PROCEEDINGS OF THE YEREVAN STATE UNIVERSITY

Chemistry and Biology 2014, № 2, p. 17–25

Chemistry

DENSITIES, EXCESS MOLAR AND PARTIAL MOLAR VOLUMES FOR DIETHYLSULFOXIDE WITH METHANOL OR ETHANOL BINARY SYSTEMS AT TEMPERATURE RANGE 298.15–323.15 *K*

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Densities of binary mixtures of diethylsulfoxide with methanol or ethanol have been measured over the full range of compositions at different temperatures by means of a vibrating-tube densimeter. The excess and partial molar volumes were calculated from the density data. It has been shown that the excess molar volumes are negative over the whole range of composition and temperature and very strong molecular interactions take place between diethylsulfoxide and alkanols.

Keywords: density, diethylsulfoxide, alkanol, excess molar volume, partial molar volumes.

Introduction. This work is a continuation of our systematic study of physicochemical peculiarities of diethylsulfoxide (DESO) and its solutions [1–4]. On the other hand, the biological significance not only of dimethylsulfoxide (DMSO), but also of DESO has been recently recognized [5].

The study of volumetric properties of binary liquid mixtures is a considerable importance in understanding the nature of molecular interactions.

It should be noted that the physicochemical properties, including volumetric properties of binary mixtures of DMSO with aliphatic alcohols, have been investigated by several groups [6–11]. The dialkylsulfoxide–alcohol system is interesting owing to the fact that its components are capable to form homo- and heteroassociates [1–4, 7, 8, 10].

The present work describes the results of the density and excess molar volumes of binary mixtures of DESO with methanol and ethanol over the entire mole fraction range at temperatures from 298.15 *K* to 323.15 *K*. The results have been used in calculating excess molar volumes, partial molar volumes and their derivatives with respect to temperature. The results confirm the deviation from ideality, such as occurs in DMSO+alkanol solutions, but to a greater extent, arises from strong intermolecular interactions occurring in this system.

Materials and Methods. DESO was prepared and purified according to [12]. Its purity, tested by gas chromatography (GC), was found to be greater than 99.5 mass. %; the water content, after drying on molecular sieves, was <0.01 mass. %.

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Methanol and ethanol were purchased from "Aldrich Chemical Co" (99.7%) and preliminary dehydrated alcohols distilled two times before measuring. The densities of solutions DESO with alcohol (methanol and ethanol), as well as pure components, were measured on an Anton Paar DMA 4500 vibrating-tube densimeter in the temperature range of 298.15–323.15 *K*. The accuracy of the density and temperature measurements was $\pm1\times10^{-5} g\cdot cm^{-3}$ and ±0.01 *K* respectively. The densimeter was calibrated with dry air and doubly-distilled water.

Results and Discussions.

Densities and Excess Molar Volumes. The density (ρ) and excess molar volume (V_m^E) of DESO with methanol and ethanol at temperatures ranging from 298.15 *K* to 323.15 *K* are given in Tab. 1 and 2 respectively.

Excess molar volumes were calculated from the experimental densities by using the equation [3, 13]

$$V_m^E = (x_1M_1 + x_2M_2)/\rho - (x_1M_1/\rho_1 + x_2M_2/\rho_2), \qquad (1)$$

were M_1 and M_2 represent the molar masses of DESO and alkanol respectively, the x_1 and x_2 are molar fractions of DESO and alkanol having densities ρ_1 and ρ_2 respectively.

