Excess Molar Volumes, Viscosities, and Refractive Indices of Diethylene Glycol Dimethyl Ether with Dimethyl Carbonate, Diethyl Carbonate, and Propylene Carbonate at (298.15, 308.15, and 318.15) K

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Excess molar volumes, viscosities, and refractive indices for the mixtures of diethylene glycol dimethyl ether + dimethyl carbonate, + diethyl carbonate, and + propylene carbonate are measured over the whole composition range at temperatures of (298.15, 308.15, and 318.15) K and 1 atm pressure. The excess volumes are fitted to the Redlich−Kister polynomial equation to obtain the binary coefficients and the standard errors.

Introduction

In recent years interest has been shown in the accumulation of thermodynamic properties of binary mixtures containing esters of carbonic acid (Muhuri and Hazra, 1995; Francesconi and Comelli, 1995a; Comelli and Francesconi, 1994; Barthel et al., 1995). In view of the importance of esters of carbonic acid as a useful solvent for resins, in the synthesis of pharmaceuticals, and in agricultural chemicals and of diethylene glycol dimethyl ether (or simply diglyme) as a sonar transducer fill fluid in underwater Navy research (Thompson, 1979), it is necessary to obtain some more experimental data on the binary mixtures of these liquids. In spite of the potential application of diethylene glycol dimethyl ether and esters of carbonic acid, there are relatively few experimental thermodynamics studies (Aminabhavi et al. 1994; Francesconi and Comelli, 1996, 1995b; Barthel et al. 1995) of this class of substances. There is no systematic study on the behavior of diethylene glycol dimethyl ether with carbonic acid esters.

In continuation of our program of research on the physicochemical properties of binary organic liquid mixtures (Pal and Singh, 1996a,b), we report here experimental excess molar volume V_m^E, viscosity η, and refractive index n_D for diethylene glycol dimethyl ether + dimethyl carbonate, + diethyl carbonate, and + propylene carbonate at (298.15, 308.15, and 318.15) K, over the whole range of mixture composition at atmospheric pressure. The aim of this work is to provide data for the characterization of the molecular interaction of these mixtures.

Experimental Section

Materials. All the chemicals used were of analytical grade and purchased from commercial sources. The manufacturer's estimates of the purity were, in each case, greater than mole fraction 0.99. Dimethyl carbonate, diethyl carbonate, and propylene carbonate were dried over calcium chloride and then fractionally distilled two times before use under reduced nitrogen gas pressure. The middle fraction was collected each time. For the purification of diethylene glycol dimethyl ether, details have been given in our earlier paper (Pal and Singh, 1996a). All liquids were stored in dark bottles to prevent contamination from air and dried over 4A molecular sieves (Fluka, AG). The purity of the solvents as found by gas−liquid chromatographic analysis was better than 99.8 mol %. The water content, measured for each sample by Karl−Fischer titration, was always found to be less than 0.002 mass %. The purity of the final sample was checked by measuring and comparing the densities, viscosities, and refractive indices at (298.15 ± 0.01) K with their corresponding literature values as shown in Table 1. The densities were measured with a bicapillary pycnometer that gave an accuracy of 5 parts in 10^5. Prior to measurements, all liquids were partially degassed under vacuum.

Table 1. Comparison of Experimental Densities (ρ), Viscosities (η), and Refractive Indices (n_D) of Pure Liquids with Literature Values at 298.15 K

liquid (source names; purity/mass %)	ρ/g·cm^{-3}		η/mPa·s		n_D	
	exptl	lit.	exptl	lit.	exptl	lit.
diethylene glycol dimethyl ether Spectrochem, Bombay; >99)	0.9321	0.939 2[a] 0.939 6[b] 0.938 4[c]	0.990	0.973[b] 0.989[c] 0.990[d]	1.4085	1.4074[b] 1.4058[c]
dimethyl carbonate (Spectrochem, Bombay >98.8)	1.0632	1.063 28[e] 1.063 30[f]	0.589		1.3710	1.3667[e]
diethyl carbonate (Sisco-Chem, Bombay; >99)	0.9690	0.969 26[e] 0.969 27[f]	0.749		1.3859	
propylene carbonate (Merck-Schuchardt; >99)	1.1988	1.198 83[g]	2.493	2.4711[g] 2.51[h]	1.4210	

[a] Dethlefsen and Hvidt (1985). [b] Aminabhavi et al. (1994). [c] Riddick et al. (1996). [d] Daubert and Danner (1992). [e] Francesconi and Comelli (1996). [f] Francesconi and Comelli (1995b). [g] Muhuri and Hazra (1995). [h] Barthel et al. (1995).

