Excess Volumes and Viscosities of Tetrachloroethylene with Branched Alcohols at 303.15 K

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Excess volumes and viscosities of binary liquid mixtures of tetrachloroethylene with homologous series of branched alcohols were measured at 303.15 K. The branched alcohols include 2-propanol, 2-methyl-1-propanol, 3-methyl-1-butanol, 2-butanol, and 2-methyl-2-propanol. Excess volumes (V^E) were measured directly using a dilatometer. Viscosities (η) were measured with an Ostwald viscometer.

Introduction

As a continuation of our research program of determining the thermodynamic and transport properties of binary mixtures (Venkatesulu and Rao, 1992; Venkatesulu et al., 1994), we report here the V^E and η of tetrachloroethylene with branched alcohols at 303.15 K. A survey of the literature reveals no studies of V^E and η data for these mixtures.

Experimental Section

Analytical reagent grade tetrachloroethylene was dried over sodium carbonate and fractionally distilled, and the five branched alcohols were purified by the standard methods described by Riddick and Bunger (1986). The purity of the samples were checked by comparing the measured densities of the purified samples with those reported in literature (Riddick and Bunger, 1986; Timmermans, 1962). Densities of pure compounds were measured with a bicapillary type pycnometer, with a capacity of 12 , which gives an accuracy of 2 parts in 10^5. The measured densities and literature values are listed in Table 1. The densities of binary mixtures were obtained from excess volumes using the relation

$$\rho = \frac{x_1 M_1 + x_2 M_2}{V + V^E} \quad (1)$$

where x_1 and x_2 denote the mole fractions and M_1 and M_2 are molar masses of components 1 and 2, respectively. V is the molar volume of the mixture.

Excess volumes were determined directly to an accuracy 0.003 $cm^3 \cdot mol^{-1}$ using dilatometers described earlier (Rao and Naidu, 1974; Venkatesu and Rao, 1994). The mixing cell contains two bulbs of differing capacities that are connected through a U-tube containing mercury to separate the components. One end of the first bulb is fitted with a capillary tube, and the other end of the second bulb is closed with a ground glass stopper. Five dilatometers with differing capacities were used to cover the entire composition range. The composition of each mixture was determined by mass. An Ostwald viscometer was used to measure the viscosities of pure liquids and liquid mixtures, and the detailed procedure was described in our earlier paper (Rao and Naidu, 1977). The measured values of viscosities are accurate to ±0.3%. All the measurements were made at a constant temperature in a thermostat that could be maintained constant to 303.15 ± 0.01 K.

Results and Discussion

The excess volumes at 303.15 K for all the mixtures are listed in Table 2 and are graphically represented in Figure 1.

Table 1. Viscosities (η) and Densities (ρ) of Pure Components at 303.15 K

	η/mPa·s		ρ/g·cm^3	
component	exptl	lit[a]	exptl	lit[a]
tetrachloroethylene	0.796	0.798	1.606 36	1.606 40
2-propanol	1.762	1.765	0.776 86	0.776 90
2-methyl-1-propanol	2.872	2.876	0.794 34	0.794 37
3-methyl-1-butanol	2.961	2.961	0.801 74	0.801 79
2-butanol	2.492	2.495	0.798 91	0.798 95
2-methyl-2-propanol	3.318	3.316	0.776 16	0.776 20

[a] Riddick and Bunger (1986) and Timmermans (1962).

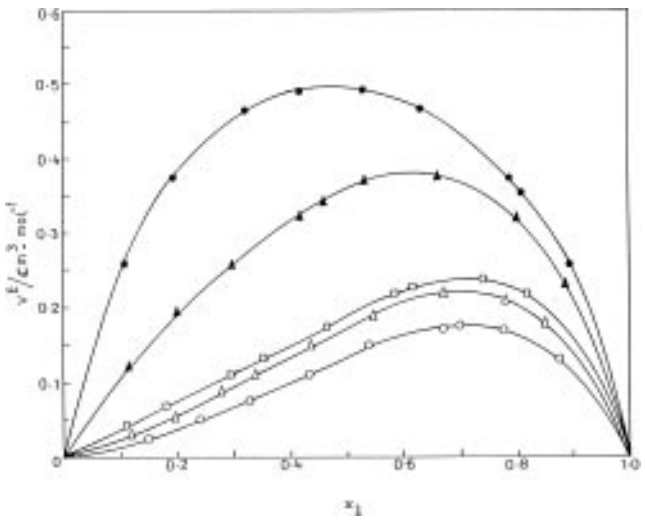

Figure 1.

Viscosities (η) were calculated from the measured flow times and density values of liquids and liquid mixtures at 303.15 K. The viscosities at 303.15 K for these mixtures are reported in Table 3. The experimental values of V^E are fitted to the polynomial equation

$$V^E = x_1 x_2 \sum_{i=0}^{2} a_i (x_1 - x_2)^i \quad (2)$$

The parameters a_i obtained by the least squares analysis are given in Table 4 along with standard deviations.