Table 1

Densities of DESO+alkanol binary mixtures at various temperature

x [DESO]	$\rho,\ g\cdot cm^{-3}$					
	298.15 *K*	303.15 *K*	308.15 *K*	313.15 *K*	318.15 *K*	323.15 *K*
DESO + methanol						
0.0000	0.78849	0.78378	0.77905	0.77429	0.76949	0.76465
0.0995	0.84377	0.83911	0.83443	0.82972	0.82498	0.82020
0.1994	0.89120	0.88660	0.88198	0.87733	0.87267	0.86798
0.2990	0.92220	0.91765	0.91308	0.90849	0.90388	0.89925
0.3990	0.95290	0.94448	0.93994	0.93538	0.93081	0.92621
0.4976	0.96850	0.96405	0.95960	0.95513	0.95065	0.94616
0.5989	0.98527	0.97650	0.97206	0.96761	0.96315	0.95868
0.7990	1.00332	0.99896	0.99461	0.99025	0.98588	0.98151
0.8699	1.00493	1.00058	0.99623	0.99187	0.98751	0.98314
1.0000	1.00945	1.00511	1.00077	0.99641	0.99206	0.98769
DESO + ethanol						
0.0000	0.78536	0.78105	0.77670	0.77231	0.76788	0.76340
0.0991	0.82291	0.81856	0.81417	0.80975	0.80528	0.80077
0.2001	0.85808	0.85371	0.84931	0.84488	0.84041	0.83591
0.2863	0.88410	0.88250	0.87870	0.87370	0.87000	0.86490
0.4001	0.91606	0.91169	0.90730	0.90289	0.89846	0.89401
0.4974	0.94005	0.93569	0.93131	0.92692	0.92251	0.91809
0.6009	0.96210	0.95840	0.95330	0.94830	0.94330	0.93960
0.6968	0.98010	0.97510	0.97130	0.96630	0.96260	0.95760
0.8033	0.99673	0.99239	0.98804	0.98369	0.97933	0.97497
0.8674	1.00453	1.00019	0.99585	0.99150	0.98715	0.98279
0.9474	1.00870	1.00380	1.00010	0.99500	0.99130	0.98630
1.0000	1.00945	1.00511	1.00077	0.99641	0.99206	0.98769

Table 2

Excess molar volumes for mixtures of DESO with methanol and ethanol at temperature increasing from 298.15 K to 323.15 K

M [DESO]	V_m^E, $cm^3 \cdot mol^{-1}$					
	298.15 *K*	303.15 *K*	308.15 *K*	313.15 *K*	318.15 *K*	323.15 *K*
DESO + methanol						
0.0000	0.000	0.000	0.000	0.000	0.000	0.000
0.0995	–0.340	–0.345	–0.351	–0.357	–0.363	–0.369
0.1994	–0.962	–0.975	–0.989	–1.002	–1.017	–1.032
0.2990	–1.148	–1.164	–1.179	–1.195	–1.211	–1.229
0.3990	–1.574	–1.469	–1.486	–1.504	–1.522	–1.540
0.4976	–1.566	–1.579	–1.600	–1.622	–1.644	–1.667
0.5989	–1.705	–1.378	–1.394	–1.412	–1.429	–1.449
0.7990	–1.233	–1.248	–1.264	–1.282	–1.299	–1.318
0.8699	–0.725	–0.735	–0.744	–0.755	–0.765	–0.777
1.0000	0.000	0.000	0.000	0.000	0.000	0.000
DESO + ethanol						
0.0000	0.000	0.000	0.000	0.000	0.000	0.000
0.0991	–0.044	–0.045	–0.045	–0.046	–0.046	–0.046
0.2001	–0.257	–0.261	–0.264	–0.268	–0.271	–0.275
0.2863	–0.398	–0.335	–0.389	–0.347	–0.416	–0.370
0.4001	–0.723	–0.732	–0.741	–0.751	–0.762	–0.774
0.4974	–0.981	–0.992	–1.004	–1.018	–1.032	–1.048
0.6009	–1.184	–1.256	–1.204	–1.163	–1.122	–1.204
0.6968	–1.333	–1.287	–1.354	–1.311	–1.391	–1.351
0.8033	–1.365	–1.380	–1.394	–1.411	–1.427	–1.446
0.8674	–1.247	–1.260	–1.273	–1.288	–1.302	–1.319
0.9474	–0.608	–0.557	–0.629	–0.558	–0.633	–0.573
1.0000	0.000	0.000	0.000	0.000	0.000	0.000