Excess volumes, which are accurate to ±0.003 cm^3·mol^{-1}, were measured using a continuous dilution dilatometer similar to that described by Dickinson et al. (1975). Details of its calibration, experimental setup, and operational procedure have been described previously (Pal and Singh,

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Table 2. Excess Molar Volumes (V_m^E) for Binary Mixtures at Various Temperatures

x_1	V_m^E/ cm^3·mol^{-1}	x_1	V_m^E/ cm^3·mol^{-1}	x_1	V_m^E/ cm^3·mol^{-1}	x_1	V_m^E/ cm^3·mol^{-1}	x_1	V_m^E/ cm^3·mol^{-1}	x_1	V_m^E/ cm^3·mol^{-1}
Diethylene Glycol Dimethyl Ether (1) + Dimethyl Carbonate (2)											
298.15 K											
0.0227	0.009	0.1513	0.060	0.2933	0.078	0.3920	0.079	0.5716	0.060	0.7886	0.028
0.0538	0.025	0.1871	0.063	0.3197	0.080	0.4290	0.074	0.6312	0.050	0.8732	0.016
0.0788	0.038	0.2289	0.070	0.3390	0.081	0.4696	0.065	0.7050	0.037	0.9333	0.009
0.1149	0.053	0.2562	0.074	0.3618	0.083	0.5148	0.064				
308.15 K											
0.0363	0.018	0.2132	0.100	0.2890	0.109	0.3676	0.105	0.4598	0.102	0.6914	0.061
0.0699	0.039	0.2323	0.103	0.3031	0.109	0.4082	0.108	0.5004	0.096	0.7574	0.043
0.1003	0.053	0.2511	0.106	0.3342	0.111	0.4130	0.105	0.5553	0.091	0.8338	0.028
0.1525	0.072	0.2748	0.108	0.3505	0.110	0.4596	0.104	0.6228	0.071	0.9439	0.008
0.2028	0.093										
318.15 K											
0.0446	0.030	0.2658	0.115	0.3416	0.119	0.4293	0.112	0.5179	0.099	0.6586	0.073
0.0838	0.056	0.2703	0.116	0.3663	0.117	0.4534	0.108	0.5287	0.096	0.7483	0.054
0.1315	0.076	0.3017	0.118	0.3878	0.116	0.4696	0.105	0.5476	0.093	0.8250	0.039
0.1773	0.096	0.3067	0.120	0.4072	0.114	0.5004	0.101	0.5871	0.085	0.9149	0.021
0.2207	0.106	0.3304	0.119								
Diethylene Glycol Dimethyl Ether (1) + Diethyl Carbonate (2)											
298.15 K											
0.0430	0.014	0.2352	0.051	0.3758	0.057	0.4922	0.058	0.6542	0.054	0.8112	0.031
0.0766	0.025	0.2782	0.051	0.3968	0.059	0.5376	0.059	0.7016	0.049	0.8585	0.024
0.1191	0.038	0.3198	0.054	0.4220	0.059	0.5910	0.059	0.7508	0.041	0.9326	0.012
0.1802	0.047	0.3554	0.055	0.4510	0.060						
308.15 K											
0.0300	0.009	0.1330	0.036	0.2687	0.068	0.3793	0.078	0.5456	0.075	0.7703	0.044
0.0409	0.013	0.1634	0.045	0.3026	0.072	0.4014	0.082	0.6058	0.066	0.8495	0.030
0.0846	0.025	0.1836	0.049	0.3356	0.075	0.4454	0.079	0.6962	0.060	0.9406	0.011
0.1140	0.031	0.2282	0.061	0.3607	0.077	0.4962	0.076				
318.15 K											
0.0227	0.013	0.2174	0.073	0.3916	0.089	0.5147	0.076	0.6239	0.061	0.7900	0.034
0.0820	0.033	0.2881	0.086	0.4347	0.085	0.5423	0.073	0.6304	0.058	0.8644	0.018
0.1325	0.052	0.3408	0.090	0.4747	0.080	0.5597	0.071	0.6960	0.049	0.9564	0.006
0.1751	0.064	0.3823	0.089	0.4809	0.079	0.5897	0.066				
Diethylene Glycol Dimethyl Ether (1) + Propylene Carbonate (2)											
298.15 K											
0.0133	−0.014	0.1675	−0.180	0.2722	−0.285	0.3577	−0.356	0.4543	−0.404	0.7000	−0.397
0.0453	−0.051	0.1986	−0.211	0.2851	−0.297	0.3709	−0.360	0.5066	−0.416	0.7726	−0.334
0.0867	−0.094	0.2354	−0.248	0.3025	−0.310	0.4014	−0.379	0.5752	−0.429	0.8643	−0.221
0.1200	−0.127	0.2641	−0.275	0.3307	−0.337	0.4244	−0.390	0.6609	−0.419	0.9505	−0.081
308.15 K											
0.0209	−0.049	0.2185	−0.455	0.3166	−0.612	0.4368	−0.727	0.5421	−0.760	0.8282	−0.474
0.0495	−0.114	0.2539	−0.513	0.3484	−0.640	0.4517	−0.733	0.6114	−0.743	0.8933	−0.324
0.0858	−0.194	0.2660	−0.534	0.3590	−0.659	0.4666	−0.741	0.6894	−0.690	0.9267	−0.229
0.1137	−0.253	0.2810	−0.554	0.3896	−0.684	0.4983	−0.756	0.7725	−0.584	0.9768	−0.076
0.1649	−0.363	0.3051	−0.588	0.4050	−0.698	0.5220	−0.763				
318.15 K											
0.0207	−0.070	0.1394	−0.362	0.2781	−0.615	0.3676	−0.733	0.5701	−0.852	0.8309	−0.505
0.0353	−0.114	0.1667	−0.415	0.2956	−0.644	0.3940	−0.760	0.6159	−0.833	0.8900	−0.342
0.0587	−0.180	0.2001	−0.484	0.3081	−0.665	0.4192	−0.784	0.6575	−0.799	0.9396	−0.193
0.0834	−0.240	0.2281	−0.531	0.3241	−0.686	0.4672	−0.819	0.7224	−0.731	0.9667	−0.101
0.1127	−0.308	0.2533	−0.575	0.3487	−0.711	0.5279	−0.850	0.7770	−0.632		

