Density, Viscosity, Refractive Index, and Speed of Sound in Binary Mixtures of 2-Ethoxyethanol with *n*-Alkanes (C_6 to C_{12}), 2,2,4-Trimethylpentane, and Cyclohexane in the Temperature Interval 298.15–313.15 K

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Experimental results of density, viscosity, refractive index, and speed of sound in mixtures of 2-ethoxyethanol with *n*-alkanes (C_6 to C_{12}), 2,2,4-trimethylpentane, and cyclohexane are presented over the entire composition range at 298.15, 303.15, 308.15, and 313.15 K. These results are fitted simultaneously with mixture composition and temperature to an empirical equation. The computed values of excess molar volume and deviations in viscosity, molar refractivity, speed of sound, and isentropic compressibility are fitted to the Redlich–Kister polynomial equation to estimate the adjustable parameters and standard deviations. The effect of the size and shape of the alkanes on excess quantities is discussed. Excess molar volumes and deviations in viscosities show a systematic increase with increasing temperature. However, the deviations in molar refractivities are not dependent on temperature.

Introduction

Binary mixtures of a polar liquid with alkanes have been known to exhibit interesting physicochemical properties (*1–6*). On the other hand, binary mixtures of 2-alkoxy alcohols with various other liquids have been studied in the literature (*7–14*). However, to the best of our knowledge, extensive physical data on binary mixtures of 2-ethoxyethanol, also known as ethyl cellosolve, with alkanes have not been published. 2-Ethoxyethanol is a useful solvent used in analytical and industrial research. Therefore, in this study, experimental values of density ϱ, viscosity η, refractive index n, and speed of sound u for the binary mixtures of 2-ethoxyethanol with hexane, heptane, octane, nonane, decane, dodecane, 2,2,4-trimethylpentane, and cyclohexane at 298.15, 303.15, 308.15, and 313.18 K over the whole range of mixture compositions are presented. From these data, excess molar volume V^E and changes in viscosity $\Delta\eta$, molar refractivity ΔR, speed of sound Δu, and isentropic compressibility Δk_S have been calculated. These results are fitted to the Redlich–Kister polynomial (*15*) to estimate the adjustable parameters and standard deviations between the calculated and experimental results. The calculated results are discussed in terms of the binary interactions and the effect of alkane chain length in addition to their shapes when mixed with 2-ethoxyethanol.

Experimental Section

Materials. The chemicals, viz., 2-ethoxyethanol, heptane, octane, nonane, decane, and dodecane (all from S.D. Fine Chemicals Pvt. Ltd., Bombay), hexane (Sarabhai Chemicals, Bombay), 2,2,4-trimethylpentane (B.D.H. Chemicals Ltd., England), and cyclohexane (B.D.H. Laboratories, Division of Glaxo Laboratories, Bombay), were high purity grade solvents. These solvents were used directly as supplied. GLC analyses were done to test their purities using a flame ionization detector (Nucon series, model 5700/5765, with fused silica columns) having a sensitivity better than 10^{-8} g of fatty acid/μL of solvent.

Measurements. Binary mixtures were prepared by mixing the appropriate volumes of pure liquids in specially designed ground glass air tight bottles and weighed in a single-pan Mettler balance (Switzerland, model AE-240) to an accuracy of ±0.01 mg. The possible error in mole fractions is estimated to be around ±0.0001.

Densities were measured using a pycnometer (Lurex, New Jersey) having a bulb volume of 15 cm^3 and a fine capillary with an internal diameter of 1 mm. These results were reproducible within ±0.0002 g·cm^{-3}. Refractive indices for the sodium-D line were measured with a thermostatically controlled Abbe refractometer (Bellingham and Stanley Ltd., London) with an accuracy of ±0.0001. Viscosities were measured with a Cannon Fenske viscometer (size 100, Industrial Research glassware Ltd., New Jersey). Flow times were reproducible within ±0.01 s, and the measured viscosities are accurate to ±0.001 mPa·s. Speeds of sound were measured within a precision of ±2 m·s^{-1} using a variable path single crystal interferometer (model M-84, Mittal Enterprises, New Delhi). A steel cell fitted with a quartz crystal of 1 MHz frequency was used. Details of the apparatus and experimental procedures used in the above measurements are the same as described previously (*4–6*). The isentropic compressibilities, k_s calculated as $k_s = u^{-2}\varrho$, are accurate to ±1.5 TPa^{-1}.