The observed excess volumes are positive over the whole range of composition for all the systems. The comparison of V^E values of tetrachloroethylene + branched alcohols with tetrachloroethylene + normal alcohols (Iloukhani et al., 1984) shows that the V^E values are more positive for the former systems than for the latter. The positive values of V^E for tetrachloroethylene + normal alcohols compared with those for the branched alcohols indicate that normal

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Table 2. Excess Volumes (V^E) for Tetrachloroethylene (1) with Branched Alcohols (2) at 303.15 K

x_1	V^E/cm^3·mol^{-1}	x_1	V^E/cm^3·mol^{-1}	x_1	V^E/cm^3·mol^{-1}	x_1	V^E/cm^3·mol^{-1}
			Tetrachloroethylene (1) + 2-Propanol (2)				
0.1128	0.040	0.3590	0.128	0.5890	0.215	0.7412	0.235
0.1822	0.068	0.4705	0.170	0.6143	0.221	0.8196	0.219
0.3033	0.107						
			Tetrachloroethylene (1) + 2-Methyl-1-Propanol (2)				
0.1225	0.030	0.3364	0.110	0.5442	0.190	0.7806	0.208
0.2004	0.055	0.4353	0.152	0.6720	0.220	0.8526	0.178
0.2843	0.089						
			Tetrachloroethylene (1) + 3-Methyl-1-Butanol (2)				
0.1473	0.025	0.4348	0.113	0.6731	0.173	0.7790	0.170
0.2402	0.051	0.5401	0.147	0.6994	0.175	0.8752	0.132
0.3344	0.075						
			Tetrachloroethylene (1) + 2-Butanol (2)				
0.1148	0.122	0.4198	0.323	0.5354	0.367	0.8001	0.320
0.2015	0.195	0.4603	0.342	0.6625	0.375	0.8871	0.232
0.2982	0.255						
			Tetrachloroethylene (1) + 2-Methyl-2-Propanol (2)				
0.1123	0.262	0.4236	0.487	0.6340	0.465	0.8067	0.355
0.1927	0.375	0.5301	0.486	0.7868	0.374	0.8888	0.255
0.3199	0.465						

Table 3. Density and Viscosity for the Binary Mixtures of Tetrachloroethylene (1) + Branched Alcohols (2) at 303.15 K

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
				Tetrachloroethylene (1) + 2-Propanol (2)				
0.0000	0.776 86	1.762	0.3926	1.159 18	1.007	0.7882	1.463 91	0.823
0.1028	0.886 45	1.473	0.5027	1.250 69	0.920	0.8976	1.538 64	0.814
0.2072	0.990 49	1.251	0.6105	1.334 87	0.864	1.0000	1.606 36	0.796
0.3070	1.083 71	1.102	0.6982	1.399 92	0.838			
				Tetrachloroethylene (1) + 2-Methyl-1-Propanol (2)				
0.0000	0.794 34	2.872	0.4057	1.142 15	1.353	0.8032	1.456 23	0.918
0.1124	0.893 87	2.280	0.5099	1.226 64	1.182	0.9080	1.536 32	0.857
0.2157	0.983 16	1.855	0.5996	1.298 01	1.077	1.0000	1.606 36	0.796
0.3156	1.067 59	1.552	0.7145	1.387 84	0.977			
				Tetrachloroethylene (1) + 3-Methyl-1-Butanol (2)				
0.0000	0.801 74	2.960	0.4163	1.123 38	1.524	0.8214	1.452 87	0.934
0.0975	0.875 71	2.635	0.5256	1.210 41	1.293	0.9161	1.533 40	0.864
0.2467	0.990 53	2.045	0.6182	1.285 11	1.148	1.0000	1.606 36	0.796
0.3283	1.054 14	1.773	0.7334	1.379 48	1.013			
				Tetrachloroethylene (1) + 2-Butanol (2)				
0.0000	0.798 91	2.492	0.4016	1.140 46	1.127	0.8032	1.456 01	0.852
0.1024	0.888 81	1.918	0.5142	1.231 12	1.005	0.9108	1.538 16	0.822
0.2130	0.983 73	1.508	0.6125	1.308 70	0.930	1.0000	1.606 36	0.796
0.3172	1.071 10	1.263	0.7018	1.378 10	0.884			
				Tetrachloroethylene (1) + 2-Methyl-2-Propanol (2)				
0.0000	0.776 16	3.318	0.4102	1.126 96	1.122	0.8124	1.455 19	0.852
0.1027	0.865 36	2.160	0.5188	1.217 05	1.006	0.9075	1.531 58	0.821
0.2143	0.961 32	1.557	0.6036	1.286 55	0.946	1.0000	1.606 36	0.796
0.3299	1.059 54	1.249	0.7072	1.370 55	0.895			

Table 4. Binary Parameters of Eq 2 and Standard Deviation $\sigma(V^E)$ at 303.15 K

	cm^3·mol^{-1}			
system	a_0	a_1	a_2	$\sigma(V^E)$
tetrachloroethylene + 2-propanol	0.7323	0.8043	0.5254	0.003
tetrachloroethylene + 2-methyl-1-propanol	0.7054	0.7740	0.2929	0.003
tetrachloroethylene + 3-methyl-1-butanol	0.5304	0.6641	0.2975	0.002
tetrachloroethylene + 2-butanol	1.4143	0.6935	0.5605	0.004
tetrachloroethylene + 2-methyl-2-propanol	1.9514	−0.0752	1.0642	0.004

alcohols interact more strongly than branched alcohols. This may be attributed to the steric hindrance of the methyl groups in branched alcohols. The algebraic values of V^E fall in the order 2-methyl-2-propanol > 2-butanol > 2-propanol > 2-methyl-1-propanol > 3-methyl-1-butanol.

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