Physical Properties of Binary Mixtures (Dimethyl Carbonate + Alcohols) at Several Temperatures

A. Rodríguez, J. Canosa, and J. Tojo*

Chemical Engineering Department, Vigo University, 36200 Vigo, Spain

Density, refractive index on mixing, and speed of sound at 293.15 K, 298.15 K, 303.15 K, and 313.15 K and atmospheric pressure have been measured over the whole composition range for dimethyl carbonate (DMC) + methanol, ethanol, 1-propanol, 2-propanol, 1-butanol, 2-butanol, and 1-pentanol. Excess molar volumes, changes of refractive index on mixing, and deviations in isentropic compressibility for the above systems have been calculated. The Redlich−Kister equation has been used to estimate the binary fitting parameters, and root-mean-square deviations from the regression lines are shown. The excess molar volumes were fitted as a function of the mole fraction and temperature to a polynomial equation.

Introduction

The thermodynamic study of esters of carbonic acid holds considerable interest owing to their uses in industry for the synthesis of many chemicals, in pharmaceuticals, and in agricultural chemistry. Such chemicals are also used as extractive solvents.

Densities, refractive indices, and speeds of sound of homogeneous binary mixtures from 293.15 K to 313.15 K and atmospheric pressure have been measured as a continuation of the thermodynamic study[1−3] of the mixture containing dimethyl carbonate. The results were used to calculate excess molar volumes, changes of refractive index on mixing, and deviations in isentropic compressibility over the entire mole fraction range for the mixtures. Experimental values were correlated by the Redlich−Kister equation.[4] The root-mean-square deviations between experimental and calculated values are shown. Excess molar volumes were fitted as a function of the mole fraction and temperature by Romaní et al.,[5] and their root-mean-square deviations are shown.

Comparison between experimental and literature data has been made. These experimental values are novel, and there are no experiemental data available in the literature for every system at these temperatures; it is possible to find them only for dimethyl carbonate + methanol, ethanol, 1-propanol, or 1-butanol relative to the density[6,7] at 313.15 K and for dimethyl carbonate + methanol relative to density and refractive index[8] at 303.15 K. In a previous work[1] we have published the properties for the binary system dimethyl carbonate + methanol at 298.15 K.

Experimental Section

Materials. The pure components were supplied by Merck except dimethyl carbonate and 1-pentanol, which were from Fluka. They were degassed ultrasonically and dried over molecular sieves type (3 and 4) Å (supplied by Aldrich) and kept in an inert argon (with a maximum content in water of 2.14×10^{-6} by mass fraction) atmosphere. Their mass fraction purities were >99 mass % for dimethyl carbonate, >99.8 mass % for methanol, >99.9 mass % for ethanol, >99.8 mass % for 1-propanol, >99.9 mass % for 2-propanol, >99.8 mass % for 1-butanol, >99.8 mass % for 2-butanol, and >99 mass % for 1-pentanol. The solvent purities are compared with recently published values in Table 1.

Table 1. Comparison of Density ρ and Refractive Index n_D with Literature Data for Pure Components at 298.15 K

	ρ/(g·cm^{-3})		n_D	
component	exptl	lit.	exptl	lit.
dimethyl carbonate	1.0635	1.06350[a]	1.36640	1.36670[a,b]
methanol	0.7866	0.78664[c,d]	1.32645	1.32652[c,d]
ethanol	0.7850	0.78509[c,d]	1.35922	1.35941[c,d]
1-propanol	0.7995	0.79975[c] 0.79960[d]	1.38307	1.38370[c,d]
2-propanol	0.7809	0.78126[d]	1.37521	1.37520[d]
1-butanol	0.8059	0.80575[d]	1.39702	1.39741[d]
2-butanol	0.8024	0.80241[d]	1.39523	1.39530[d]
1-pentanol	0.8109	0.81080[d]	1.40789	1.40800[d]

[a] García et al.[10] [b] Pal et al.[11] [c] Das et al.[12] [d] Riddick et al.[13]

Apparatus and Procedure. The mixtures were prepared by weighing amounts of the pure liquids after they had been placed into stoppered bottles by syringe to prevent evaporation and reduce possible errors in mole fraction calculations. A Mettler AT-261 Delta Range balance was used with a precision of $\pm 10^{-5}$ g, covering the whole composition range of the mixture. The density and the speed of sound of the pure liquids and mixtures were measured with an Anton Paar DSA-48 densimeter and sound analyzer with precisions of $\pm 10^{-4}$ g·cm^{-3} and ± 1 m·s^{-1}, respectively. The refractive index was measured by automatic refractometer ABBEMAT-HP Dr Kernchen with a precision of $\pm 10.^{-5}$ Before measurements were taken, these instruments were calibrated with Millipore quality water and ambient air, respectively, in accordance with the instructions. The accuracy in the calculation of mole fraction, excess molar volumes, changes of refractive index on mixing, and deviations in isentropic compressibility were estimated as better than 10^{-4}, 10^{-2} cm^3·mol^{-1}, 5×10^{-5}, and 2 TPa^{-1}, respectively.

* Author to whom correspondence should be addressed (e-mail jtojo@uvigo.es).

10.1021/je0101193 CCC: $20.00
Published on Web 10/02/2001

Table 2. Density ρ, Refractive Index n_D, Excess Molar Volume V_m^E, Change of Refractive Index on Mixing Δn_D, Speed of Sound u, Isentropic Compressibility κ_S, and Deviation in Isentropic Compressibility $\Delta\kappa_S$ for Binary Mixtures at Several Temperatures

x	$\{\rho\}/\{(g\cdot cm^{-3})\}$	n_D	$\{u\}/\{(m\cdot s^{-1})\}$	$\{V_m^E\}/\{(cm^3\cdot mol^{-1})\}$	Δn_D	$\{\kappa_S\}/\{(TPa^{-1})\}$	$\{\Delta\kappa_S\}/\{(TPa^{-1})\}$
			Dimethyl Carbonate (1) + Methanol (2)				
			T = 293.15 K				
0	0.7912	1.32843	1119	0	0	1009	0
0.0537	0.8208	1.33300	1127	−0.009	0.0024	960	−29
0.0996	0.8438	1.33636	1134	−0.025	0.0040	922	−49
0.2058	0.8896	1.34325	1147	−0.044	0.0066	854	−77
0.3135	0.9280	1.34870	1160	−0.060	0.0078	801	−89
0.4100	0.9570	1.35305	1170	−0.064	0.0083	764	−90
0.5086	0.9825	1.35664	1180	−0.062	0.0079	731	−85
0.6104	1.0053	1.35993	1190	−0.053	0.0071	703	−75
0.7229	1.0272	1.36320	1200	−0.043	0.0059	676	−59
0.8338	1.0459	1.36574	1210	−0.022	0.0040	653	−39
0.9067	1.0569	1.36718	1215	−0.004	0.0026	641	−24
0.9509	1.0632	1.36787	1217	0.003	0.0015	635	−13
1	1.0700	1.36835	1219	0	0	629	0
			T = 303.15 K				
0	0.7818	1.32410	1086	0	0	1085	0
0.0260	0.7966	1.32646	1089	−0.034	0.0013	1058	−16
0.0707	0.8200	1.33003	1095	−0.073	0.0031	1017	−40
0.1832	0.8702	1.33761	1110	−0.085	0.0062	933	−78
0.2839	0.9071	1.34310	1121	−0.044	0.0076	878	−93
0.3823	0.9376	1.34749	1131	−0.018	0.0081	833	−98
0.4869	0.9652	1.35145	1140	−0.030	0.0079	797	−93
0.5847	0.9875	1.35460	1149	−0.049	0.0071	767	−83
0.6832	1.0071	1.35748	1157	−0.069	0.0060	741	−69
0.8119	1.0293	1.36053	1167	−0.047	0.0039	713	−46
0.8969	1.0423	1.36236	1173	0.001	0.0023	697	−28
0.9581	1.0509	1.36338	1176	0.019	0.0009	689	−12
1	1.0565	1.36414	1177	0	0	684	0
			T = 313.15 K				
0	0.7726	1.32048	1054	0	0	1166	0
0.0648	0.8066	1.32527	1061	0.007	0.0023	1102	−37
0.1008	0.8239	1.32776	1065	−0.004	0.0034	1070	−53
0.1978	0.8648	1.33385	1075	−0.020	0.0057	1000	−82
0.3027	0.9016	1.33922	1085	−0.028	0.0070	942	−96
0.3928	0.9285	1.34318	1093	−0.032	0.0074	902	−99
0.4855	0.9526	1.34668	1101	−0.037	0.0073	867	−94
0.5738	0.9727	1.34953	1108	−0.036	0.0068	838	−86
0.7009	0.9977	1.35289	1117	−0.027	0.0052	803	−67
0.7838	1.0120	1.35481	1123	−0.022	0.0039	784	−51
0.9029	1.0303	1.35748	1130	−0.016	0.0019	761	−24
0.9283	1.0338	1.35806	1131	−0.007	0.0015	757	−17
1	1.0434	1.35932	1135	0	0	744	0
			Dimethyl Carbonate (1) + Ethanol (2)				
			T = 293.15 K				
0	0.7893	1.36125	1160	0	0	941	0
0.0498	0.8086	1.36197	1163	0.032	0.0004	914	−12
0.0978	0.8265	1.36238	1166	0.056	0.0004	891	−20
0.1760	0.8540	1.36297	1169	0.104	0.0005	857	−29
0.2928	0.8924	1.36386	1174	0.137	0.0005	813	−37
0.4053	0.9264	1.36459	1180	0.152	0.0005	776	−39
0.4981	0.9524	1.36527	1186	0.161	0.0005	747	−39
0.5982	0.9786	1.36602	1191	0.167	0.0005	720	−35
0.6962	1.0026	1.36671	1199	0.168	0.0005	694	−30
0.8024	1.0271	1.36751	1207	0.151	0.0006	669	−22
0.8894	1.0464	1.36806	1213	0.103	0.0005	649	−14
0.9516	1.0597	1.36836	1217	0.058	0.0004	637	−8
1	1.0700	1.36835	1219	0	0	629	0
			T = 298.15 K				
0	0.7850	1.35922	1143	0	0	975	0
0.0598	0.8079	1.35970	1145	0.040	0.0001	944	−12
0.0950	0.8209	1.35998	1145	0.057	0.0001	929	−16
0.1692	0.8471	1.36054	1149	0.088	0.0001	894	−27
0.2725	0.8812	1.36128	1154	0.115	0.0001	852	−36
0.3854	0.9155	1.36204	1159	0.137	0.0001	813	−39
0.4778	0.9415	1.36266	1164	0.151	0.0000	784	−39
0.5686	0.9655	1.36325	1169	0.156	−0.0001	758	−36
0.6777	0.9925	1.36400	1176	0.152	−0.0001	729	−31
0.7915	1.0188	1.36478	1183	0.134	−0.0001	701	−22
0.8775	1.0377	1.36541	1189	0.097	−0.0001	682	−15
0.9366	1.0503	1.36589	1193	0.057	−0.0001	669	−9
1	1.0635	1.36640	1196	0	0	657	0