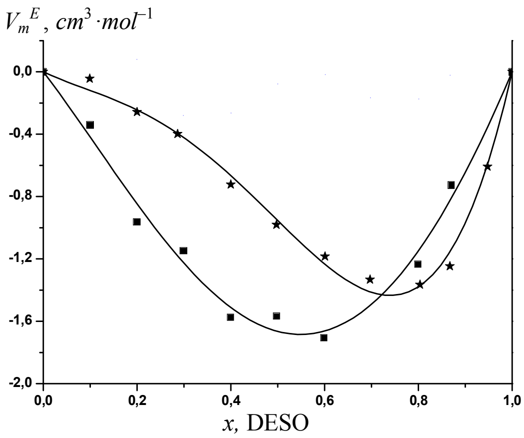

Fig. 1. Excess molar volumes, plotted against *x* (DESO) for DESO+methanol (■) and DESO+ethanol (★) mixtures at the temperature *T*=298.15 *K*.

As it follows from these data, the excess molar volumes are negative over the whole range of composition and temperature for mentioned two binary mixtures. Increase of the temperature decreases the value of V_m^E extrema, implying that the intermolecular forces between different molecules becomes less strong. It should be noted that at each temperature the minimum is slightly deeper for DESO+methanol mixtures, than for the corresponding DESO+ethanol mixtures (Fig. 1). Moreover, the temperature effect on V_m^E for DESO+methanol mixtures is much greater in comparison with DESO+ethanol mixtures. It is interesting to notice that these data well conform with those for DMSO+alkanol systems known from literature at different temperatures as well [8, 10].

Excess molar volumes were described by the Redlich–Kister polynomial equation [14]:

$$V_m^E = x_1(1-x_1)\sum_{i=0}^{n} A_i (2x_1-1)^i . \quad (2)$$

The Redlich–Kister coefficients A_i and standard deviations σ are summarized in Tab. 3. σ is evaluated from the equation

$$\sigma = \left[\sum \left(V_{\text{exp}}^E - V_{\text{calc}}^E \right)^2 / (m-n) \right]^{1/2} , \quad (3)$$

where m is the number of results and n is the number of parameters retained in Eq. (2).

Table 3

Coefficients (A_i) and standard deviations (σ) for representation of excess molar volume by the Redlich–Kister equation for mixtures of DESO with methanol and ethanol at temperature range 298.15–323.15 K

T, *K*	A_0	A_1	A_2	σ
		DESO + methanol		
298.15	–6.661	–1.569	1.176	0.104
303.15	–6.136	–1.179	–0.178	0.127
308.15	–6.210	–1.183	–0.198	0.140
313.15	–6.291	–1.206	–0.221	0.144
318.15	–6.366	–1.215	–0.245	0.147
323.15	–6.455	–1.235	–0.275	0.149
		DESO + ethanol		
298.15	–3.814	–5.903	–3.501	0.063
303.15	–3.873	–6.004	–3.138	0.081
308.15	–3.881	–6.044	–3.579	0.069
313.15	–3.834	–5.992	–3.503	0.092
318.15	–3.872	–6.044	–3.931	0.088
323.15	–3.965	–6.133	–3.534	0.091

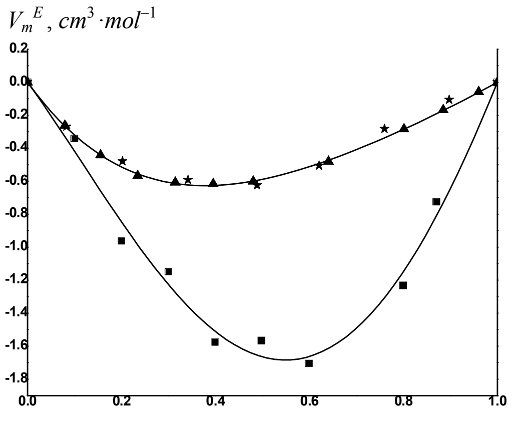

Fig. 2. Excess molar volumes plotted against *x*: DMSO+methanol (▲) [13], (★), DESO+methanol (■), at the *T*=298.15 *K*.

