J. Chem. Eng. Data 1992, 37, 387–390

Excess Volumes, Dielectric Constants, Refractive Indexes, and Viscosities for Anisole + Methylene Chloride, 1,2-Dichloroethane, Trichloroethene, Tetrachloroethene, and Cyclohexane

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Dilatometric measurements of excess volumes, V_m^E, have been made for anisole + methylene chloride and trichloroethene at 293.15 and 303.15 K, for anisole + 1,2-dichloroethane at 298.15 and 308.15 K, for anisole + tetrachloroethene at 303.15 and 313.15 K, and for anisole + cyclohexane at 308.15 K. Dielectric constants, refractive indexes, and dynamic viscosities have also been measured for anisole + methylene chloride, 1,2-dichloroethane, trichloroethene, tetrachloroethene, and cyclohexane at 303.15 K. The quantities $\Delta\epsilon$ and $\Delta\eta$, which refer, respectively, to the deviations of the dielectric constants and viscosities of the mixtures from the values arising from the mole fraction mixture law, have been calculated. The results of V_m^E, $\Delta\eta$, and refractive indexes for the various systems have been fitted by the method of least squares to the various smoothing equations.

Introduction

Mixtures of anisole ($C_6H_5OCH_3$) with methylene chloride (CH_2Cl_2), 1,2-dichloroethane (CH_2ClCH_2Cl), trichloroethene ($CHClCCl_2$), tetrachloroethene (CCl_2CCl_2), and cyclohexane (c-C_6H_{12}) are of considerable interest from the viewpoint of the existence of a specific interaction between the components. As described by Mulliken (*1*), $C_6H_5OCH_3$, which contains a $-OCH_3$ group, can act as a nπ-type donor. Due to the presence of Cl and H atoms in $CHClCCl_2$, CH_2ClCH_2Cl, and CH_2Cl_2, these compounds can act as a σ-acceptor toward, and be involved in the formation of a hydrogen bond with, $C_6H_5OCH_3$. Also CCl_2CCl_2 can act as a σ-acceptor toward $C_6H_5OCH_3$. The system $C_6H_5OCH_3$ + c-C_6H_{12}, in which only nonspecific forces between the components are believed to be present, can be considered as a reference system (*2–4*). In this work we present excess volumes, V_m^E, dielectric constants, ϵ, refractive indexes, n, and viscosities for $C_6H_5OCH_3$ + CH_2Cl_2, CH_2ClCH_2Cl, $CHClCCl_2$, CCl_2CCl_2, and c-C_6H_{12}.

Experimental Section

Materials. Methylene chloride (SRL), cyclohexane (SRL), and tetrachloroethene (E. Merck, Darmstadt, FRG), all spectral grade chemicals, were dried over anhydrous calcium chloride prior to use. 1,2-Dichloroethane (SRL, A.R.) was washed with an aqueous solution of sodium hydrogen carbonate, dried over anhydrous calcium chloride, and then fractionally distilled from phosphorus pentoxide. Trichloroethene (SRL, A.R.) was shaken with an aqueous solution of potassium carbonate, washed with water, dried over anhydrous potassium carbonate and calcium chloride, and then subjected to fractional distillations. Anisole (SRL, A.R.) was distilled from sodium.

Methods. (i) Excess volumes, V_m^E, were measured with an accuracy of ±0.002 cm^3 mol^{-1}, using a two-limbed Pyrex glass dilatometer (*5–7*). Known amounts of the two liquid components were confined over mercury in the absence of air spaces in the two limbs of the dilatometer. The dilatometer (mounted on a stand) was immersed in a thermostat bath which was controlled to ±0.01 K. The mixing of the components was achieved by rocking the cell back and forth through a defined angle, and the mercury levels in the capillary of the dilatometer were noted with a cathetometer which could read correct to ±0.001 cm.