Table 2 (Continued)

x	$\{\rho\}/\{(g{\cdot}cm^{-3})\}$	n_D	$\{u\}/\{(m{\cdot}s^{-1})\}$	$\{V_m^E\}/\{(cm^3{\cdot}mol^{-1})\}$	Δn_D	$\{\kappa_S\}/\{(TPa^{-1})\}$	$\{\Delta\kappa_S\}/\{(TPa^{-1})\}$
			Dimethyl Carbonate (1) + Ethanol (2)				
			T = 303.15 K				
0	0.7807	1.35680	1126	0	0	1011	0
0.0673	0.8058	1.35749	1128	0.071	0.0002	975	−14
0.1142	0.8226	1.35795	1130	0.106	0.0003	953	−21
0.2249	0.8600	1.35868	1134	0.164	0.0002	905	−32
0.2894	0.8804	1.35908	1136	0.187	0.0002	880	−36
0.3906	0.9107	1.35975	1141	0.198	0.0001	844	−39
0.4848	0.9372	1.36038	1146	0.185	0.0000	813	−39
0.5996	0.9672	1.36123	1152	0.164	0.0000	779	−35
0.6931	0.9899	1.36189	1158	0.149	0.0000	754	−30
0.8038	1.0152	1.36265	1165	0.114	0.0000	726	−22
0.9072	1.0373	1.36334	1172	0.077	−0.0001	702	−12
0.9462	1.0454	1.36364	1174	0.053	−0.0001	694	−7
1	1.0565	1.36414	1177	0	0	684	0
			T = 313.15 K				
0	0.7721	1.35303	1093	0	0	1084	0
0.0504	0.7901	1.35307	1093	0.104	−0.0003	1059	−9
0.0934	0.8051	1.35323	1094	0.170	−0.0004	1038	−14
0.2082	0.8431	1.35387	1096	0.292	−0.0005	987	−26
0.3087	0.8742	1.35445	1099	0.341	−0.0005	947	−32
0.3930	0.8989	1.35496	1102	0.344	−0.0005	917	−34
0.5026	0.9293	1.35562	1106	0.308	−0.0006	879	−34
0.6011	0.9547	1.35626	1111	0.270	−0.0006	849	−31
0.7052	0.9798	1.35689	1116	0.223	−0.0006	819	−25
0.7968	1.0008	1.35750	1122	0.158	−0.0005	794	−19
0.9075	1.0246	1.35830	1128	0.078	−0.0004	767	−9
0.9507	1.0335	1.35881	1131	0.042	−0.0002	757	−3
1	1.0434	1.35932	1135	0	0	744	0
			Dimethyl Carbonate (1) + 1-Propanol (2)				
			T = 293.15 K				
0	0.8034	1.38494	1223	0	0	832	0
0.0508	0.8178	1.38384	1219	0.069	−0.0003	822	0
0.0875	0.8278	1.38307	1217	0.143	−0.0004	815	1
0.1647	0.8495	1.38130	1212	0.209	−0.0009	801	2
0.2944	0.8853	1.37870	1207	0.288	−0.0014	775	2
0.3858	0.9102	1.37698	1205	0.312	−0.0016	756	2
0.5440	0.9522	1.37423	1205	0.335	−0.0017	723	2
0.6026	0.9676	1.37349	1206	0.325	−0.0015	711	1
0.7041	0.9940	1.37225	1208	0.287	−0.0010	689	0
0.8900	1.0415	1.37016	1216	0.169	0.0000	649	−2
0.9015	1.0446	1.37008	1217	0.145	0.0001	647	−2
0.9510	1.0572	1.36922	1219	0.090	0.0001	637	−2
1	1.0700	1.36835	1219	0	0	629	0
			T = 298.15 K				
0	0.7995	1.38307	1206	0	0	860	0
0.0517	0.8138	1.38166	1202	0.091	−0.0005	851	2
0.0898	0.8244	1.38078	1199	0.140	−0.0008	844	3
0.1903	0.8521	1.37848	1193	0.242	−0.0014	825	4
0.2896	0.8791	1.37642	1189	0.310	−0.0018	805	4
0.3944	0.9071	1.37438	1186	0.360	−0.0021	784	4
0.4980	0.9345	1.37264	1185	0.372	−0.0021	762	4
0.5993	0.9609	1.37107	1185	0.361	−0.0020	741	3
0.7016	0.9873	1.36961	1187	0.320	−0.0018	718	1
0.8007	1.0126	1.36842	1191	0.256	−0.0013	696	−1
0.8994	1.0377	1.36741	1195	0.158	−0.0007	675	−2
0.949	1.0503	1.36690	1196	0.095	−0.0004	665	−2
1	1.0635	1.36640	1196	0	0	657	0
			T = 303.15 K				
0	0.7955	1.38104	1189	0	0	889	0
0.0728	0.8145	1.37904	1183	0.210	−0.0008	878	4
0.0829	0.8171	1.37878	1182	0.239	−0.0009	876	5
0.1840	0.8439	1.37647	1175	0.417	−0.0015	858	6
0.2605	0.8644	1.37493	1172	0.483	−0.0017	843	7
0.3758	0.8952	1.37273	1168	0.522	−0.0020	819	7
0.4849	0.9242	1.37068	1166	0.499	−0.0022	796	7
0.6278	0.9616	1.36839	1167	0.426	−0.0020	764	4
0.7071	0.9822	1.36721	1167	0.355	−0.0019	748	4
0.8061	1.0074	1.36590	1170	0.269	−0.0015	726	2
0.9018	1.0317	1.36481	1173	0.150	−0.0010	705	1
0.9507	1.0441	1.36439	1174	0.076	−0.0006	694	1
1	1.0565	1.36414	1177	0	0	684	0