The effect of the ethyl group within DESO has been taken into account by lowering the excess molar volume compared with the excess molar volume of the methanolic solutions of DMSO. The V_m^E values for the (DESO+ +methanol) and (DMSO+methanol) mixtures are negative over the whole mole fraction range throughout the temperature range from 298.15 *K* to 323.15 *K*, as it is seen in Fig. 2. The greater ability of DESO to form hydrogen bonds with methanol molecules results in more negative V_m^E values in the DESO+methanol mixtures compared with those in the DMSO+methanol mixtures.

In the concentration range, where a minimum appears, the interaction of DESO (DMSO) with methanol is presumably attributed to hydrogen bonding between methanol and sulfonyl group of sulfoxides. This explanation agrees well with the fact that very strong interactions take place between DESO and methanol, even stronger than those between DMSO and methanol.

Apparent and Partial Molar Volumes. In a binary liquid mixture the apparent molar volumes $V_{\phi,1}$ and $V_{\phi,2}$ of components 1 (DESO) and 2 (methanol or ethanol) are calculated by the following equations [3]:

$$V_{\phi,1} = V_1^* - V_m^E / x_1, \qquad V_{\phi,2} = V_2^* - V_m^E / x_2, \tag{4}$$

where V_1^* and V_2^* are the molar volume of pure DESO and methanol or ethanol respectively. The data for the DESO+methanol and DESO+ethanol mixtures at temperature from 298.15 *K* to 323.15 *K* are presented in Tab. 4.

The partial molar volumes $(\overline{V}_i)$ can be determined from excess molar $\overline{V}_i^E$ volumes data using equation [10, 13]

$$\overline{V}_i = V_m^E + V_1^* + (1 - x_i)(\partial V_m^E / \partial x_i)_{T,P}, \tag{5}$$

were $(\partial V_m^E / \partial x_i)_{T,P}$ is calculated from Eq. (2), using the parameters in Tab. 3, and V_i^* represent the molar volumes of the component 1 (DESO) or 2 (alkanol).

The excess partial molar volumes $(\overline{V}_i^E)$ of a component in a binary mixture can be determined from the relation

$$\overline{V}_i^E = \overline{V}_i - V_i^*. \tag{6}$$

The partial molar volumes and excess partial molar volumes of components are given in Tab. 5. As it is seen from the data, the excess partial molar volumes of components in both DESO+methanol and DESO+ethanol mixtures mainly are negative. In addition, the excess partial molar volumes of DESO in solutions with methanol are more negative than with ethanol (Fig. 3).

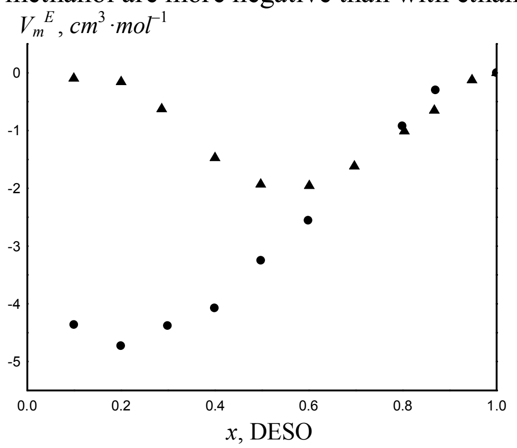

Fig. 3. Partial excess molar volumes of DESO in DESO+methanol (●) and DESO+methanol (▲) binary solutions at *T*=298.15 *K*.

Partial molar volumes at infinite dilution (V_i^∞) are considered of particular interest, because of their usefulness in examining solute–solvent interactions, as solute–solute interactions can be assumed to be eliminated at infinite dilution. At infinite dilution the partial molar volume and apparent molar volume are equal. The limiting partial molar volumes were estimated by extrapolating the apparent molar volumes to infinite dilution. The limiting partial molar volumes of DESO in both

DESO+methanol and DESO+ethanol mixtures at temperatures from 298.15 *K* to 323.15 *K* are given in Tab. 6.