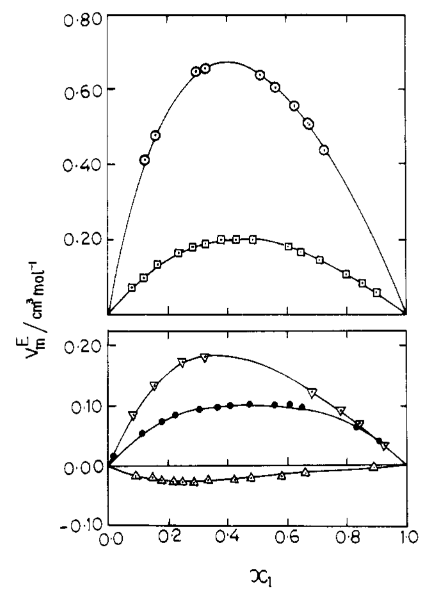

Figure 1. V_m^E versus x_1 for the following systems: ⊙, $C_6H_5OCH_3$ (1) + c-C_6H_{12} (2) at 308.15 K; ⊡, $C_6H_5OCH_3$ (1) + CH_2ClCH_2Cl (2) at 298.15 K; ▼, $C_6H_5OCH_3$ (1) + CCl_2CCl_2 (2) at 313.15 K; ●, $C_6H_5OCH_3$ (1) + CH_2Cl_2 (2) at 293.15 K; ▲, $C_6H_5OCH_3$ (1) + $CHClCCl_2$ (2) at 293.15 K.

(ii) Dielectric constants, ϵ, were measured at 303.15 ± 0.01 K and at a frequency of 1.8 MHz with a dekameter (type DK$_{03}$, Wissenschaftlich-Technische, Werkstätten, Germany), using two cells: cell MFL 1/S, no. 2078, for mixtures having $\epsilon < 7.0$ and cell MFL 2/S, no. 2084, for mixtures having $\epsilon > 7.0$, as described previously (*4*). The precision in ϵ is $\sim\pm0.005$ unit for mixtures of $C_6H_5OCH_3$ + c-C_6H_{12}, $CHClCCl_2$, and

0021-9568/92/1737-0387$03.00/0

Table I. Experimental Values of Excess Volumes, V_m^E, for $C_6H_5OCH_3$ + CH_2Cl_2, CH_2ClCH_2Cl, $CHClCCl_2$, CCl_2CCl_2, and c-C_6H_{12} 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/ ($cm^3\ mol^{-1}$)
		$C_6H_5OCH_3$ (1) + CH_2Cl_2 (2)			
		T = 293.15 K			
0.0217	0.013	0.3647	0.097	0.6495	0.097
0.1133	0.052	0.4112	0.100	0.8333	0.064
0.1789	0.073	0.4676	0.103	0.9136	0.039
0.2225	0.082	0.5542	0.100		
0.3040	0.092	0.6044	0.101		
		T = 303.15 K			
0.0616	0.017	0.2929	0.071	0.6278	0.090
0.1421	0.037	0.3585	0.080	0.6966	0.081
0.1882	0.050	0.4036	0.082	0.8308	0.054
		$C_6H_5OCH_3$ (1) + CH_2ClCH_2Cl (2)			
		T = 298.15 K			
0.0820	0.075	0.3290	0.188	0.6500	0.166
0.1180	0.101	0.3782	0.200	0.7083	0.145
0.1674	0.131	0.4292	0.198	0.8000	0.109
0.2395	0.163	0.4859	0.198	0.8517	0.085
0.2882	0.181	0.6068	0.178	0.9008	0.057
		T = 308.15 K			
0.0486	0.049	0.3707	0.195	0.7131	0.137
0.1616	0.136	0.4041	0.195	0.7426	0.127
0.2380	0.169	0.4518	0.195	0.8413	0.089
0.2790	0.182	0.5465	0.183		
0.3411	0.192	0.6711	0.149		
		$C_6H_5OCH_3$ (1) + $CHClCCl_2$ (2)			
		T = 293.15 K			
0.0935	−0.015	0.2494	−0.026	0.4754	−0.020
0.1533	−0.020	0.2883	−0.028	0.5794	−0.017
0.1767	−0.025	0.3344	−0.022	0.6614	−0.011
0.2224	−0.027	0.4193	−0.021	0.8873	−0.004
		T = 303.15 K			
0.0714	−0.007	0.2874	−0.028	0.6057	−0.018
0.0993	−0.010	0.3038	−0.028	0.7644	−0.009
0.1419	−0.018	0.3332	−0.030	0.8222	−0.007
0.1643	−0.021	0.4643	−0.030	0.8728	−0.005
0.2345	−0.023	0.5050	−0.026		
		$C_6H_5OCH_3$ (1) + CCl_2CCl_2 (2)			
		T = 303.15 K			
0.1772	0.132	0.4340	0.195	0.7229	0.147
0.1878	0.139	0.4583	0.200	0.8093	0.114
0.2036	0.148	0.5845	0.180	0.8839	0.077
		T = 313.15 K			
0.0866	0.088	0.3217	0.178	0.8400	0.068
0.1558	0.131	0.6863	0.122	0.9202	0.033
0.2468	0.171	0.7736	0.091		
		$C_6H_5OCH_3$ (1) + c-C_6H_{12} (2)			
		T = 308.15 K			
0.1313	0.412	0.5092	0.634	0.6744	0.503
0.1621	0.477	0.5608	0.603	0.7263	0.433
0.2970	0.644	0.6228	0.552		
0.3304	0.653	0.6695	0.504		