Table 2 (Continued)

x	$\{\rho\}/\{(g\cdot cm^{-3})\}$	n_D	$\{u\}/\{(m\cdot s^{-1})\}$	$\{V_m^E\}/\{(cm^3\cdot mol^{-1})\}$	Δn_D	$\{\kappa_S\}/\{(TPa^{-1})\}$	$\{\Delta\kappa_S\}/\{(TPa^{-1})\}$
			Dimethyl Carbonate (1) + 1-Propanol (2)				
			$T = 313.15$ K				
0	0.7873	1.37676	1155	0	0	952	0
0.0498	0.8005	1.37526	1149	0.108	−0.0006	946	4
0.0973	0.8131	1.37396	1144	0.193	−0.0011	939	7
0.1985	0.8398	1.37156	1137	0.330	−0.0017	921	10
0.3015	0.8668	1.36913	1132	0.413	−0.0024	901	12
0.4025	0.8931	1.36713	1128	0.446	−0.0026	880	11
0.5021	0.9186	1.36544	1126	0.457	−0.0026	859	11
0.6029	0.9440	1.36383	1125	0.449	−0.0024	836	10
0.7038	0.9695	1.36233	1126	0.383	−0.0022	813	8
0.8033	0.9943	1.36119	1128	0.298	−0.0016	790	5
0.9073	1.0202	1.36009	1131	0.165	−0.0008	767	4
0.9510	1.0310	1.35975	1133	0.103	−0.0004	756	2
1	1.0434	1.35932	1135	0	0	744	0
			Dimethyl Carbonate (1) + 2-Propanol (2)				
			$T = 293.15$ K				
0	0.7849	1.37702	1156	0	0	953	0
0.0526	0.8003	1.37628	1157	0.096	−0.0003	933	−3
0.0934	0.8122	1.37559	1158	0.163	−0.0006	919	−4
0.2033	0.8441	1.37410	1161	0.302	−0.0012	879	−8
0.3129	0.8758	1.37275	1165	0.381	−0.0016	842	−10
0.4065	0.9027	1.37171	1169	0.412	−0.0018	811	−11
0.5000	0.9292	1.37089	1174	0.433	−0.0018	780	−11
0.6079	0.9596	1.37008	1182	0.422	−0.0017	746	−10
0.7026	0.9862	1.36953	1190	0.378	−0.0014	716	−10
0.8048	1.0145	1.36908	1199	0.324	−0.0010	685	−7
0.9008	1.0416	1.36873	1209	0.196	−0.0005	656	−5
0.9507	1.0558	1.36866	1215	0.108	−0.0001	642	−4
1	1.0700	1.36835	1219	0	0	629	0
			$T = 298.15$ K				
0	0.7809	1.37521	1139	0	0	987	0
0.0498	0.7951	1.37425	1139	0.118	−0.0005	969	−2
0.0979	0.8090	1.37344	1140	0.197	−0.0009	952	−3
0.2031	0.8392	1.37177	1142	0.337	−0.0017	914	−6
0.2999	0.8668	1.37070	1145	0.425	−0.0019	881	−8
0.3972	0.8945	1.36958	1149	0.465	−0.0021	847	−9
0.4892	0.9205	1.36882	1154	0.475	−0.0021	816	−10
0.5938	0.9497	1.36802	1161	0.471	−0.0020	781	−10
0.6971	0.9784	1.36735	1169	0.430	−0.0017	748	−9
0.7983	1.0067	1.36687	1178	0.333	−0.0013	716	−7
0.9012	1.0352	1.36658	1188	0.219	−0.0007	685	−5
0.9451	1.0477	1.36658	1192	0.131	−0.0003	672	−3
1	1.0635	1.36640	1196	0	0	657	0
			$T = 303.15$ K				
0	0.7766	1.37261	1122	0	0	1023	0
0.0437	0.7891	1.37185	1121	0.090	−0.0004	1008	−1
0.1028	0.8059	1.37083	1121	0.201	−0.0009	987	−2
0.2013	0.8338	1.36935	1123	0.344	−0.0016	951	−4
0.3062	0.8635	1.36810	1126	0.432	−0.0019	914	−5
0.3840	0.8854	1.36726	1129	0.469	−0.0021	886	−6
0.4951	0.9165	1.36619	1134	0.484	−0.0022	848	−7
0.5998	0.9455	1.36530	1141	0.472	−0.0022	812	−7
0.7053	0.9748	1.36451	1149	0.403	−0.0021	777	−7
0.8047	1.0022	1.36411	1158	0.315	−0.0017	744	−6
0.9062	1.0304	1.36388	1168	0.169	−0.0011	712	−3
0.9370	1.0389	1.36390	1170	0.123	−0.0008	703	−2
1	1.0565	1.36414	1177	0	0	684	0
			$T = 313.15$ K				
0	0.7678	1.36821	1086	0	0	1104	0
0.0507	0.7813	1.36705	1085	0.183	−0.0007	1087	1
0.0997	0.7946	1.36627	1084	0.317	−0.0011	1070	2
0.1984	0.8217	1.36459	1085	0.507	−0.0019	1034	2
0.2975	0.8494	1.36316	1087	0.583	−0.0024	996	0
0.4001	0.8780	1.36205	1090	0.613	−0.0026	958	−2
0.4884	0.9024	1.36121	1094	0.615	−0.0027	925	−3
0.5959	0.9321	1.36029	1100	0.569	−0.0026	886	−3
0.7017	0.9611	1.35964	1108	0.491	−0.0023	848	−3
0.8014	0.9885	1.35923	1115	0.373	−0.0019	813	−2
0.9053	1.0170	1.35893	1124	0.213	−0.0012	778	0
0.9492	1.0291	1.35916	1127	0.128	−0.0006	765	3
1	1.0434	1.35932	1135	0	0	744	0

Table 2 (Continued)

x	$\{\rho\}/\{(g\cdot cm^{-3})\}$	n_D	$\{u\}/\{(m\cdot s^{-1})\}$	$\{V_m^E\}/\{(cm^3\cdot mol^{-1})\}$	Δn_D	$\{\kappa_S\}/\{(TPa^{-1})\}$	$\{\Delta\kappa_S\}/\{(TPa^{-1})\}$
			Dimethyl Carbonate (1) + 1-Butanol (2)				
			T = 293.15 K				
0	0.8095	1.39924	1257	0	0	782	0
0.0518	0.8210	1.39733	1250	0.108	−0.0003	779	5
0.0975	0.8314	1.39569	1245	0.179	−0.0005	775	8
0.1961	0.8541	1.39235	1236	0.330	−0.0008	767	15
0.3064	0.8806	1.38871	1227	0.421	−0.0011	755	20
0.4108	0.9066	1.38540	1220	0.455	−0.0012	741	22
0.4769	0.9234	1.38338	1217	0.466	−0.0011	731	22
0.6101	0.9582	1.37936	1214	0.453	−0.0010	709	20
0.7043	0.9838	1.37675	1213	0.399	−0.0007	691	16
0.8043	1.0119	1.37383	1215	0.304	−0.0006	670	11
0.9052	1.0411	1.37111	1217	0.185	−0.0002	648	5
0.9508	1.0548	1.36984	1218	0.105	0.0000	639	2
1	1.0700	1.36835	1219	0	0	629	0
			T = 298.15 K				
0	0.8059	1.39702	1240	0	0	806	0
0.0527	0.8172	1.39530	1233	0.141	−0.0001	804	6
0.1009	0.8279	1.39362	1227	0.235	−0.0003	802	10
0.2002	0.8505	1.39014	1217	0.389	−0.0007	794	17
0.2986	0.8738	1.38688	1209	0.478	−0.0010	783	21
0.3974	0.8981	1.38369	1202	0.509	−0.0012	771	24
0.5039	0.9249	1.38031	1197	0.525	−0.0013	754	23
0.6008	0.9501	1.37739	1194	0.501	−0.0012	738	22
0.7028	0.9774	1.37442	1193	0.448	−0.0011	719	18
0.8011	1.0048	1.37165	1194	0.343	−0.0008	698	12
0.8965	1.0322	1.36918	1196	0.216	−0.0004	677	5
0.9503	1.0481	1.36778	1197	0.126	−0.0001	666	2
1	1.0635	1.36640	1196	0	0	657	0
			T = 303.15 K				
0	0.8018	1.39521	1224	0	0	833	0
0.0249	0.8072	1.39432	1220	0.053	−0.0001	832	3
0.0960	0.8227	1.39157	1211	0.203	−0.0007	829	11
0.1911	0.8442	1.38817	1200	0.342	−0.0011	823	18
0.2998	0.8696	1.38441	1190	0.447	−0.0015	812	23
0.3877	0.8909	1.38149	1184	0.483	−0.0017	801	26
0.4799	0.9138	1.37846	1179	0.497	−0.0018	788	26
0.5865	0.9411	1.37524	1175	0.474	−0.0017	770	24
0.6907	0.9686	1.37215	1173	0.420	−0.0016	750	20
0.7931	0.9966	1.36933	1173	0.326	−0.0012	729	14
0.8925	1.0248	1.36670	1175	0.191	−0.0008	707	7
0.9464	1.0406	1.36542	1176	0.096	−0.0004	695	4
1	1.0565	1.36414	1177	0	0	684	0
			T = 313.15 K				
0	0.7941	1.39090	1190	0	0	889	0
0.0499	0.8043	1.38897	1183	0.156	−0.0004	889	7
0.0998	0.8147	1.38714	1176	0.294	−0.0006	887	12
0.2234	0.8416	1.38282	1163	0.533	−0.0010	878	22
0.3000	0.8591	1.38005	1155	0.612	−0.0014	873	28
0.3991	0.8824	1.37681	1148	0.673	−0.0015	860	29
0.5054	0.9084	1.37316	1141	0.676	−0.0018	846	30
0.6030	0.9332	1.37021	1137	0.624	−0.0016	829	28
0.6904	0.9561	1.36756	1135	0.545	−0.0015	813	24
0.8009	0.9860	1.36436	1134	0.407	−0.0012	789	16
0.9014	1.0144	1.36165	1134	0.226	−0.0008	767	9
0.9471	1.0277	1.36053	1134	0.126	−0.0005	757	5
1	1.0434	1.35932	1135	0	0	744	0
			Dimethyl Carbonate (1) + 2-Butanol (2)				
			T = 293.15 K				
0	0.8067	1.39722	1230	0	0	819	0
0.0505	0.8173	1.39542	1224	0.182	−0.0003	817	7
0.0986	0.8278	1.39370	1219	0.317	−0.0007	813	13
0.2131	0.8539	1.38975	1210	0.543	−0.0013	800	22
0.2801	0.8698	1.38757	1206	0.630	−0.0016	790	25
0.4092	0.9016	1.38360	1201	0.720	−0.0018	769	27
0.5110	0.9278	1.38058	1200	0.729	−0.0019	748	26
0.6172	0.9562	1.37760	1201	0.684	−0.0018	725	23
0.7072	0.9813	1.37530	1203	0.594	−0.0015	704	19
0.7997	1.0079	1.37312	1208	0.473	−0.0010	680	13
0.8229	1.0148	1.37244	1210	0.432	−0.0010	673	10
0.9518	1.0543	1.36951	1217	0.154	−0.0002	641	3
1	1.0700	1.36835	1219	0	0	629	0