Table 3. Values of the Parameters of Eq 1 and Standard Deviation $s(V_m^E)$ at 298.15, 308.15, and 318.15 K

	T/K	a_1	a_2	a_3	a_4	$s(V_m^E)$/cm^3·mol^{-1}
diethylene glycol dimethyl ether (1) + dimethyl carbonate (2)	298.15	0.268	−0.241	0.076	0.043	0.003
	308.15	0.389	−0.336	−0.336	0.020	0.003
	318.15	0.407	−0.347	0.136	0.127	0.001
diethylene glycol dimethyl ether (1) + diethyl carbonate (2)	298.15	0.238	−0.005	0.047	−0.166	0.002
	308.15	0.313	−0.119	−0.075	0.131	0.003
	318.15	0.316	−0.247	−0.005	0.103	0.002
diethylene glycol dimethyl ether (1) + propylene carbonate (2)	298.15	−1.695	−0.536	0.215	0.183	0.004
	308.15	−3.020	−0.578	−0.105	0.044	0.003
	318.15	−3.360	−0.804	0.102	0.876	0.004

Table 4. Densities (ρ) and Viscosities (η) for Binary Mixtures at Various Temperatures

x_1	ρ/g·cm^{-3}	η/mPa·s	x_1	ρ/g·cm^{-3}	η/mPa·s	x_1	ρ/g·cm^{-3}	η/mPa·s
Diethylene Glycol Dimethyl Ether (1) + Dimethyl Carbonate (2)								
				298.15 K				
0.0000	1.0632	0.589	0.3937	0.9976	0.784	0.8944	0.9471	0.958
0.0428	1.0542	0.608	0.4775	0.9873	0.818	0.9047	0.9463	0.961
0.0832	1.0463	0.626	0.5765	0.9763	0.855	0.9232	0.9449	0.966
0.1490	1.0343	0.660	0.6623	0.9676	0.884	0.9316	0.9442	0.969
0.2102	1.0240	0.693	0.7219	0.9619	0.903	0.9372	0.9438	0.970
0.2752	1.0140	0.723	0.8014	0.9548	0.930	0.9528	0.9426	0.975
0.3253	1.0068	0.752	0.8649	0.9495	0.949	1.0000	0.9391	0.990
				308.15 K				
0.0000	1.0508	0.520	0.3937	0.9865	0.674	0.8944	0.9374	0.813
0.0428	1.0420	0.536	0.4775	0.9765	0.701	0.9047	0.9366	0.816
0.0832	1.0342	0.550	0.5765	0.9657	0.733	0.9232	0.9352	0.821
0.1490	1.0224	0.576	0.6623	0.9573	0.758	0.9316	0.9346	0.823
0.2102	1.0125	0.600	0.7219	0.9518	0.774	0.9372	0.9341	0.823
0.2752	1.0025	0.626	0.8014	0.9449	0.792	0.9528	0.9330	0.826
0.3253	0.9954	0.647	0.8649	0.9397	0.807	1.0000	0.9296	0.839
				318.15 K				
0.0000	1.0377	0.472	0.3937	0.9749	0.592	0.8944	0.9269	0.708
0.0428	1.0291	0.485	0.4775	0.9651	0.615	0.9047	0.9261	0.710
0.0832	1.0214	0.496	0.5765	0.9546	0.641	0.9232	0.9248	0.713
0.1490	1.0099	0.516	0.6623	0.9463	0.661	0.9316	0.9241	0.714
0.2102	1.0000	0.536	0.7219	0.9409	0.675	0.9372	0.9237	0.715
0.2752	0.9905	0.556	0.8014	0.9342	0.691	0.9528	0.9226	0.718
0.3253	0.9836	0.571	0.8649	0.9291	0.702	1.0000	0.9193	0.728
Diethylene Glycol Dimethyl Ether (1) + Diethyl Carbonate (2)								
				298.15 K				
0.0000	0.9690	0.749	0.3935	0.9557	0.849	0.7618	0.9451	0.933
0.0487	0.9672	0.761	0.4303	0.9545	0.857	0.8134	0.9438	0.945
0.0871	0.9658	0.774	0.4835	0.9529	0.870	0.8478	0.9429	0.952