CCl_2CCl_2 and ~±0.01 units for mixtures of $C_6H_5OCH_3$ + CH_2Cl_2 and CH_2ClCH_2Cl.

(iii) Refractive indexes, n, were measured at the Na^D line with an accuracy of ±0.0002 units at 303.15 ± 0.01 K using a thermostated Abbe refractometer (Carl Zeiss).

(iv) The viscosities, η, which are accurate to $\pm 0.02 \times 10^{-4}$ kg m^{-1} s^{-1}, were measured at 303.15 ± 0.01 K, by measuring the flow times in a viscometer similar to that described by Tuan and Fuoss (8). The viscometer was calibrated with $CHCl_3$ and C_6H_5Cl. The results were used to calculate constants A and B from the equation

$$\eta/\rho = At - B/t \quad (1)$$

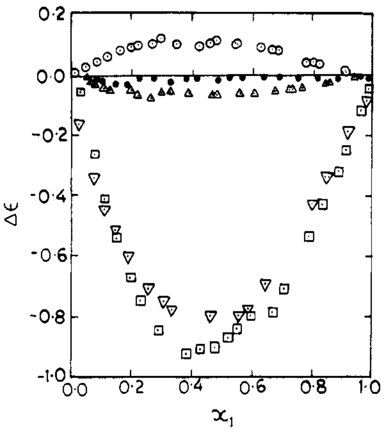

Figure 2. Δε versus x_1 for the following systems at 303.15 K: ▼, $C_6H_5OCH_3$ (1) + CH_2Cl_2 (2); ⊡, $C_6H_5OCH_3$ (1) + CH_2ClCH_2Cl (2); ⊙, $C_6H_5OCH_3$ (1) + $CHClCCl_2$ (2); ●, $C_6H_5OCH_3$ (1) + CCl_2CCl_2 (2); ▲, $C_6H_5OCH_3$ (1) + c-C_6H_{12} (2).

Table II. Dielectric Constants ε for $C_6H_5OCH_3$ + CH_2Cl_2, CH_2ClCH_2Cl, $CHClCCl_2$, CCl_2CCl_2, and c-C_6H_{12} at 303.15 K

