, S.; Huang, Z.; Kang, B. Excess molar volumes and surface tensions of xylene with acetone or 2-butanone at 298.15 K. *J. Chem. Eng. Data* **2004**, *49*, 330−332.

(3) Ouyang, G.; Lu, G.; Pan, C.; Yang, Y.; Huang, Z.; Kang, B. Excess molar volumes and surface tensions of xylene with isopropyl ether or methyl *tert*-butyl ether at 298.15 K. *J. Chem. Eng. Data* **2004**, *49*, 732−734.

(4) Pan, C.; Ouyang, G.; Lin, J.; Rao, Y.; Zhen, X.; Lu, G.; Huang, Z. Excess molar volumes and surface tensions of 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene with 1-butanol, 2-methyl-1-propanol, 2-butanol, and 2-methyl-2-propanol at 298.15 K. *J. Chem. Eng. Data* **2004**, *49*, 1744−1747.

(5) Pan, C.; Ke, Q.; Ouyang, G.; Zhen, X.; Yang, Y.; Huang, Z. Excess molar volumes and surface tensions of trimethylbenzene with tetrahydrofuran tetrachloromethane and dimethyl sulfoxide at 298.15 K. *J. Chem. Eng. Data* **2004**, *49*, 1839−1842.

(6) Menke, T. J.; Funke, Z.; Maier, R. D.; Kressler, J. Surface tension measurements on ethene−butene random copolymers and different polypropenes. *Macromolecules* **2000**, *33*, 6120−6125.

(7) Eulogio, J.; Herminio, C.; Luisa, S.; Carlos, F. Surface tensions, refractive indexes and excess molar volumes of hexane + 1-alkanol mixtures at 298.15 K. *J. Chem. Eng. Data* **2000**, *45*, 862−866.

(8) Wang, H. J.; Zhu, C.; Chen, M. Z.; Liu, H. L. Excess volumes of (a polar liquid + an aromatic hydrocarbon) at the temperature 298.15 K. *J. Chem. Thermodyn.* **1995**, *27*, 991−996.

(9) Redlich, O.; Kister, A. Algebraic representation of thermodynamic properties and the classification of solutions. *Ind. Eng. Chem.* **1948**, *40*, 345−348.

(10) Das, B.; Hazra, D. K. Viscosities and excess molar volumes for 2-methoxy-1-ethanol + water at different temperatures. *J. Chem. Eng. Data* **1993**, *38*, 361−363.

(11) Pal, A.; Douhéret, G. Dielectric constants and densities of aqueous mixtures of 2-alkoxyethanols at 25 °C. *J. Chem. Eng. Data* **1988**, *33*, 40−43.

(12) Ohji, H.; Tamura, K. Excess enthalpies and excess volumes of (2-methoxyethanol + 1,4-dioxane) and (1,2-dimethoxyethane + benzene) at temperatures between 283.15 K and 313.15 K. *J. Chem. Thermodyn.* **2003**, *35*, 1591−1599.

(13) Riddick, J. A., Bunger, W. B., Sakano, T. K., Ed. *Techniques of Chemistry*, 4th ed.; Wiley-Interscience: New York, 1986.

(14) Kinart, C. M.; Cwiklinska, A.; Kinart, W. J.; Bald, A. Density and relative permittivity of 2-methoxyethanol + dipropylamine mixtures at various temperatures. *J. Chem. Eng. Data* **2004**, *49*, 1425−1428.

(15) Tovar, C. A.; Carballo, E.; Cerderina, C. A.; Romani, L. Excess molar volumes and excess molar heat capacities of mixtures containing (mono and poly)ethers + ethyl acetate. *J. Chem. Eng. Data* **1997**, *42*, 1085−1089.

(16) Muhuri, P. K.; Hazra, D. K. Density and viscosity for propylene carbonate + 1,2-dimethoxyethane at 298.15, 308.15, and 318.15 K. *J. Chem. Eng. Data* **1994**, *39*, 375−377.

(17) Douhéret, G.; Reis, J. C. R.; Davis, M. I.; Fjellanger, I. J.; Høiland, H. Aggregative processes in aqueous solutions of mono- to tetraethylene glycol dimethyl ether at 298.15 K. *Phys. Chem. Chem. Phys.* **2004**, *6*, 784−792.

(18) Andrzej, A. Excess volumes of (phenol + butyl benzene or propylbenzene or isopropyl benzene or 1,2,4-trimethylbenzene or ethyl benzene) at 318.15 and 348.15K. *J. Chem. Thermodyn.* **1990**, *22*, 55−60.

(19) Wilhelm, E.; Faradjzadeh, A.; Grolier, J. P. E. Molar excess heat capacities and excess volumes of 1,2-dichloroehane + cyclooctane, + mesitylene, and + terachloromethane. *J. Chem. Thermodyn.* **1979**, *11*, 979−984.

(20) *Handbook of Chemistry*, 15th ed.; Lange, N. A., Ed.; McGraw Hill: New York, 1999.

(21) Kumar, A.; Mohandas, V. P.; Ghosh, P. K. Experimental surface tensions and derived surface properties of binary mixtures of water + alkoxyethanols (C_1E_m, $m = 1, 2, 3$) and water + ethylene glycol dimethyl ether ($C_1E_1C_1$) at (298.15, 308.15, and 318.15) K. *J. Chem. Eng. Data* **2003**, *48*, 1318−1322.

(22) Treszczanowicz, A. J.; Kiyohara, O.; Benson, G. C. Excess molar volumes for *n*-alkanes binary mixtures of decan-1-ol + *n*-pentane, + *n*-hexane, + *n*-octane, + *n*-decane, and + n-hexadecane. *J. Chem. Thermodyn.* **1981**, *13*, 253−260.

Received for review November 18, 2005. Accepted January 24, 2006. The authors acknowledge the financial support of Sun Yat-sen University, the National Key Basic Research and Development Program of China (G 2000026302), and Guangdong Natural Science Foundation (04300564).

JE050484K