In all property measurements, triplicate measurements were made and the average of these runs was considered. An INSREF (model 016 AP) thermostat having a digital display of temperature control within ±0.01 K at the desired temperature was used in the measurement of physical properties.

Results

Table 1 presents experimental densities, viscosities, refractive indices, and speeds of sound of all the liquids at 298.15 K used in this work as well as the accepted literature values (*6, 16–28*). The estimated mole percent purities are also included.

Experimental results of ϱ, n, u, and η for the binary mixtures at four temperatures are given in Table 2. These values are fitted simultaneously to study the effect of

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

liquid (mol % purity)	ϱ/(g·cm^{-3}) exptl	ϱ/(g·cm^{-3}) lit.	η/(mPa·s) exptl	η/(mPa·s) lit.	n exptl	n lit.	u/(m·s^{-1}) exptl	u/(m·s^{-1}) lit.
2-ethoxyethanol (99.5)	0.9253	0.9252 (*16*)	1.784	1.850 (*16*)	1.4054	1.4057 (*16*)	1296	
hexane (99.3)	0.6606	0.6552 (*17*)	0.311	0.298 (*6*)	1.3727	1.3725 (*18*)	1073	1076 (*19*)
heptane (99.6)	0.6794	0.6795 (*20*)	0.395	0.397 (*16*)	1.3848	1.3851 (*21*)	1133	1130 (*19*)
octane (99.7)	0.6986	0.6985 (*20*)	0.510	0.506 (*6*)	1.3944	1.3951 (*20*)	1180	1172 (*19*)
nonane (99.6)	0.7145	0.7140 (*22*)	0.650	0.657 (*22*)	1.4034	1.4035 (*18*)	1209	1209 (*5*)
decane (99.5)	0.7266	0.7266 (*18*)	0.832	0.843 (*22*)	1.4090	1.4096 (*23*)	1238	1234 (*19*)
dodecane (99.2)	0.7461	0.7457 (*24*)	1.331	1.345 (*22*)	1.4190	1.4197 (*24*)	1284	1278 (*25*)
cyclohexane (99.4)	0.7737	0.7737 (*19*)	0.877	0.898 (*26*)	1.4232	1.4231 (*27*)	1266	1254 (*28*)
2,2,4-trimethylpentane (99.5)	0.6885	0.6877 (*6*)	0.462	0.478 (*6*)	1.3884	1.3892 (*6*)	1080	1084 (*6*)

temperature and composition using (*29*)

$$Y(T,x_1) = \{[a_0 \exp(a_1 T)](b_0 + b_1 x_1 + b_2 x_1^2 + b_3 x_1^3)\}^{1/2} \quad (1)$$

This equation calculates the property Y (=ϱ, n, u, and η) for any values of T and x_1 of the mixture. The estimated coefficients and standard errors are listed in Table 3. Equation 1 fits the experimental data within the average uncertainty of experimental errors in the temperature range of $298.15 \leq T/\mathrm{K} \leq 313.15$ and composition range of $0 \leq x_1 \leq 1$.

Experimental densities of the binary mixtures are used to calculate V^E as

$$V^E/(\mathrm{cm^3 \cdot mol^{-1}}) = x_1 M_1(\varrho_m^{-1} - \varrho_1^{-1}) + x_2 M_2(\varrho_m^{-1} - \varrho_2^{-1}) \quad (2)$$

where x_1, ϱ_1, and M_1 are the mole fraction, density, and molecular weight of 2-ethoxyethanol. The same symbols with subscript 2 refer to alkanes. The ϱ_m is the density of the mixture at a given composition.