x_1	ε	x_1	ε	x_1	ε
		$C_6H_5OCH_3$ (1) + CH_2Cl_2 (2)			
0.0000	8.704	0.3104	6.57	0.8431	4.61
0.0268	8.42	0.3365	6.43	0.8511	4.58
0.0767	8.02	0.4670	5.77	0.9199	4.422
0.1111	7.77	0.5520	5.45	0.9256	4.397
0.1442	7.55	0.5885	5.31	0.9784	4.258
0.1896	7.26	0.6441	5.14	1.0000	4.247
0.2587	6.85	0.7993	4.72		
		$C_6H_5OCH_3$(1) + CH_2ClCH_2Cl (2)			
0.0000	10.072	0.3811	6.93	0.8373	4.768
0.0281	9.85	0.4266	6.68	0.8830	4.616
0.0732	9.39	0.4755	6.40	0.9118	4.515
0.1099	9.02	0.5182	6.19	0.9604	4.363
0.1477	8.67	0.5504	6.03	0.9879	4.279
0.1939	8.27	0.5900	5.843	1.0000	4.247
0.2294	7.99	0.7122	5.223		
0.2868	7.56	0.7907	4.932		
		$C_6H_5OCH_3$ (1) + $CHClCCl_2$ (2)			
0.0000	3.347	0.2961	3.738	0.6870	4.049
0.0102	3.367	0.3483	3.761	0.7762	4.088
0.0450	3.415	0.4242	3.826	0.8023	4.112
0.0841	3.468	0.4589	3.867	0.8213	4.119
0.1227	3.519	0.4724	3.888	0.9072	4.177
0.1590	3.573	0.5439	3.942	0.9121	4.179
0.1983	3.621	0.5592	3.955	1.0000	4.247
0.2215	3.649	0.6292	4.005		
0.2680	3.692	0.6647	4.030		
		$C_6H_5OCH_3$ (1) + CCl_2CCl_2 (2)			
0.0000	2.296	0.1861	2.629	0.6418	3.547
0.0044	2.304	0.2258	2.731	0.6946	3.653
0.0055	2.306	0.2765	2.832	0.7565	3.779
0.0069	2.307	0.3289	2.915	0.8213	3.904
0.0184	2.321	0.3879	3.050	0.8796	4.002
0.0573	2.405	0.4188	3.111	0.8930	4.036
0.0805	2.441	0.4887	3.237	0.9603	4.159
0.1038	2.478	0.5235	3.316	0.9959	4.226
0.1477	2.554	0.5668	3.405	1.0000	4.247
		$C_6H_5OCH_3$ (1) + c-C_6H_{12} (2)			
0.0000	2.007	0.2192	2.430	0.6733	3.466
0.0039	2.015	0.2623	2.519	0.7232	3.580
0.0123	2.036	0.2984	2.622	0.7324	3.602
0.0506	2.115	0.3302	2.694	0.7641	3.677
0.0637	2.126	0.3899	2.822	0.8474	3.879
0.0756	2.145	0.4731	3.002	0.8564	3.901
0.1055	2.199	0.4850	3.160	0.9385	4.102
0.1267	2.243	0.5643	3.210	1.0000	4.247
0.1950	2.393	0.6049	3.301		

The values of η and ρ of $CHCl_3$ and C_6H_5Cl, needed to evaluate A and B from eq 1, were obtained from the data available in

Table III. Refractive Indexes for $C_6H_5OCH_3$ + CH_2Cl_2, CH_2ClCH_2Cl, $CHClCCl_2$, CCl_2CCl_2, and c-C_6H_{12} at 303.15 K