Table 2 (Continued)

x	$\{\rho\}/\{(g\cdot cm^{-3})\}$	n_D	$\{u\}/\{(m\cdot s^{-1})\}$	$\{V_m^E\}/\{(cm^3\cdot mol^{-1})\}$	Δn_D	$\{\kappa_S\}/\{(TPa^{-1})\}$	$\{\Delta\kappa_S\}/\{(TPa^{-1})\}$
Dimethyl Carbonate (1) + 2-Butanol (2)							
T = 298.15 K							
0	0.8024	1.39523	1212	0	0	849	0
0.0572	0.8143	1.39285	1204	0.210	−0.0007	847	9
0.0994	0.8234	1.39120	1200	0.333	−0.0012	844	14
0.1958	0.8451	1.38769	1191	0.532	−0.0019	834	22
0.3029	0.8703	1.38413	1185	0.671	−0.0024	818	28
0.3339	0.8778	1.38308	1183	0.698	−0.0025	814	29
0.5075	0.9214	1.37792	1179	0.754	−0.0027	780	29
0.6051	0.9472	1.37535	1180	0.716	−0.0024	759	26
0.7037	0.9743	1.37271	1182	0.628	−0.0022	735	21
0.8080	1.0040	1.37033	1186	0.494	−0.0016	708	14
0.9046	1.0332	1.36814	1191	0.278	−0.0010	682	7
0.9523	1.0481	1.36733	1194	0.152	−0.0004	669	3
1	1.0635	1.36640	1196	0	0	657	0
T = 303.15 K							
0	0.7984	1.39288	1195	0	0	877	0
0.0573	0.8104	1.39046	1187	0.188	−0.0008	876	9
0.0842	0.8161	1.38942	1184	0.271	−0.0010	874	13
0.1936	0.8402	1.38534	1174	0.525	−0.0020	864	24
0.2981	0.8645	1.38198	1167	0.662	−0.0023	850	30
0.3926	0.8872	1.37902	1163	0.744	−0.0026	833	32
0.4938	0.9126	1.37605	1161	0.758	−0.0026	813	32
0.5900	0.9377	1.37337	1160	0.719	−0.0026	792	29
0.6561	0.9554	1.37161	1161	0.673	−0.0024	776	26
0.7945	0.9942	1.36832	1166	0.488	−0.0017	740	17
0.8916	1.0230	1.36613	1170	0.280	−0.0011	714	9
0.9483	1.0403	1.36516	1174	0.143	−0.0005	698	4
1	1.0565	1.36414	1177	0	0	684	0
T = 313.15 K							
0	0.7895	1.38818	1157	0	0	946	0
0.0498	0.7992	1.38607	1151	0.230	−0.0007	945	9
0.1005	0.8094	1.38398	1145	0.432	−0.0013	943	17
0.2009	0.8309	1.38030	1135	0.697	−0.0021	935	30
0.2952	0.8522	1.37715	1128	0.850	−0.0025	923	37
0.4047	0.8782	1.37370	1123	0.927	−0.0028	902	38
0.5109	0.9048	1.37058	1121	0.906	−0.0029	879	37
0.6072	0.9297	1.36799	1121	0.850	−0.0027	856	33
0.6982	0.9543	1.36565	1122	0.734	−0.0024	832	27
0.7992	0.9827	1.36322	1125	0.554	−0.0019	804	20
0.8977	1.0116	1.36124	1129	0.327	−0.0010	776	11
0.9583	1.0303	1.35994	1132	0.136	−0.0006	758	6
1	1.0434	1.35932	1135	0	0	744	0
Dimethyl Carbonate (1) + 1-Pentanol (2)							
T = 293.15 K							
0	0.8142	1.40986	1292	0	0	736	0
0.0482	0.8227	1.40807	1285	0.155	0.0002	736	6
0.0991	0.8321	1.40609	1277	0.287	0.0003	736	11
0.1941	0.8505	1.40226	1265	0.493	0.0005	735	20
0.2974	0.8724	1.39815	1252	0.596	0.0006	731	27
0.3939	0.8943	1.39407	1242	0.638	0.0006	725	31
0.4993	0.9196	1.38981	1234	0.662	0.0007	714	31
0.6000	0.9457	1.38560	1227	0.617	0.0006	703	31
0.7013	0.9737	1.38143	1222	0.542	0.0007	688	27
0.8013	1.0035	1.37736	1220	0.412	0.0008	670	19
0.8915	1.0323	1.37337	1220	0.259	0.0005	651	10
0.9503	1.0522	1.37071	1220	0.136	0.0003	639	4
1	1.0700	1.36835	1219	0	0	629	0
T = 298.15 K							
0	0.8109	1.40789	1276	0	0	758	0
0.0457	0.8190	1.40599	1267	0.133	0.0000	760	7
0.1016	0.8293	1.40370	1259	0.267	0.0000	761	13
0.1979	0.8480	1.39972	1246	0.448	0.0000	760	22
0.3057	0.8707	1.39526	1232	0.553	0.0001	756	29
0.4024	0.8924	1.39125	1222	0.604	0.0001	750	33
0.5030	0.9164	1.38709	1213	0.621	0.0001	741	34
0.5793	0.9356	1.38395	1208	0.614	0.0001	732	33
0.7034	0.9692	1.37879	1202	0.532	0.0001	715	28
0.8003	0.9976	1.37480	1199	0.416	0.0001	697	20
0.9018	1.0296	1.37052	1198	0.248	0.0000	676	10
0.9494	1.0456	1.36854	1198	0.142	0.0000	667	5
1	1.0635	1.36640	1196	0	0	657	0