0.1367	0.9640	0.787	0.5570	0.9508	0.886	0.9380	0.9406	0.970
0.1800	0.9625	0.798	0.6202	0.9490	0.899	0.9718	0.9398	0.979
0.2621	0.9598	0.817	0.6549	0.9480	0.907	0.9927	0.9393	0.987
0.3060	0.9584	0.828	0.7104	0.9465	0.920	1.0000	0.9391	0.990
				308.15 K				
0.0000	0.9577	0.658	0.3935	0.9450	0.731	0.7618	0.9352	0.799
0.0487	0.9560	0.669	0.4303	0.9439	0.739	0.8134	0.9340	0.809
0.0871	0.9547	0.674	0.4835	0.9425	0.747	0.8478	0.9331	0.814
0.1367	0.9530	0.680	0.5570	0.9405	0.766	0.9380	0.9310	0.825
0.1800	0.9516	0.687	0.6202	0.9388	0.772	0.9718	0.9302	0.832
0.2621	0.9490	0.706	0.6549	0.9379	0.783	0.9927	0.9298	0.837
0.3060	0.9476	0.713	0.7104	0.9365	0.790	1.0000	0.9296	0.839
				318.15 K				
0.0000	0.9438	0.578	0.3935	0.9326	0.640	0.7618	0.9242	0.695
0.0487	0.9423	0.572	0.4303	0.9317	0.652	0.8134	0.9231	0.702
0.0871	0.9411	0.593	0.4835	0.9305	0.656	0.8478	0.9224	0.707
0.1367	0.9396	0.600	0.5570	0.9288	0.665	0.9380	0.9206	0.719
0.1800	0.9383	0.607	0.6202	0.9273	0.674	0.9718	0.9199	0.725
0.2621	0.9360	0.618	0.6549	0.9266	0.679	0.9927	0.9194	0.727
0.3060	0.9349	0.626	0.7104	0.9253	0.687	1.0000	0.9193	0.728
Diethylene Glycol Dimethyl Ether (1) + Propylene Carbonate (2)								
				298.15 K				
0.0000	1.1988	2.493	0.3441	1.0807	1.782	0.8341	0.9685	1.148
0.0210	1.1901	2.427	0.3815	1.0704	1.719	0.8725	0.9614	1.107
0.0421	1.1816	2.372	0.4148	1.0615	1.669	0.9275	0.9515	1.060
0.0759	1.1684	2.295	0.4853	1.0436	1.573	0.9513	0.9474	1.035
0.0976	1.1603	2.245	0.5455	1.0291	1.488	0.9796	0.9425	1.005
0.1779	1.1319	2.081	0.6708	1.0012	1.324	1.0000	0.9391	0.990
0.2468	1.1096	1.953	0.7643	0.9820	1.223			
				308.15 K				
0.0000	1.1897	2.041	0.3441	1.0743	1.458	0.8341	0.9605	0.959
0.0210	1.1814	2.000	0.3815	1.0640	1.412	0.8725	0.9531	0.928
0.0421	1.1732	1.940	0.4148	1.0550	1.362	0.9275	0.9428	0.889
0.0759	1.1605	1.870	0.4853	1.0370	1.291	0.9513	0.9384	0.874
0.0976	1.1526	1.835	0.5455	1.0224	1.226	0.9796	0.9333	0.852
0.1779	1.1249	1.693	0.6708	0.9940	1.101	1.0000	0.9296	0.829
0.2468	1.1029	1.595	0.7643	0.9744	1.017			
				318.15 K				
0.0000	1.1780	1.718	0.3441	1.0637	1.216	0.8341	0.9501	0.829
0.0210	1.1699	1.666	0.3815	1.0534	1.176	0.8725	0.9426	0.804
0.0421	1.1619	1.641	0.4148	1.0446	1.145	0.9275	0.9322	0.774
0.0759	1.1493	1.565	0.4853	1.0267	1.083	0.9513	0.9279	0.758
0.0976	1.1415	1.529	0.5455	1.0122	1.038	0.9796	0.9229	0.739
0.1779	1.1140	1.420	0.6708	0.9838	0.938	1.0000	0.9193	0.728
0.2468	1.0920	1.332	0.7643	0.9641	0.877			