x_1	n	x_1	n	x_1	n
		$C_6H_5OCH_3$ (1) + CH_2Cl_2 (2)			
0.0000	1.4184	0.1431	1.4372	0.4884	1.4758
0.0335	1.4235	0.2214	1.4478	0.7009	1.4932
0.0475	1.4248	0.2785	1.4540	0.8911	1.5058
0.0688	1.4282	0.3051	1.4572	1.0000	1.5116
0.0923	1.4320	0.3622	1.4632		
		$C_6H_5OCH_3$ (1) + CH_2ClCH_2Cl (2)			
0.0000	1.4394	0.2670	1.4618	0.5997	1.4864
0.0267	1.4418	0.2918	1.4638	0.7783	1.4980
0.0564	1.4444	0.3427	1.4680	0.8070	1.5002
0.0725	1.4454	0.3642	1.4692	1.0000	1.5116
0.1781	1.4546	0.3974	1.4718		
0.2160	1.4578	0.5292	1.4815		
		$C_6H_5OCH_3$ (1) + $CHClCCl_2$ (2)			
0.0000	1.4712	0.3720	1.4880	0.5967	1.4972
0.0435	1.4732	0.4456	1.4906	0.6428	1.4988
0.0647	1.4742	0.4896	1.4925	0.7860	1.5043
0.0813	1.4748	0.5332	1.4942	0.8680	1.5066
0.1660	1.4792	0.5539	1.4948	0.9260	1.5088
0.2139	1.4812	0.5822	1.4958	1.0000	1.5116
		$C_6H_5OCH_3$ (1) + CCl_2CCl_2 (2)			
0.0000	1.5002	0.2537	1.5028	0.6133	1.5072
0.0414	1.5010	0.3072	1.5034	0.6322	1.5074
0.0717	1.5014	0.4719	1.5056	0.7074	1.5082
0.1086	1.5018	0.5101	1.5060	0.8111	1.5096
0.1386	1.5020	0.5341	1.5062	0.9509	1.5110
0.2159	1.5026	0.5657	1.5067	1.0000	1.5116
		$C_6H_5OCH_3$ (1) + c-C_6H_{12} (2)			
0.0000	1.4202	0.1688	1.4338	0.7863	1.4898
0.0553	1.4252	0.1957	1.4360	0.8308	1.4948
0.0999	1.4285	0.3563	1.4502	0.9068	1.5028
0.1029	1.4286	0.4247	1.4558	1.0000	1.5116
0.1272	1.4302	0.6306	1.4752		

Table IV. Dynamic Viscosities for $C_6H_5OCH_3$ + CH_2Cl_2, CH_2ClCH_2Cl, $CHClCCl_2$, CCl_2CCl_2, and c-C_6H_{12} at 303.15 K

x_1	$\eta/(10^{-4}$ kg m^{-1} s^{-1})	x_1	$\eta/(10^{-4}$ kg m^{-1} s^{-1})	x_1	$\eta/(10^{-4}$ kg m^{-1} s^{-1})
		$C_6H_5OCH_3$ (1) + CCl_2CCl_2 (2)			
0.0000	7.99	0.2742	7.83	0.7292	8.56
0.0193	7.93	0.3317	7.87	0.7745	8.62
0.0390	7.90	0.3643	7.90	0.8665	8.78
0.0561	7.92	0.4286	8.01	0.8991	8.85
0.1158	7.81	0.4726	8.12	0.9485	8.99
0.1890	7.76	0.6096	8.31	1.0000	9.15
0.2303	7.78	0.6829	8.48		
		$C_6H_5OCH_3$ (1) + $CHClCCl_2$ (2)			
0.0000	5.09	0.2818	5.77	0.6480	7.30
0.1234	5.23	0.4018	6.23	0.7243	7.65
0.1791	5.41	0.5204	6.72	0.8135	8.14
0.2335	5.61	0.5501	6.82	1.0000	9.15
		$C_6H_5OCH_3$ (1) + CH_2ClCH_2Cl (2)			
0.0000	7.30	0.3833	7.40	0.6717	7.97
0.0479	7.08	0.5479	7.76	0.9751	8.96
0.2944	7.26	0.6192	7.85	1.0000	9.15
		$C_6H_5OCH_3$ (1) + CH_2Cl_2 (2)			
0.0000	3.94	0.3570	5.40	0.6580	6.88
0.0690	4.25	0.4045	5.67	0.8807	8.20
0.3210	5.27	0.6109	6.65	1.0000	9.15
		$C_6H_5OCH_3$ (1) + c-C_6H_{12} (2)			
0.0000	8.21	0.4829	7.08	0.7744	7.92
0.0224	7.99	0.5172	7.14	0.8952	8.46
0.0385	7.83	0.5409	7.20	0.9478	8.84
0.0614	7.73	0.5731	7.29	1.0000	9.15

the literature (*9, 10*). The values of A and B for the viscometer used for the present measurements were found to be 0.030952 × 10^{-7} m^2 s^{-2} and 80.298727 × 10^{-7} m^2, respectively. The densities of the mixtures were calculated using the excess volume values reported in this paper.