Table 4

Apparent molar volumes V_ϕ ($cm^3 mol^{-1}$) for DESO and alkanols in DESO+methanol and DESO+ethanol binary solutions at temperature from 298.15 to 323.15 K

T, K	298.15	303.15	308.15	313.15	318.15	323.15
DESO + methanol						
[DESO]	$V_{\phi,1}$ **for DESO**					
0.0995	101.780	102.178	102.580	102.987	103.395	103.808
0.1994	100.372	100.759	101.150	101.547	101.940	102.336
0.2990	101.356	101.758	102.166	102.576	102.989	103.404
0.3990	101.252	101.967	102.384	102.804	103.226	103.653
0.4976	102.071	102.485	102.901	103.322	103.746	104.172
0.5989	102.350	103.350	103.781	104.215	104.653	105.095
0.7990	103.652	104.088	104.526	104.968	105.414	105.864
0.8699	104.362	104.806	105.253	105.705	106.160	106.620
[methanol]	$V_{\phi,2}$ **for methanol**					
0.9005	40.207	40.444	40.686	40.932	41.183	41.440
0.8006	39.383	39.610	39.841	40.077	40.316	40.560
0.7010	38.946	39.167	39.394	39.623	39.858	40.096
0.6010	37.726	38.383	38.603	38.826	39.054	39.287
0.5010	37.459	37.675	37.882	38.091	38.305	38.521
0.4011	36.334	37.392	37.600	37.808	38.022	38.238
0.2010	34.449	34.618	34.785	34.950	35.125	35.293
0.1301	35.007	35.180	35.355	35.524	35.703	35.876
DESO + ethanol						
[DESO]	$V_{\phi,1}$ **for DESO**					
0.0991	104.750	105.198	105.654	106.109	106.580	107.051
0.2001	103.910	104.348	104.790	105.235	105.687	106.140
0.3001	103.806	104.535	104.812	105.417	105.654	106.281
0.4001	103.390	103.822	104.257	104.695	105.136	105.580
0.4974	103.225	103.655	104.089	104.525	104.966	105.407
0.6009	103.226	103.560	104.104	104.637	105.173	105.510
0.6968	103.283	103.803	104.165	104.691	105.044	105.575
0.8033	103.496	103.933	104.373	104.816	105.264	105.714
0.8674	103.758	104.197	104.640	105.088	105.538	105.993
0.9474	104.554	105.062	105.445	105.983	106.372	106.909
[ethanol]	$V_{\phi,2}$ **for ethanol**					
0.9009	58.523	58.845	59.175	59.511	59.855	60.206
0.7999	58.250	58.569	58.895	59.227	59.567	59.913
0.7137	58.014	58.417	58.669	59.066	59.311	59.729
0.5999	57.367	57.676	57.990	58.309	58.636	58.967
0.5026	56.621	56.920	57.226	57.535	57.852	58.172
0.3991	55.606	55.748	56.207	56.647	57.094	57.241
0.3032	54.175	54.648	54.759	55.237	55.317	55.802
0.1967	51.632	51.882	52.139	52.390	52.652	52.908
0.1326	49.163	49.391	49.621	49.847	50.082	50.312
0.0526	47.011	48.308	47.275	48.950	47.881	49.367

Table 5

Partial molar volumes $\bar{V}_i$ $(cm^3 mol^{-1})$ and excess partial molar volumes $\bar{V}_i^E$ $(cm^3 mol^{-1})$ for DESO and alkanols in DESO+methanol and DESO+ethanol binary solutions at temperature from 298.15K to 323.15 K