In order to obtain further information on intermolecular interactions in 2-ethoxyethanol + alkane mixtures, the deviations in viscosity $\Delta\eta$, molar refractivity ΔR, speed of sound Δu, and isentropic compressibility Δk_s have been calculated, respectively, from viscosity, refractive index, and speed of sound data using the general equation (5)

$$\Delta Y = Y_m - Y_1 C_1 - Y_2 C_2 \quad (3)$$

where ΔY refers to $\Delta\eta$, ΔR, Δu, and Δk_s. Y_m is the measured mixture property under consideration, i.e., viscosity, molar refractivity, speed of sound, and isentropic compressibility; C_1 and C_2 are the mixture compositions containing components 1 and 2. To calculate $\Delta\eta$ and Δu, mole fraction x_i is used for C_i.

For the calculation of ΔR, the Lorentz–Lorenz relation (*30, 31*) for refractivity R_i is used:

$$R_i = [(n_i^2 - 1)/(n_i^2 + 2)](M_i/\varrho_i) \quad (4)$$

Following the general practice in the literature (*32–34*), ΔR and Δk_s have been calculated on the basis of volume fraction ϕ_i, defined as

$$\phi_i = x_i V_i / \sum_{i=1}^{2} x_i V_i \quad (5)$$

where V_i is the molar volume of the ith component of the mixture. The results of V^E, $\Delta\eta$, ΔR, Δu, and Δk_s have been fitted to the Redlich–Kister polynomial (15),

$$\Delta Y \text{ or } V^E = C_1 C_2 \sum_{i=0}^{4} A_i (C_2 - C_1)^i \quad (6)$$

to estimate the adjustable parameters A_0, A_1, A_2, A_3, and

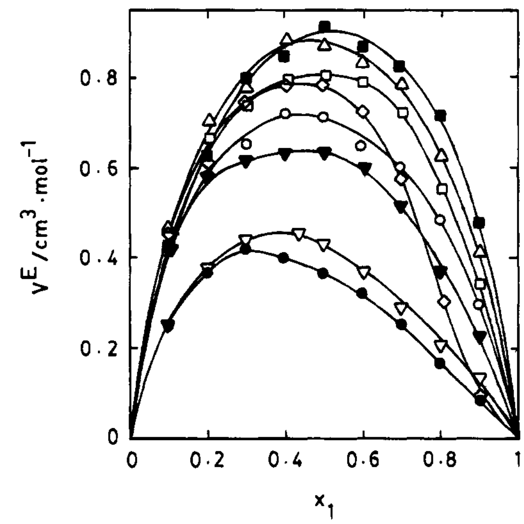

Figure 1. Excess molar volumes at 298.15 K for mixtures of 2-ethoxyethanol with hexane (●), heptane (▼), octane (○), nonane (□), decane (△), dodecane (■), cyclohexane (◇), and 2,2,4-trimethylpentane (▽).

A_4 by the method of least squares using the Marquardt algorithm (*35*). For none of the mixtures does the precision warrant the use of more than five adjustable parameters. The standard deviation σ between the calculated and experimental values is calculated as

$$\sigma(\Delta Y \text{ or } V^E) = [\sum_{i=1}^{m}\{(\Delta Y \text{ or } V^E)_{\mathrm{exptl}} - (\Delta Y \text{ or } V^E)_{\mathrm{calcd}}\}^2/(m - p)]^{1/2} \quad (7)$$

where m is the number of data points and p is the number of estimated parameters. The results of the coefficients A_i and σ values for V^E, $\Delta\eta$, Δu, ΔR, and Δk_s are given in Table 4.