Table 2 (Continued)

x	$\{\rho\}/\{(g\cdot cm^{-3})\}$	n_D	$\{u\}/\{(m\cdot s^{-1})\}$	$\{V^E_m\}/\{(cm^3\cdot mol^{-1})\}$	Δn_D	$\{\kappa_S\}/\{(TPa^{-1})\}$	$\{\Delta\kappa_S\}/\{(TPa^{-1})\}$
			Dimethyl Carbonate (1) + 1-Pentanol (2)				
			T = 303.15 K				
0	0.8070	1.40578	1259	0	0	782	0
0.0539	0.8166	1.40350	1250	0.135	−0.00004	784	7
0.0906	0.8233	1.40190	1244	0.221	−0.00011	785	12
0.1979	0.8440	1.39743	1228	0.407	−0.00011	786	23
0.2613	0.8570	1.39484	1220	0.479	−0.00006	784	28
0.3902	0.8849	1.38942	1205	0.588	−0.00011	778	34
0.4928	0.9089	1.38520	1196	0.612	−0.00006	769	36
0.5918	0.9337	1.38109	1188	0.586	−0.00005	758	35
0.6923	0.9606	1.37678	1183	0.519	−0.00017	744	30
0.792	0.9893	1.37269	1179	0.400	−0.00011	727	23
0.8943	1.0210	1.36837	1178	0.231	−0.00017	706	12
0.9808	1.0499	1.36490	1176	0.040	−0.00004	688	3
1	1.0565	1.36414	1177	0	0	684	0
			T = 313.15 K				
0	0.7995	1.40160	1225	0	0	833	0
0.0467	0.8075	1.39970	1215	0.135	0.0001	839	10
0.1037	0.8176	1.39728	1203	0.285	0.0001	844	20
0.2514	0.8459	1.39094	1182	0.540	0.0000	846	36
0.3005	0.8560	1.38881	1177	0.590	−0.0001	844	37
0.3996	0.8771	1.38454	1166	0.683	−0.0002	839	41
0.5052	0.9014	1.38005	1156	0.703	−0.0002	830	42
0.6059	0.9263	1.37572	1148	0.665	−0.0003	819	40
0.7024	0.9518	1.37152	1142	0.586	−0.0004	805	35
0.8053	0.9811	1.36727	1138	0.442	−0.0003	787	26
0.9051	1.0117	1.36317	1135	0.253	−0.0002	767	15
0.9651	1.0313	1.36079	1133	0.112	0.0000	755	8
1	1.0434	1.35932	1135	0	0	744	0

Table 3. Parameters and Root-Mean-Square Deviations σ[a]

		Dimethyl Carbonate (1) + Methanol (2)			
		T = 293.15 K			
$V^E/(cm^3\cdot mol^{-1})$	$B_0 = -0.256$	$B_1 = 0.097$	$B_2 = 0.130$		$\sigma_a = 0.003$
Δn_D	$B_0 = 0.03180$	$B_1 = -0.00923$	$B_2 = 0.00853$		$\sigma_b = 0.00005$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = -341$	$B_1 = 161$	$B_2 = -110$		$\sigma_c = 0.4$
		T = 303.15 K			
$V^E/(cm^3\cdot mol^{-1})$	$B_0 = -0.276$	$B_1 = 0.171$			$\sigma_a = 0.003$
Δn_D	$B_0 = 0.03112$	$B_1 = -0.01229$	$B_2 = -0.00630$		$\sigma_b = 0.00005$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = -367$	$B_1 = 172$	$B_2 = -110$		$\sigma_c = 0.3$
		T = 313.15 K			
$V^E/(cm^3\cdot mol^{-1})$	$B_0 = -0.139$	$B_1 = -0.016$	$B_2 = 0.033$		$\sigma_a = 0.004$
Δn_D	$B_0 = 0.02898$	$B_1 = -0.01019$	$B_2 = -0.00095$		$\sigma_b = 0.00006$
$\Delta\kappa_S/(TPa^{1-})$	$B_0 = -373$	$B_1 = 183$	$B_2 = -91$		$\sigma_c = 0.8$
		Dimethyl Carbonate (1) + Ethanol (2)			
		T = 293.15 K			
$V^E/(cm^3\cdot mol^{-1})$	$B_0 = 0.654$	$B_1 = 0.215$	$B_2 = 0.394$		$\sigma_a = 0.004$
Δn_D	$B_0 = 0.00180$	$B_1 = 0.00023$	$B_2 = -0.00497$		$\sigma_b = 0.00004$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = -154$	$B_1 = 50$	$B_2 = -51$		$\sigma_c = 0.5$
		T = 298.15 K			
$V^E/(cm^3\cdot mol^{-1})$	$B_0 = 0.602$	$B_1 = 0.177$	$B_2 = 0.289$		$\sigma_a = 0.001$
Δn_D	$B_0 = 0.00003$	$B_1 = -0.00120$			$\sigma_b = 0.00001$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = -158$	$B_1 = 43$			$\sigma_c = 0.8$
		T = 303.15 K			
$V^E/(cm^3\cdot mol^{-1})$	$B_0 = 0.735$	$B_1 = -0.199$	$B_2 = 0.371$		$\sigma_a = 0.005$
Δn_D	$B_0 = 0.00014$	$B_1 = -0.00164$	$B_2 = 0.00117$		$\sigma_b = 0.00006$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = -154$	$B_1 = 42$	$B_2 = -31$		$\sigma_c = 0.1$
		T = 313.15 K			
$V^E/(cm^3\cdot mol^{-1})$	$B_0 = 1.263$	$B_1 = -0.682$	$B_2 = 0.345$		$\sigma_a = 0.004$
Δn_D	$B_0 = -0.00213$	$B_1 = -0.00025$	$B_2 = -0.00344$		$\sigma_b = 0.00003$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = -135$	$B_1 = 38$	$B_2 = -3$		$\sigma_c = 0.5$
		Dimethyl Carbonate (1) + 1-Propanol (2)			
		T = 293.15 K			
$V^E/(cm^3\cdot mol^{-1})$	$B_0 = 1.315$	$B_1 = 0.040$	$B_2 = 0.533$		$\sigma_a = 0.007$
Δn_D	$B_0 = -0.00680$	$B_1 = 0.00300$	$B_2 = 0.00652$		$\sigma_b = 0.00007$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = 8$	$B_1 = -19$	$B_2 = -26$		$\sigma_c = 0.4$
		T = 298.15 K			
$V^E/(cm^3\cdot mol^{-1})$	$B_0 = 1.477$	$B_1 = 0.032$	$B_2 = 0.362$		$\sigma_a = 0.004$
Δn_D	$B_0 = -0.00857$	$B_1 = 0.00100$	$B_2 = -0.00024$		$\sigma_b = 0.00003$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = 15$	$B_1 = -14$	$B_2 = -17$	$B_3 = -31$	$\sigma_c = 0.5$

Table 3 (Continued)