Results and Discussion

The excess volumes V_m^E for $C_6H_5OCH_3$ + CH_2Cl_2, CH_2ClCH_2Cl, $CHClCCl_2$, CCl_2CCl_2, and c-C_6H_{12} at various temperatures are given in Table I, and the dielectric constants ϵ at 303.15 K are given in Table II. The refractive indexes n for the same systems at 303.15 K are given in Table III, and dynamic viscosities η are given in Table IV. The experimental values of ϵ for CH_2Cl_2, CH_2ClCH_2Cl, $CHClCCl_2$, CCl_2CCl_2, c-C_6H_{12}, and $C_6H_5OCH_3$ at 303.15 K are found to be 8.704, 10.072, 3.347, 2.296, 2.0070, and 4.247, respectively, which are in good agreement with the literature (*2, 11*) values 8.712, 10.076, 3.340, 2.290, 2.0070, and 4.250, respectively. The experimental values of the refractive indexes n for the pure liquids are in good agreement with the literature (*9, 10*) values. The values of $10^4\,\eta$ for CH_2Cl_2, CH_2ClCH_2Cl, CCl_2CCl_2, and c-C_6H_{12} at 303.15 K are found to be 3.94, 7.30, 7.99, and 8.21 kg m^{-1} s^{-1}, respectively, which are in good agreement with the literature (*9, 10*) values of 3.93, 7.30, 7.98, and 8.20 kg m^{-1} s^{-1}, respectively. The value of η for $CHClCCl_2$ at 303.15 K is 5.09 × 10^{-4} kg m^{-1} s^{-1}, whereas the literature (*10*) value of η for $CHClCCl_2$ is 5.66 × 10^{-4} kg m^{-1} s^{-1} at 293.15 K and 5.32 × 10^{-4} kg m^{-1} s^{-1} at 298.15 K. The value of η for $C_6H_5OCH_3$ at 303.15 K, as reported by Timmermann (*9*) is 7.89 × 10^{-4} kg m^{-1} s^{-1}, whereas our value of η for $C_6H_5OCH_3$ at 303.15 K is 9.15 × 10^{-4} kg m^{-1} s^{-1}, which is in very good agreement with the value 9.15 × 10^{-4} kg m^{-1} s^{-1} based on the viscosity data for $C_6H_5OCH_3$ as available in the literature (*12*). The value of η for $C_6H_5OCH_3$ at 303.15 K, as reported by Geddes and Bingham (*13*), is 9.28 × 10^{-4} kg m^{-1} s^{-1}.

The V_m^E for $C_6H_5OCH_3$ + CH_2Cl_2, CH_2ClCH_2Cl, $CHClCCl_2$, CCl_2CCl_2, and c-C_6H_{12} at various temperatures have been fitted by the method of least squares to the equation

$$V_m^E/(\mathrm{cm^3\,mol^{-1}}) = x_1x_2[A_0 + A_1(x_1 - x_2) + A_2(x_1 - x_2)^2] \quad (2)$$

where x_1 and x_2 refer to the mole fractions of $C_6H_5OCH_3$ and the second component, respectively, and A_0, A_1, and A_2 are constants characteristic of a system at a given temperature. The values of the constants A_0, A_1, and A_2 of eq 2, and those of the standard deviations $\delta(V_m^E)$ for the various systems are given in Table V. The values of V_m^E for each system at one temperature have been plotted against x_1 in Figure 1. The experimental values of the refractive indexes n_{12} of the various present mixtures have been fitted by the method of least squares to the equation

$$n_{12} = a + bx_1 + cx_1^2 \quad (3)$$

where a, b, and c are constants. The values of the constants along with those of the standard deviations $\delta(n)$ for the various systems are given in Table VI. The dielectric constants ϵ of the various mixtures have been used to calculate the quantity $\Delta\epsilon$ (see Figure 2) from the relation

$$\Delta\epsilon = \epsilon - x_1\epsilon_1 - x_2\epsilon_2 \quad (4)$$

where ϵ_1 and ϵ_2 refer to the dielectric constants of the two pure components 1 and 2.