x_1	$\bar{V}_1$	$\bar{V}_2$	$\bar{V}_1^E$	$\bar{V}_2^E$	$\bar{V}_1$	$\bar{V}_2$	$\bar{V}_1^E$	$\bar{V}_2^E$
1	2	3	4	5	6	7	8	9
DESO(1)+methanol(2)								
	T = 298.15 *K*				*T* = 303.15 *K*			
0.0000	101.281	40.584	–3.915	0.000	100.515	40.828	–5.135	0.000
0.0995	100.834	40.651	–4.362	0.068	100.792	40.913	–4.858	0.085
0.1994	100.467	39.939	–4.729	–0.645	100.826	40.200	–4.824	–0.628
0.2990	100.816	39.296	–4.380	–1.288	101.359	39.574	–4.292	–1.254
0.3990	101.121	37.933	–4.075	–2.411	101.832	38.608	–3.818	–2.220
0.4976	101.945	37.361	–3.251	–3.223	102.529	37.722	–3.121	–3.105
0.5989	102.638	36.394	–2.558	–4.190	103.506	37.118	–2.144	–3.709
0.7990	104.274	35.590	–0.922	–4.994	104.745	35.742	–0.906	–5.086
0.8699	104.897	35.879	–0.299	–4.705	105.367	35.778	–0.283	–5.050
1.0000	105.196	36.669	0.000	–3.915	105.650	35.693	0.000	–5.135
	T=308.15 *K*				*T*=313.15 *K*			
0.0000	100.883	41.076	–5.226	0.000	101.267	41.328	–5.305	0.000
0.0995	101.173	41.161	–4.935	0.085	101.570	41.415	–5.003	0.086
0.1994	101.214	40.440	–4.894	–0.636	101.616	40.684	–4.957	–0.644
0.2990	101.759	39.806	–4.349	–1.269	102.168	40.042	–4.404	–1.287
0.3990	102.244	38.830	–3.865	–2.245	102.661	39.055	–3.912	–2.273
0.4976	102.947	37.931	–3.161	–3.145	103.370	38.142	–3.203	–3.186
0.5989	103.939	37.320	–2.169	–3.755	104.376	37.525	–2.197	–3.803
0.7990	105.191	35.917	–0.917	–5.158	105.643	36.103	–0.929	–5.225
0.8699	105.822	35.950	–0.286	–5.126	106.283	36.134	–0.290	–5.194
1.0000	106.108	35.850	0.000	–5.226	106.573	36.023	0.000	–5.305
	T = 318.15 *K*				*T* = 323.15 *K*			
0.0000	101.644	41.586	–5.396	0.000	102.019	41.849	–5.495	0.000
0.0995	101.960	41.673	–5.079	0.087	102.353	41.938	–5.161	0.088
0.1994	102.014	40.932	–5.026	–0.654	102.413	41.186	–5.100	–0.663
0.2990	102.578	40.283	–4.462	–1.303	102.988	40.528	–4.525	–1.322
0.3990	103.080	39.286	–3.960	–2.300	103.502	39.520	–4.012	–2.329
0.4976	103.796	38.359	–3.244	–3.227	104.224	38.577	–3.289	–3.273
0.5989	104.816	37.736	–2.224	–3.850	105.260	37.947	–2.254	–3.902
0.7990	106.099	36.290	–0.941	–5.296	106.560	36.476	–0.954	–5.373
0.8699	106.746	36.316	–0.294	–5.270	107.216	36.498	–0.297	–5.351
1.0000	107.040	36.190	0.000	–5.396	107.513	36.354	0.000	–5.495
	T = 298.15 *K*				*T* = 303.15 *K*			
0.0000	103.785	58.572	–13.218	0.000	104.644	58.895	–1.006	0.000
0.0991	105.100	59.151	–0.096	0.579	105.754	59.462	0.104	0.567
0.2001	105.040	58.650	–0.156	0.079	105.571	58.958	–0.080	0.063
0.2863	104.568	57.991	–0.627	–0.581	105.036	58.280	–0.614	–0.615
0.4001	103.722	57.074	–1.474	–1.498	104.159	57.375	–1.491	–1.521
0.4974	103.263	56.638	–1.933	–1.934	103.690	56.934	–1.960	–1.961
0.6009	103.240	56.640	–1.956	–1.932	103.608	56.883	–2.042	–2.012
0.6968	103.576	56.927	–1.620	–1.645	104.063	57.312	–1.587	–1.583
0.8033	104.184	57.315	–1.012	–1.256	104.611	57.706	–1.039	–1.189
0.8674	104.546	57.424	–0.650	–1.148	104.975	57.887	–0.675	–1.008
0.9474	105.072	57.470	–0.124	–1.102	105.570	58.129	–0.080	–0.766
1.0000	105.196	57.161	0.000	1.411	105.650	57.889	0.000	–1.006