1994, 1995). The mole fraction of each mixture was obtained from the measured apparent masses of the components with an accuracy of 1×10^{-4}. All the mass measurements were made on an electric balance (Dhona 200D, India) accurate to ±0.01 mg. Corrections were made for buoyancy. Each run covered just over half of the range of x_1 so as to give an overlap between two runs.

The kinematic viscosities of the pure components and the mixtures were measured using a suspended Ubbelohde type viscometer. The viscometer was calibrated with thrice-distilled water and twice-distilled benzene and kept in a water thermostat controlled to ±0.01 K. Care was taken to reduce evaporation during the measurements. An average of four or five sets of flow time for each fluid was taken for the purpose of the calculation of viscosity. After multiplication by density, the dynamic viscosity, η, was deduced with a relative error of ±0.003 mPa·s. The flow−time measurements were made with an electronic stopwatch having a precision of ±0.01 s. The performance of the viscometer was assessed by measuring and comparing the viscosities of the pure liquids with the value reported in the literature (Riddick et al., 1986).

Refractive indices were measured with a thermostated Bausch and Lomb Abbe 3L refractometer with an error of less than 0.0001 units. Water was circulated into the prisms of the refractometer by using a circulation pump connected from a constant temperature bath. The instrument was calibrated by measuring the refractive index of purified water, benzene, *n*-hexane, and carbon tetrachloride at known temperatures (Riddick et al., 1986). The sample mixtures were directly injected into the prism assembly of the instrument by means of an airtight hypodermic syringe, and the refractive index values were noted after the liquid mixtures attained the constant temperature of the refractometer. An average of triplicate measurements was considered for the calculation of refractive index values.