The experimental values of the dynamic viscosities η of the various mixtures have been used to calculate the quantity $\Delta\eta$

Table V. Values of the Constants A_0, A_1, and A_2 of Equation 2 and the Standard Deviations $\delta(V_m^E)$ for $C_6H_5OCH_3$ + CH_2Cl_2, CH_2ClCH_2Cl, $CHClCCl_2$, CCl_2CCl_2, and c-C_6H_{12}

system	T/K	A_0	A_1	A_2	$\delta(V_m^E)/(cm^3\ mol^{-1})$
$C_6H_5OCH_3$ (1) + CH_2Cl_2 (2)	293.15	0.3978	−0.0251	0.2055	0.0026
	303.15	0.3656	0.0541	−0.0324	0.0016
$C_6H_5OCH_3$ (1) + CH_2ClCH_2Cl (2)	298.15	0.7827	−0.2060	0.0535	0.0014
	308.15	0.7760	−0.2589	0.0527	0.0034
$C_6H_5OCH_3$ (1) + $CHClCCl_2$ (2)	293.15	−0.0773	0.0910	−0.0523	0.0018
	303.15	−0.1120	0.0663	0.0575	0.0023
$C_6H_5OCH_3$ (1) + CCl_2CCl_2 (2)	303.15	0.7750	−0.1381	0.1291	0.0027
	313.15	0.6790	−0.3798	0.1516	0.0026
$C_6H_5OCH_3$ (1) + c-C_6H_{12} (2)	308.15	2.5624	−1.0330	0.5364	0.0037

Table VI. Values of the Constants a, b, and c of Equation 3 and the Standard Deviations $\delta(n)$ for $C_6H_5OCH_3$ + CH_2Cl_2, CH_2ClCH_2Cl, $CHClCCl_2$, CCl_2CCl_2, and c-C_6H_{12} at 303.15 K

system	a	b	c	$\delta(n)$
$C_6H_5OCH_3$ (1) + CH_2Cl_2 (2)	1.418 651	0.140 364	−0.047 629	0.000 33
$C_6H_5OCH_3$ (1) + CH_2ClCH_2Cl (2)	1.439 118	0.090 148	−0.018 176	0.000 28
$C_6H_5OCH_3$ (1) + $CHClCCl_2$ (2)	1.471 549	0.044 811	−0.004 605	0.000 32
$C_6H_5OCH_3$ (1) + CCl_2CCl_2 (2)	1.500 54	0.009 610	0.001 691	0.000 18
$C_6H_5OCH_3$ (1) + c-C_6H_{12} (2)	1.420 589	0.076 499	0.015 101	0.000 36

Table VII. Values of the Constants B_0, B_1, and B_2 of Equation 6, the Standard Deviations $\delta(\Delta\eta)$, Maximum Percentage Deviations $\Delta_{max}/\%$, Average Percentage Deviations $\Delta_{av}/\%$, and the Average Values of the Parameter d for $C_6H_5OCH_3$ + CH_2Cl_2, CH_2ClCH_2Cl, $CHClCCl_2$, CCl_2CCl_2, and c-C_6H_{12} at 303.15 K

system	B_0	B_1	B_2	$\delta(\Delta\eta)/(10^{-4}\ kg\ m^{-1}\ s^{-1})$	$\Delta_{max}/\%$	$\Delta_{av}/\%$	d_{av}
$C_6H_5OCH_3$ (1) + CCl_2CCl_2 (2)	−1.7237	0.8383	−1.2381	0.026	0.58	0.21	−0.26
$C_6H_5OCH_3$ (1) + $CHClCCl_2$ (2)	−1.9659	0.8120	−0.7777	0.027	0.57	0.32	−0.17
$C_6H_5OCH_3$ (1) + CH_2ClCH_2Cl (2)	−1.9793	0.3055	−5.7162	0.059	0.69	0.52	−0.43
$C_6H_5OCH_3$ (1) + CH_2Cl_2 (2)	−1.8648	−0.5608	0.5064	0.041	0.73	0.38	+0.02
$C_6H_5OCH_3$ (1) + c-C_6H_{12} (2)	−6.3214	2.5780	−2.3120	0.036	0.65	0.31	−0.90