		Dimethyl Carbonate (1) + 1-Propanol (2)			
		$T = 303.15$ K			
$V^E/(cm^3 \cdot mol^{-1})$	$B_0 = 1.978$	$B_1 = -0.843$	$B_2 = 0.617$		$\sigma_a = 0.003$
Δn_D	$B_0 = -0.00837$	$B_1 = -0.00027$	$B_2 = -0.00382$		$\sigma_b = 0.00003$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = 24$	$B_1 = -24$	$B_2 = 14$		$\sigma_c = 0.2$
		$T = 313.15$ K			
$V^E/(cm^3 \cdot mol^{-1})$	$B_0 = 1.839$	$B_1 = -0.129$	$B_2 = 0.402$		$\sigma_a = 0.005$
Δn_D	$B_0 = -0.01042$	$B_1 = 0.00128$	$B_2 = -0.00093$		$\sigma_b = 0.00004$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = 44$	$B_1 = -23$	$B_2 = 21$		$\sigma_c = 0.3$
		Dimethyl Carbonate (1) + 2-Propanol (2)			
		$T = 293.15$ K			
$V^E/(cm^3 \cdot mol^{-1})$	$B_0 = 1.721$	$B_1 = 0.127$	$B_2 = 0.556$		$\sigma_a = 0.005$
Δn_D	$B_0 = -0.00728$	$B_1 = 0.00092$	$B_2 = 0.00202$		$\sigma_b = 0.00004$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = -44$	$B_1 = 0.3$	$B_2 = -17$		$\sigma_c = 0.4$
		$T = 298.15$ K			
$V^E/(cm^3 \cdot mol^{-1})$	$B_0 = 1.914$	$B_1 = 0.035$	$B_2 = 0.619$		$\sigma_a = 0.006$
Δn_D	$B_0 = -0.00841$	$B_1 = 0.00160$	$B_2 = -0.00114$		$\sigma_b = 0.00005$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = -39$	$B_1 = -9$	$B_2 = -9$		$\sigma_c = 0.3$
		$T = 303.15$ K			
$V^E/(cm^3 \cdot mol^{-1})$	$B_0 = 1.953$	$B_1 = -0.106$	$B_2 = 0.259$		$\sigma_a = 0.003$
Δn_D	$B_0 = -0.00897$	$B_1 = -0.00126$	$B_2 = -0.00337$		$\sigma_b = 0.00003$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = -29$	$B_1 = -10$	$B_2 = -0.7$		$\sigma_c = 0.1$
		$T = 313.15$ K			
$V^E/(cm^3 \cdot mol^{-1})$	$B_0 = 2.426$	$B_1 = -0.626$	$B_2 = 0.923$		$\sigma_a = 0.005$
Δn_D	$B_0 = -0.01070$	$B_1 = -0.00011$	$B_2 = -0.00330$		$\sigma_b = 0.00005$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = -11$	$B_1 = -22$	$B_2 = 2$	$B_3 = 22$	
	$B_4 = 68$				$\sigma_c = 0.5$
		Dimethyl Carbonate (1) + 1-Butanol (2)			
		$T = 293.15$ K			
$V^E/(cm^3 \cdot mol^{-1})$	$B_0 = 1.878$	$B_1 = -0.051$	$B_2 = 0.373$		$\sigma_a = 0.006$
Δn_D	$B_0 = 0.00452$	$B_1 = 0.00183$	$B_2 = 0.00069$		$\sigma_b = 0.00004$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = 88$	$B_1 = 21$	$B_2 = -18$		$\sigma_c = 0.3$
		$T = 298.15$ K			
$V^E/(cm^3 \cdot mol^{-1})$	$B_0 = 2.092$	$B_1 = -0.180$	$B_2 = 0.628$		$\sigma_a = 0.005$
Δn_D	$B_0 = -0.00517$	$B_1 = -0.00052$	$B_2 = 0.00168$		$\sigma_b = 0.00004$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = 95$	$B_1 = -30$	$B_2 = -14$		$\sigma_c = 0.5$
		$T = 303.15$ K			
$V^E/(cm^3 \cdot mol^{-1})$	$B_0 = 1.989$	$B_1 = -0.197$	$B_2 = 0.237$		$\sigma_a = 0.003$
Δn_D	$B_0 = -0.00721$	$B_1 = -0.00043$	$B_2 = -0.00049$		$\sigma_b = 0.00003$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = 104$	$B_1 = -24$	$B_2 = -8$		$\sigma_c = 0.2$
		Dimethyl Carbonate (1) + 1-Butanol (2)			
		$T = 313.15$ K			
$V^E/(cm^3 \cdot mol^{-1})$	$B_0 = 2.696$	$B_1 = -0.463$	$B_2 = 0.321$		$\sigma_a = 0.003$
Δn_D	$B_0 = -0.00667$	$B_1 = -0.00130$	$B_2 = -0.00130$		$\sigma_b = 0.00005$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = 120$	$B_1 = -22$	$B_2 = -4$		$\sigma_c = 0.5$
		Dimethyl Carbonate (1) + 2-Butanol (2)			
		$T = 293.15$ K			
$V^E/(cm^3 \cdot mol^{-1})$	$B_0 = 2.905$	$B_1 = -0.276$	$B_2 = 0.620$		$\sigma_a = 0.005$
Δn_D	$B_0 = -0.00762$	$B_1 = 0.00073$	$B_2 = 0.00112$		$\sigma_b = 0.00004$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = 107$	$B_1 = -42$	$B_2 = -5$		$\sigma_c = 0.5$
		$T = 298.15$ K			
$V^E/(cm^3 \cdot mol^{-1})$	$B_0 = 2.998$	$B_1 = -0.218$	$B_2 = 0.739$		$\sigma_a = 0.005$
Δn_D	$B_0 = -0.01060$	$B_1 = 0.00121$	$B_2 = -0.00206$		$\sigma_b = 0.00004$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = 117$	$B_1 = -43$	$B_2 = 1$		$\sigma_c = 0.3$
		$T = 303.15$ K			
$V^E/(cm^3 \cdot mol^{-1})$	$B_0 = 3.031$	$B_1 = -0.305$	$B_2 = 0.283$		$\sigma_a = 0.004$
Δn_D	$B_0 = -0.01056$	$B_1 = 0.00119$	$B_2 = -0.00266$		$\sigma_b = 0.00005$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = 126$	$B_1 = -41$	$B_2 = 6$		$\sigma_c = 0.2$
		$T = 313.15$ K			
$V^E/(cm^3 \cdot mol^{-1})$	$B_0 = 3.667$	$B_1 = -0.749$	$B_2 = 0.701$		$\sigma_a = 0.004$
Δn_D	$B_0 = -0.01133$	$B_1 = 0.00111$	$B_2 = -0.00270$		$\sigma_b = 0.00004$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = 149$	$B_1 = -49$	$B_2 = 15$		$\sigma_c = 0.5$
		Dimethyl Carbonate (1) + 1-Pentanol (2)			
		$T = 293.15$ K			
$V^E/(cm^3 \cdot mol^{-1})$	$B_0 = 2.618$	$B_1 = -0.362$	$B_2 = 0.603$		$\sigma_a = 0.006$
Δn_D	$B_0 = 0.00252$	$B_1 = 0.00099$	$B_2 = 0.00349$		$\sigma_b = 0.00004$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = 129$	$B_1 = -6$	$B_2 = -18$		$\sigma_c = 0.6$
		$T = 298.15$ K			
$V^E/(cm^3 \cdot mol^{-1})$	$B_0 = 2.490$	$B_1 = -0.107$	$B_2 = 0.601$		$\sigma_a = 0.004$
Δn_D	$B_0 = 0.00030$	$B_1 = 0.00029$	$B_2 = 0.00028$		$\sigma_b = 0.00001$
$\Delta\kappa_S/(TPa^{-1})$	$B_0 = 137$	$B_1 = -13$	$B_2 = -13$		$\sigma_c = 0.5$

Table 3 (Continued)

		Dimethyl Carbonate (1) + 1-Pentanol (2)		
		T = 303.15 K		
V^E/(cm^3·mol^{-1})	$B_0 = 2.440$	$B_1 = -0.097$	$B_2 = 0.147$	$\sigma_a = 0.003$
Δn_D	$B_0 = -0.00026$	$B_1 = -0.00028$	$B_2 = -0.00154$	$\sigma_b = 0.00003$
$\Delta\kappa_S$/(TPa^{-1})	$B_0 = 144$	$B_1 = -6$	$B_2 = -6$	$\sigma_c = 0.3$
		T = 313.15 K		
V^E/(cm^3·mol^{-1})	$B_0 = 2.792$	$B_1 = -0.054$	$B_2 = 0.265$	$\sigma_a = 0.006$
Δn_D	$B_0 = -0.00096$	$B_1 = -0.00155$	$B_2 = 0.00044$	$\sigma_b = 0.00003$
$\Delta\kappa_S$/(TPa^{-1})	$B_0 = 167$	$B_1 = -21$	$B_2 = 43$	$\sigma_c = 0.7$

[a] The deviation units are as follows: σ_a, (cm^3·mol^{-1}); σ_b, (without units); σ_c, (TPa^{-1}).

Table 4. Parameters and Standard Deviations (σ)[a]