Results and Discussion

The experimental excess molar volumes, viscosities, and refractive indices of the different binary mixtures as a function of the mole fraction of diglyme at (298.15, 308.15, and 318.15) K are shown in Tables 2, 4, and 5.

Excess volumes at various temperatures have been fitted by a least-squares technique to the equation (Redlich and Kister, 1948)

$$V_m^E/\mathrm{cm}^3\cdot\mathrm{mol}^{-1} = x_1x_2\sum_{j=1}^{n} a_j\,(x_2 - x_1)j^{-1} \qquad (1)$$

where x_1 and x_2 are the mole fractions of diethylene glycol dimethyl ether and esters of carbonic acid molecules, respectively. The values of the coefficients, a_j, are summarized in Table 3 along with standard deviations $s(V_m^E)$. In each case, the optimum number of coefficeints was ascertained from an examination of the variation of the standard deviation with n

$$s(V_m^E) = [\sum(V_{m,exptl}^E - V_{m,calcd}^E)^2/(p - n)]^{1/2} \qquad (2)$$

where p is the total number of experimental data and n is the number of parameters considered.

Plots of excess molar volume at 298.15 K versus mole fraction of diglyme for the three system are shown in Figure 1. Mixtures containing propylene carbonate have negative V_m^E values, while those with dimethyl carbonate or diethyl carbonate have (smaller) positive values of V_m^E. The binary mixtures with propylene carbonate show

Table 5. Refractive Indices (n_D) for Binary Mixtures at Various Temperatures

x_1	n_D	x_1	n_D	x_1	n_D
Diethylene Glycol Dimethyl Ether (1) + Dimethyl Carbonate (2)					
298.15 K					
0.0000	1.3710	0.4863	1.3950	0.9340	1.4077
0.0227	1.3722	0.5651	1.3979	0.9682	1.4082
0.0853	1.3758	0.6520	1.4007	0.9783	1.4083
0.1127	1.3772	0.7598	1.4038	0.9827	1.4084
0.1987	1.3818	0.8742	1.4065	0.9927	1.4085
0.2725	1.3858	0.9050	1.4070	1.0000	1.4085
0.3921	1.3910				
308.15 K					
0.0000	1.3661	0.4863	1.3905	0.9340	1.4035
0.0227	1.3675	0.5651	1.3935	0.9682	1.4043
0.0853	1.3710	0.6520	1.3965	0.9783	1.4044
0.1127	1.3725	0.7598	1.3999	0.9827	1.4045
0.1987	1.3773	0.8742	1.4025	0.9927	1.4046
0.2725	1.3809	0.9050	1.4031	1.0000	1.4047
0.3921	1.3864				
318.15 K					
0.0000	1.3629	0.4863	1.3863	0.9340	1.3990
0.0227	1.3640	0.5651	1.3892	0.9682	1.3998
0.0853	1.3676	0.6520	1.3922	0.9783	1.3999
0.1127	1.3693	0.7598	1.3955	0.9827	1.4000
0.1987	1.3740	0.8742	1.3971	0.9927	1.4001
0.2725	1.3775	0.9050	1.3982	1.0000	1.4002
0.3921	1.3826				
Diethylene Glycol Dimethyl Ether (1) + Diethyl Carbonate (2)					
298.15 K					
0.0000	1.3859	0.4860	1.3980	0.9155	1.4074
0.0087	1.3861	0.5584	1.4000	0.9502	1.4080
0.0619	1.3870	0.6730	1.4025	0.9635	1.4082
0.1978	1.3909	0.7540	1.4040	0.9911	1.4084
0.2501	1.3918	0.8782	1.4060	1.000	1.4085
0.3717	1.3949				
308.15 K					
0.0000	1.3809	0.4860	1.3934	0.9155	1.4030
0.0087	1.3810	0.5584	1.3955	0.9502	1.4035
0.0619	1.3825	0.6730	1.3980	0.9635	1.4040
0.1978	1.3864	0.7540	1.3998	0.9911	1.4045
0.2501	1.3875	0.8782	1.4013	1.0000	1.4047
0.3717	1.3908				
318.15 K					
0.0000	1.3769	0.4860	1.3891	0.9155	1.3984
0.0087	1.3770	0.5584	1.3910	0.9502	1.3990
0.0619	1.3785	0.6730	1.3936	0.9635	1.3995
0.1978	1.3818	0.7540	1.3952	0.9911	1.3999
0.2501	1.3831	0.8782	1.3965	1.0000	1.4002
0.3717	1.3860				
Diethylene Glycol Dimethyl Ether (1) + Propylene Carbonate (2)					
298.15 K					
0.0000	1.4210	0.5893	1.4140	0.9579	1.4090
0.0504	1.4203	0.6647	1.4130	0.9632	1.4090
0.1130	1.4195	0.7477	1.4119	0.9744	1.4088
0.1969	1.4185	0.7942	1.4113	0.9893	1.4086
0.2660	1.4176	0.8955	1.4099	0.9914	1.4086
0.3752	1.4164	0.9112	1.4097	1.0000	1.4085
0.4943	1.4151	0.9241	1.4095		
308.15 K					
0.0000	1.4185	0.5893	1.4120	0.9579	1.4058
0.0504	1.4180	0.6647	1.4107	0.9632	1.4056
0.1130	1.4173	0.7477	1.4093	0.9744	1.4053
0.1969	1.4163	0.7942	1.4086	0.9893	1.4050
0.2660	1.4156	0.8955	1.4069	0.9914	1.4048
0.3752	1.4144	0.9112	1.4066	1.0000	1.4047
0.4943	1.4132	0.9241	1.4064		
318.15 K					
0.0000	1.4139	0.5893	1.4080	0.9579	1.4014
0.0504	1.4135	0.6647	1.4070	0.9632	1.4012
0.1130	1.4131	0.7477	1.4056	0.9744	1.4009
0.1969	1.4123	0.7942	1.4045	0.9893	1.4006
0.2660	1.4116	0.8955	1.4027	0.9914	1.4004
0.3752	1.4105	0.9112	1.4023	1.0000	1.4002
0.4943	1.4092	0.9241	1.4020		