from the relation

$$\Delta\eta = \eta - x_1\eta_1 - x_2\eta_2 \quad (5)$$

The values of the quantity $\Delta\eta$ for the various mixtures have been fitted by the method of least squares to the equation

$$\Delta\eta/(10^{-4}\ kg\ m^{-1}\ s^{-1}) = x_1x_2[B_0 + B_1(x_1 - x_2) + B_2(x_1 - x_2)^2] \quad (6)$$

The values of B_0, B_1, and B_2 of eq 6, along with the standard deviations $\delta(\Delta\eta)$ are given in Table VII. The maximum percentage deviations, $\Delta_{max}/\%$, and average percentage deviations, $\Delta_{av}/\%$, of the experimental values of $\Delta\eta$ from those obtained from eq 6 are also given in Table VII. Attempts have been made to describe the viscosities of the mixtures in terms of the viscosities of the pure components and a parameter attributed to the intermolecular interaction between them. According to Grunberg and Nissan (*14*), the viscosity η of a binary mixture is represented by the equation

$$\ln \eta = x_1 \ln \eta_1 + x_2 \ln \eta_2 + x_1x_2d \quad (7)$$

In eq 7, d is a parameter proportional to ω/RT, where ω is an interchange energy. The average values of d for the various systems are given in Table VII.

Acknowledgment

We are extremely grateful to the Head, Department of Chemistry, Gorakhpur University, Gorakhpur, for providing laboratory facilities.

Literature Cited

(1) Mulliken, R. S. *J. Chim. Phys.* **1963**, 20–38.
(2) Nath, J.; Dixit, A. P. *J. Chem. Soc., Faraday Trans. 2* **1985**, *81*, 11–19.
(3) Nath, J.; Singh, G. *J. Chem. Soc., Faraday Trans. 1* **1987**, *83*, 3167–3175.
(4) Nath, J.; Rashmi. *J. Chem. Soc., Faraday Trans.* **1990**, *86*, 3399–3404.
(5) Nath, J.; Dubey, S. N. *J. Chem. Thermodyn.* **1979**, *11*, 1163–1165.
(6) Nath, J.; Tripathi, A. D. *J. Chem. Eng. Data* **1983**, *28*, 263–266.
(7) Nath, J.; Dixit, A. P. *J. Chem. Eng. Data* **1984**, *29*, 313–316.
(8) Taun, D. F. T.; Fuoss, R. M. *J. Phys. Chem.* **1963**, *67*, 1343–1347.
(9) Timmermans, J. *Physico-Chemical Constants of Pure Organic Compounds*; Elsevier: Amsterdam, 1950.
(10) Riddick, J. A.; Bunger, W. B. *Techniques of Chemistry, Organic Solvents: Physical Properties and Methods of Purification*, 3rd ed.; Wiley-Interscience: New York, 1970; Vol. II.
(11) Lange, N. A. *Lange's Handbook of Chemistry*; McGraw-Hill: New York, 1973.
(12) Riddick, J. A.; Bunger, W. B. *Techniques of Chemistry, Organic Solvents: Physical Properties and Methods of Purification*, 3rd ed.; Wiley-Interscience: New York, 1970; Vol. II, p 34.
(13) Geddes, J. A.; Bingham, E. C. *J. Am. Chem. Soc.* **1934**, *56*, 2625–2626.
(14) Grunberg, L.; Nissan, A. N. *Nature (London)* **1949**, *164*, 799.

Received for review November 25, 1991. Revised April 28, 1992. Accepted May 9, 1992. Thanks are due to the University Grants Commission, New Delhi, for financial support.

Registry No. CH_2Cl_2, 75-09-2; C_2Cl_4, 127-18-4; anisole, 100-66-3; 1,2-dichloroethane, 107-06-2; trichloroethene, 79-01-6; cyclohexane, 110-82-7.