			Dimethyl Carbonate (1) + Methanol (2)				
V^E/(cm^3·mol^{-1})	$A_{11} = -0.4527$	$A_{12} = -0.0129$	$A_{13} = 0.0025$	$A_{21} = 0.2682$	$A_{22} = 0.0131$	$A_{23} = -0.0024$	$\sigma_a = 0.006$
Δn_D	$A_{11} = 0.0533$	$A_{12} = 0.0003$	$A_{13} = -0.00005$	$A_{21} = -0.0305$	$A_{22} = -0.0007$	$A_{23} = 0.00007$	$\sigma_b = 0.0001$
$\Delta\kappa_S$/(TPa^{-1})	$A_{11} = -680$	$A_{12} = -4.4431$	$A_{13} = 0.0849$	$A_{21} = 443$	$A_{22} = 2.8174$	$A_{23} = 0.0292$	$\sigma_c = 1.7$
			Dimethyl Carbonate (1) + Ethanol (2)				
V^E/(cm^3·mol^{-1})	$A_{11} = 0.5810$	$A_{12} = 0.0747$	$A_{13} = 0.0040$	$A_{21} = 0.1415$	$A_{22} = -0.0981$	$A_{23} = -0.0024$	$\sigma_a = 0.012$
Δn_D	$A_{11} = 0.0033$	$A_{12} = 0.00004$	$A_{13} = -0.00003$	$A_{21} = -0.0035$	$A_{22} = -0.0004$	$A_{23} = 0.00004$	$\sigma_b = 0.0001$
$\Delta\kappa_S$/(TPa^{-1})	$A_{11} = -244$	$A_{12} = 2.0805$	$A_{13} = 0.0284$	$A_{21} = 120$	$A_{22} = -2.6401$	$A_{23} = 0.0918$	$\sigma_c = 0.8$
			Dimethyl Carbonate (1) + 1-Propanol (2)				
V^E/(cm^3·mol^{-1})	$A_{11} = 2.4134$	$A_{12} = 0.2006$	$A_{13} = -0.0139$	$A_{21} = -1.0126$	$A_{22} = -0.2009$	$A_{23} = 0.0155$	$\sigma_a = 0.028$
Δn_D	$A_{11} = -0.0097$	$A_{12} = 0.00007$	$A_{13} = -0.00002$	$A_{21} = 0.0024$	$A_{22} = -0.0006$	$A_{23} = 0.00004$	$\sigma_b = 0.0001$
$\Delta\kappa_S$/(TPa^{-1})	$A_{11} = 56$	$A_{12} = 3.8382$	$A_{13} = -0.0985$	$A_{21} = -59$	$A_{22} = -2.3575$	$A_{23} = 0.1394$	$\sigma_c = 0.7$
			Dimethyl Carbonate (1) + 2-Propanol (2)				
V^E/(cm^3·mol^{-1})	$A_{11} = 1.8792$	$A_{12} = 0.0618$	$A_{13} = 0.0044$	$A_{21} = 0.0531$	$A_{22} = -0.0571$	$A_{23} = -0.0044$	$\sigma_a = 0.020$
Δn_D	$A_{11} = -0.0092$	$A_{12} = 0.00002$	$A_{13} = -0.00001$	$A_{21} = 0.0011$	$A_{22} = -0.0004$	$A_{23} = 0.00002$	$\sigma_b = 0.0001$
$\Delta\kappa_S$/(TPa^{-1})	$A_{11} = -27$	$A_{12} = 3.9078$	$A_{13} = -0.0390$	$A_{21} = -18$	$A_{22} = -3.2387$	$A_{23} = 0.1027$	$\sigma_c = 0.8$
			Dimethyl Carbonate (1) + 1-Butanol (2)				
V^E/(cm^3·mol^{-1})	$A_{11} = 2.3181$	$A_{12} = 0.0445$	$A_{13} = 0.0026$	$A_{21} = -0.4275$	$A_{22} = -0.0417$	$A_{23} = -0.0008$	$\sigma_a = 0.020$
Δn_D	$A_{11} = -0.0058$	$A_{12} = 0.0002$	$A_{13} = -0.00001$	$A_{21} = 0.0002$	$A_{22} = -0.0006$	$A_{23} = 0.00003$	$\sigma_b = 0.0001$
$\Delta\kappa_S$/(TPa^{-1})	$A_{11} = 140$	$A_{12} = 2.6814$	$A_{13} = -0.1002$	$A_{21} = -67$	$A_{22} = -1.3981$	$A_{23} = 0.1427$	$\sigma_c = 0.7$
			Dimethyl Carbonate (1) + 2-Butanol (2)				
V^E/(cm^3·mol^{-1})	$A_{11} = 3.5180$	$A_{12} = 0.0125$	$A_{13} = 0.0066$	$A_{21} = -0.7134$	$A_{22} = -0.0033$	$A_{23} = -0.0058$	$\sigma_a = 0.017$
Δn_D	$A_{11} = -0.0126$	$A_{12} = -0.0005$	$A_{13} = 0.00003$	$A_{21} = 0.0036$	$A_{22} = 0.0002$	$A_{23} = -0.00001$	$\sigma_b = 0.0001$
$\Delta\kappa_S$/(TPa^{-1})	$A_{11} = 192$	$A_{12} = 2.0409$	$A_{13} = 0.0833$	$A_{21} = -109$	$A_{22} = 0.1255$	$A_{23} = -0.1030$	$\sigma_c = 0.5$
			Dimethyl Carbonate (1) + 1-Pentanol (2)				
V^E/(cm^3·mol^{-1})	$A_{11} = 2.8830$	$A_{12} = -0.0783$	$A_{13} = 0.0055$	$A_{21} = -0.4982$	$A_{22} = 0.0796$	$A_{23} = -0.0039$	$\sigma_a = 0.013$
Δn_D	$A_{11} = 0.00005$	$A_{12} = -0.0002$	$A_{13} = 0.00002$	$A_{21} = 0.0009$	$A_{22} = -0.0003$	$A_{23} = -0.00001$	$\sigma_b = 0.0001$
$\Delta\kappa_S$/(TPa^{-1})	$A_{11} = 147$	$A_{12} = 2.0608$	$A_{13} = 0.1615$	$A_{21} = -18$	$A_{22} = -0.5030$	$A_{23} = -0.1468$	$\sigma_c = 0.9$

[a] The deviation units are as follows: σ_a, (cm^3·mol^{-1}); σ_b, (without units); σ_c, (TPa^{-1}).

Results

Density, refractive index, speed of sound, excess molar volume, change of refractive index on mixing, isentropic compressibility (determined by means of the Laplace equation, $\kappa_S = \rho^{-1}u^{-2}$), and deviation in isentropic compressibility are reported in Table 2. Excess molar volumes, changes of refractive indices on mixing, and deviations in isentropic compressibility were derived, respectively, from

$$V^E = \sum_{i=1}^{N} x_i M_i(\rho^{-1} - \rho_i^{\circ -1}) \tag{1}$$

$$\Delta n_D = n_D - \sum_{i=1}^{N} x_i n_{Di}^{\circ} \tag{2}$$

$$\Delta\kappa_S = \kappa_S - \sum_{i=1}^{N} x_i \kappa_{S,i} \tag{3}$$

In these equations, ρ and n_D are the density and refractive index of the mixture, $\rho_i n_{Di}{}^{\circ}$and $n_{Di}{}^{\circ}$are the density and refractive index of pure components, κ_S is the isentropic compressibility of the mixture, and $\kappa_{S,i}$ is the isentropic compressibility of the pure component.

The binary values were fitted to a Redlich–Kister type equation

$$\Delta Q = x_i(1 - x_i) \sum_{p=0}^{M} B_p(x_i - x_j)^p \tag{4}$$

where ΔQ is the deviations of the properties, x is the mole fraction, B_p is the fitting parameter, and M is the degree of the polynomic expansion. By applying the F test,[9] the degree of polynomial expression was optimized. The correlation parameters calculated using eqs 4 and 5 are listed in Table 3, together with the root-mean-square deviations (σ). This deviation is calculated by applying the expression

$$\sigma = (\{\sum_{i}^{n_{DAT}} (z_{i,exp} - z_{i,calcd})^2\}/\{n_{DAT}\})^{1/2} \tag{5}$$

where property values and the number of experimental data are represented by z and n_{DAT}, respectively.

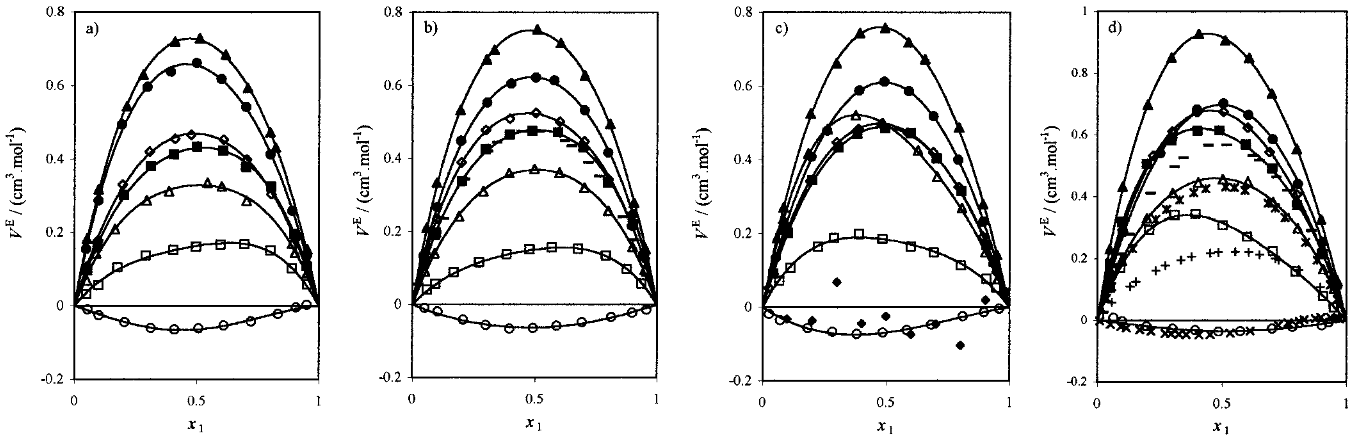

Figure 1. Curves of excess molar volumes for the following systems: ○, dimethyl carbonate + methanol; □, dimethyl carbonate + ethanol; △, dimethyl carbonate + 1-propanol; ■, dimethyl carbonate + 2-propanol; ◇, dimethyl carbonate + 1-butanol; ▲, dimethyl carbonate + 2-butanol; and ●, dimethyl carbonate + 1-pentanol at (a) 293.15 K, (b) 298.15 K, (c) 303.15 K, and (d) 313.15 K. Comparison with literature data: ×, dimethyl carbonate; + methanol, Comelli and Francesconi;[6] ◆, dimethyl carbonate + methanol, Aminabhavi and Banerjee;[8] +, dimethyl carbonate + ethanol, Comelli and Francesconi;[6] ∗, dimethyl carbonate + 1-propanol, Comelli and Francesconi;[6] and −, dimethyl carbonate + 1-butanol, Francesconi and Comelli[7].