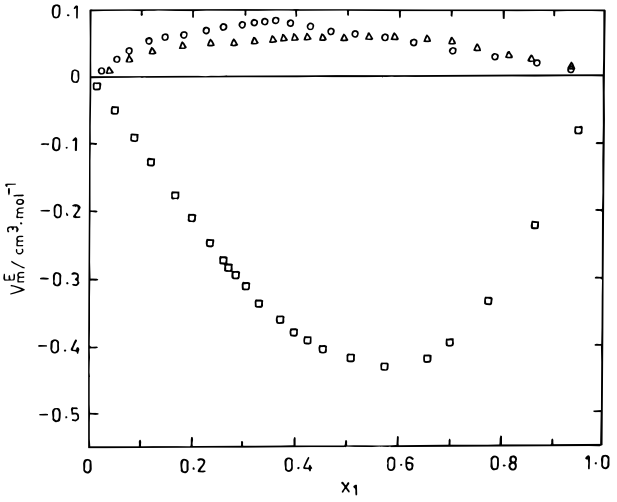

Figure 1. Comparison of the excess molar volume (V_m^E) of different mixtures at 298.15 K: (○) dimethyl carbonate, (△) diethyl carbonate, and (□) propylene carbonate.

V_m^E values that decrease with an increase in temperature, while for the mixtures with dimethyl carbonate or diethyl carbonate V_m^E shows a negligible temperature dependence. However, this dependence is not shown graphically to avoid overcrowding of graphs. The temperature coefficient $(\partial V^E/\partial T)_p$ is positive for mixtures with propylene carbonate and negative for mixtures with dimethyl carbonate or diethyl carbonate over the whole mole fraction range.

The η and n_D results of the mixtures at all the three temperatures follow the sequence dimethyl carbonate < diethyl carbonate < propylene carbonate. At any particular temperature as x_1 increases, the η and n_D of dimethyl carbonate and diethyl carbonate increases whereas for propylene carbonate it decreases. There is a systematic decrease in η and n_D with a rise in temperature for all mixtures. A further comparison of data at different temperatures reveals that the temperature coefficient $(\partial\eta/\partial T)_p$ or $(\partial n/\partial T)_p$ is decreasing in values for the three mixtures with increasing temperature.

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