Discussion

Excess molar volumes of the binary mixtures at 298.15 K are presented in Figure 1. The continuous curves represent the calculated values. In all cases, the values of V^E are positive and increase systematically with increasing chain length of the alkanes from C_6 to C_{12}. However, the V^E versus x_1 curves for cyclohexane lie between those of octane- and nonane-containing mixtures. Similarly, the curves for 2,2,4-trimethylpentane lie between those of hexane and heptane. Several contributions may appear in the interaction of 2-ethoxyethanol with alkanes, but the net effect leading to positive values of V^E may be due to the decrease in dipole–dipole interactions between the mixing molecules. The progressive increase in V^E is directly related to an increase in the length of the alkane chains. The observed maxima in V^E vs x_1 curves tend to

Table 2. Experimental Densities (ϱ), Viscosities (η), Refractive Indices (*n*), and Speeds of Sound (*u*) of Binary Mixtures at Different Temperatures

x_1	ϱ/(g·cm^{-3})	η/(mPa·s)	n	u/(m·s^{-1})	x_1	ϱ/(g·cm^{-3})	η/(mPa·s)	n	u/(m·s^{-1})
				2-Ethoxyethanol (1) + Hexane (2)					
				298.15 K					
0.0000	0.6606	0.311	1.3727	1073	0.5958	0.7970	0.716	1.3898	1146
0.0967	0.6789	0.335	1.3749	1076	0.6979	0.8262	0.875	1.3929	1170
0.1963	0.6994	0.376	1.3776	1082	0.7955	0.8562	1.087	1.3966	1213
0.2958	0.7213	0.433	1.3800	1089	0.8993	0.8900	1.452	1.4007	1252
0.3940	0.7444	0.504	1.3829	1099	1.0000	0.9253	1.784	1.4054	1296
0.4948	0.7700	0.595	1.3856	1116					
				303.15 K					
0.0000	0.6559	0.296	1.3709		0.5958	0.7925	0.663	1.3875	
0.0967	0.6738	0.318	1.3723		0.6979	0.8218	0.803	1.3905	
0.1963	0.6947	0.357	1.3749		0.7955	0.8516	0.987	1.3949	
0.2958	0.7166	0.406	1.3776		0.8993	0.8855	1.315	1.3985	
0.3940	0.7396	0.472	1.3802		1.0000	0.9208	1.587	1.4033	
0.4948	0.7655	0.554	1.3835						
				308.15 K					
0.0000	0.6511	0.284	1.3684		0.5958	0.7878	0.615	1.3853	
0.0967	0.6688	0.303	1.3700		0.6979	0.8170	0.741	1.3891	
0.1963	0.6898	0.339	1.3725		0.7955	0.8468	0.907	1.3927	
0.2958	0.7116	0.385	1.3749		0.8993	0.8807	1.199	1.3965	
0.3940	0.7349	0.443	1.3778		1.0000	0.9161	1.427	1.4014	
0.4948	0.7606	0.517	1.3814						
				313.15 K					
0.0000	0.6464	0.270	1.3653		0.5958	0.7830	0.573	1.3832	
0.0967	0.6641	0.290	1.3670		0.6979	0.8125	0.686	1.3871	
0.1963	0.6851	0.322	1.3699		0.7955	0.8422	0.829	1.3904	
0.2958	0.7069	0.361	1.3725		0.8993	0.8751	1.083	1.3952	
0.3940	0.7301	0.415	1.3757		1.0000	0.9116	1.281	1.4000	
0.4948	0.7560	0.484	1.3799						
				2-Ethoxyethanol (1) + Heptane (2)					
				298.15 K					
0.0000	0.6794	0.395	1.3848	1133	0.6074	0.7995	0.720	1.3930	1180
0.1091	0.6957	0.422	1.3851	1134	0.6986	0.8243	0.922	1.3956	1202