1	2	3	4	5	6	7	8	9
	$T = 308.15\ K$				$T = 313.15\ K$			
0.0000	104.692	59.225	–1.416	0.000	105.227	59.562	–1.345	0.000
0.0991	106.033	59.816	–0.075	0.591	106.530	60.143	–0.043	0.582
0.2001	105.967	59.304	–0.142	0.079	106.444	59.631	–0.129	0.069
0.2863	105.429	58.562	–0.679	–0.663	105.948	58.942	–0.625	–0.619
0.4001	104.608	57.693	–1.500	–1.532	105.074	58.028	–1.499	–1.534
0.4974	104.134	57.250	–1.974	–1.975	104.596	57.584	–1.976	–1.977
0.6009	104.116	57.264	–1.992	–1.960	104.630	57.654	–1.943	–1.907
0.6968	104.461	57.565	–1.647	–1.660	104.970	57.957	–1.602	–1.605
0.8033	105.075	57.961	–1.034	–1.264	105.516	58.297	–1.056	–1.264
0.8674	105.445	58.075	–0.663	–1.150	105.886	58.422	–0.687	–1.139
0.9474	105.975	58.117	–0.134	–1.108	106.503	58.571	–0.070	–0.991
1.0000	106.108	57.809	0.000	–1.416	106.573	58.216	0.000	–1.345
	$T = 318.15\ K$				$T = 323.15\ K$			
0.0000	105.281	59.905	–1.759	0.000	106.147	60.257	–1.366	0.000
0.0991	106.809	60.513	–0.231	0.608	107.459	60.853	–0.054	0.596
0.2001	106.837	59.992	–0.203	0.086	107.360	60.327	–0.153	0.070
0.2863	106.324	59.222	–0.716	–0.683	106.839	59.607	–0.675	–0.650
0.4001	105.521	58.355	–1.519	–1.550	105.959	58.677	–1.555	–1.580
0.4974	105.041	57.905	–1.999	–2.000	105.475	58.217	–2.038	–2.039
0.6009	105.133	58.029	–1.907	–1.876	105.507	58.275	–2.006	–1.981
0.6968	105.362	58.199	–1.678	–1.707	105.863	58.585	–1.650	–1.672
0.8033	105.988	58.552	–1.052	–1.354	106.431	58.941	–1.083	–1.316
0.8674	106.365	58.612	–0.675	–1.293	106.811	59.075	–0.703	–1.182
0.9474	106.915	58.563	–0.125	–1.343	107.440	59.238	–0.073	–1.018
1.0000	107.040	58.146	0.000	–1.759	107.513	58.891	0.000	–1.366

It should be noted that the temperature derivatives of thermodynamic properties often give important information. As seen in Tab. 6, the limiting partial molar volume of DESO increases with increasing temperature. In addition, the limiting partial molar volumes of DESO in methanol are less, than for cases of ethanol that is the increasing of length of alkanols hydrocarbon chain leads to increasing of limiting partial molar volume of DESO.

Table 6

Limiting partial molar volumes (V^{∞}) of DESO in binary systems with methanol or ethanol at temperature range 298.15 K to 323.15 K

T, K	V^{∞}, $cm^3\ mol^{-1}$	
	DESO + methanol	**DESO + ethanol**
298.15	101.200	103.594
303.15	101.741	104.062
308.15	102.147	104.489
313.15	102.557	104.968
318.15	102.968	105.394
323.15	103.382	105.858

Conclusion. In this paper densities of the binary mixtures of DESO with methanol or ethanol have been measured at a wide temperature range. The calculated excess molar volumes are negative at all temperatures and compositions.

Our data additionally confirm that very strong interactions take place between DESO and alkanol, even stronger than those between DMSO and alkanol. The limiting partial molar volume of DESO in alkanol solutions increases with increasing temperature and length of hydrocarbon chain of alkanol.

Received 27.02.2014

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