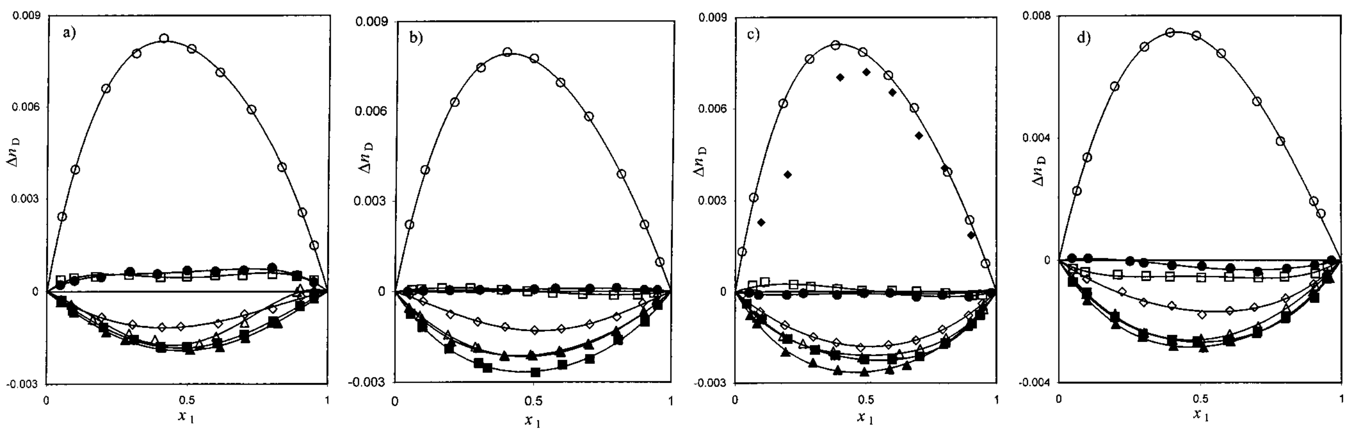

Figure 2. Curves of changes of refractive index on mixing for the following systems: ○, dimethyl carbonate + methanol; □, dimethyl carbonate + ethanol; △, dimethyl carbonate + 1-propanol; ■, dimethyl carbonate + 2-propanol; ◇, dimethyl carbonate + 1-butanol; ▲, dimethyl carbonate + 2-butanol; and ●, dimethyl carbonate + 1-pentanol at (a) 293.15 K, (b) 298.15 K, (c) 303.15 K, and (d) 313.15 K. Comparison with literature data: ◆, dimethyl carbonate + methanol, Aminabhavi and Banerjee[8].

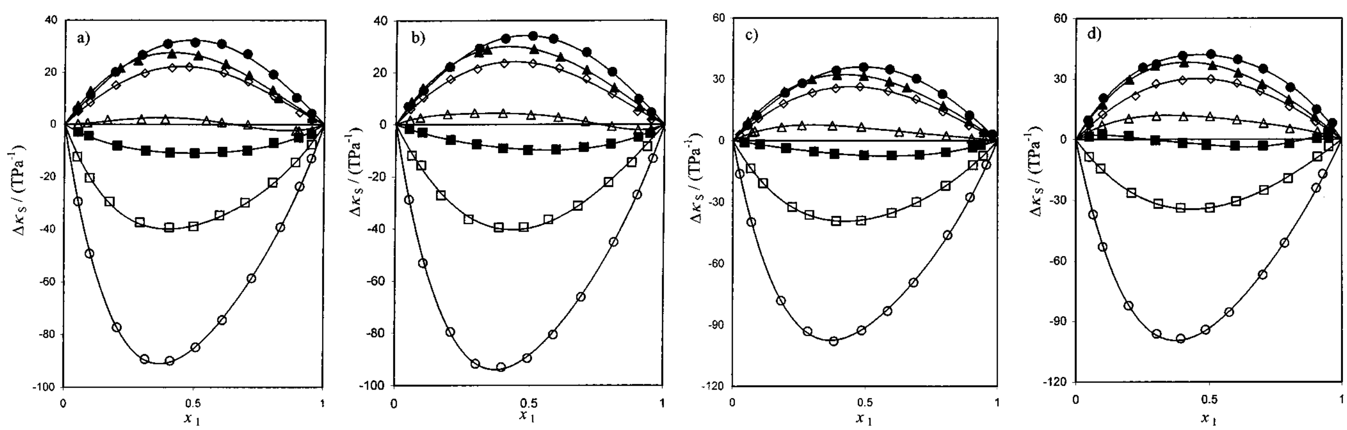

Figure 3. Curves of deviations in isentropic compressibility for the following systems: ○, dimethyl carbonate + methanol; □, dimethyl carbonate + ethanol; △, dimethyl carbonate + 1-propanol; ■, dimethyl carbonate + 2-propanol; ◇, dimethyl carbonate + 1-butanol; ▲, dimethyl carbonate + 2-butanol; and ●, dimethyl carbonate + 1-pentanol at (a) 293.15 K, (b) 298.15 K, (c) 303.15 K and (d) 313.15 K.

The excess molar volumes were fitted as a function of the mole fraction and temperature to a polynomial[5] of the form

$$V^E = x(1 - x)\sum_{i=1}^{2}\sum_{j=1}^{2} A_{ij}x^{(i-1)/2}(T - 298.15)^{j-1} \quad (6)$$

where A_{ij} and the corresponding root-mean-square deviations are given in Table 4.

Discussion

Figures 1−3 show the fitted curves, as well as excess, changes on mixing, and deviation values at 293.15 K, 298.15 K, 303.15 K, and 313.15 K for binary mixtures

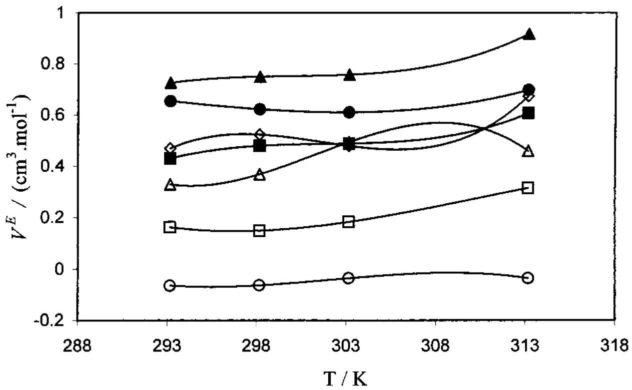

Figure 4. Curves of excess molar volumes for the following systems: ○, dimethyl carbonate + methanol; □, dimethyl carbonate + ethanol; △, dimethyl carbonate + 1-propanol; ■, dimethyl carbonate + 2-propanol; ◇, dimethyl carbonate + 1-butanol; ▲, dimethyl carbonate + 2-butanol; and ●, dimethyl carbonate + 1-pentanol versus temperature from 293.15 K to 313.15 K when the composition is equimolar.

(dimethyl carbonate + methanol, ethanol, 1-propanol, 2-propanol, 1-butanol, 2-butanol, or 1-pentanol), and comparison is made with previous literature data.[6−8] Excess molar volumes are positive in the entire composition range except for the binary mixture (dimethyl carbonate + methanol), where the excess values are negative, due to the facility of packing of methanol with the ester; this effect is the same, although the temperature is increasing. For changes of refractive index on mixing, the sign is negative for every binary mixture, except for (dimethyl carbonate + methanol, ethanol, or 1-pentanol) for 293.15 K; however, when the temperature is rising (313.15 K), only the binary mixture (dimethyl carbonate + 1-pentanol) shows positive values. For deviation in isentropic compressibility negative values are observed in the entire composition range for the binary mixtures (dimethyl carbonate + alcohol) when the length of chain of the alcohol is small; when it is larger (1-butanol, 2-butanol, or 1-pentanol), positive values are observed.

Figure 4 shows the variation of the excess molar volume with the temperature when the composition is equimolar. It must be taken into account that the sign and the magnitude of excess molar volumes are a reflection of the type of interactions taking place in the mixture. The packing effect, in the binary systems containing dimethyl carbonate + alcohols is less when the length of the chain of the alcohols and the temperature rise, probably due to the growing molecular size.

Acknowledgment

We thank Lucía Fernandez and Silvia Maceiras for technical assistance in the experimental development of the paper.

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Received for review April 9, 2001. Accepted July 19, 2001.

JE0101193