0.1973	0.7107	0.455	1.3859	1136	0.7990	0.8545	1.120	1.3995	1228
0.2990	0.7300	0.510	1.3876	1137	0.8989	0.8876	1.390	1.4016	1255
0.4000	0.7508	0.585	1.3894	1146	1.0000	0.9253	1.784	1.4054	1296
0.5014	0.7735	0.671	1.3915	1159					
				303.15 K					
0.0000	0.6750	0.375	1.3824		0.6074	0.7950	0.673	1.3915	
0.1091	0.6913	0.398	1.3825		0.6986	0.8198	0.843	1.3934	
0.1973	0.7063	0.428	1.3832		0.7990	0.8498	1.013	1.3977	
0.2990	0.7254	0.478	1.3850		0.8989	0.8830	1.247	1.4000	
0.4000	0.7462	0.541	1.3869		1.0000	0.9208	1.587	1.4033	
0.5014	0.7689	0.619	1.3891						
				308.15 K					
0.0000	0.6707	0.356	1.3796		0.6074	0.7903	0.630	1.3886	
0.1091	0.6867	0.377	1.3800		0.6986	0.8151	0.772	1.3908	
0.1973	0.7017	0.404	1.3823		0.7990	0.8451	0.927	1.3945	
0.2990	0.7208	0.449	1.3825		0.8989	0.8783	1.133	1.3980	
0.4000	0.7416	0.506	1.3849		1.0000	0.9161	1.427	1.4014	
0.5014	0.7642	0.574	1.3873						
				313.15 K					
0.0000	0.6664	0.339	1.3777		0.6074	0.7858	0.592	1.3870	
0.1091	0.6821	0.355	1.3774		0.6986	0.8105	0.713	1.3891	
0.1973	0.6972	0.382	1.3797		0.7990	0.8406	0.844	1.3927	
0.2990	0.7162	0.422	1.3800		0.8989	0.8736	1.026	1.3959	
0.4000	0.7368	0.472	1.3827		1.0000	0.9116	1.281	1.4000	
0.5014	0.7596	0.535	1.3850						
				2-Ethoxyethanol (1) + Octane (2)					
				298.15 K					
0.0000	0.6986	0.510	1.3944	1180	0.5944	0.8001	0.870	1.3973	1203
0.0976	0.7104	0.524	1.3938	1176	0.6962	0.8252	1.003	1.3980	1218
0.1994	0.7251	0.566	1.3940	1176	0.7983	0.8540	1.179	1.4001	1242
0.3003	0.7414	0.619	1.3943	1175	0.8969	0.8861	1.421	1.4020	1267
0.4001	0.7591	0.687	1.3953	1179	1.0000	0.9253	1.784	1.4054	1296
0.5004	0.7790	0.772	1.3959	1188					
				303.15 K					
0.0000	0.6945	0.479	1.3923		0.5944	0.7953	0.795	1.3950	
0.0976	0.7062	0.490	1.3910		0.6962	0.8206	0.911	1.3956	
0.1994	0.7208	0.527	1.3916		0.7983	0.8494	1.069	1.3978	
0.3003	0.7370	0.574	1.3919		0.8969	0.8816	1.279	1.3999	
0.4001	0.7546	0.632	1.3928		1.0000	0.9208	1.587	1.4033	
0.5004	0.7746	0.710	1.3935						

Table 2 (Continued)

x_1	ϱ/(g·cm^{-3})	η/(mPa·s)	n	u/(m·s^{-1})	x_1	ϱ/(g·cm^{-3})	η/(mPa·s)	n	u/(m·s^{-1})
308.15 K									
0.0000	0.6903	0.453	1.3898		0.5944	0.7906	0.732	1.3924	
0.0976	0.7019	0.463	1.3886		0.6962	0.8159	0.834	1.3935	
0.1994	0.7164	0.494	1.3892		0.7983	0.8448	0.972	1.3954	
0.3003	0.7326	0.538	1.3898		0.8969	0.8769	1.155	1.3978	
0.4001	0.7501	0.591	1.3903		1.0000	0.9161	1.427	1.4014	
0.5004	0.7700	0.657	1.3908						
313.15 K									
0.0000	0.6864	0.426	1.3873		0.5944	0.7861	0.673	1.3902	
0.0976	0.6977	0.434	1.3863		0.6962	0.8114	0.763	1.3913	
0.1994	0.7123	0.462	1.3884		0.7983	0.8404	0.896	1.3938	
0.3003	0.7284	0.500	1.3869		0.8969	0.8725	1.050	1.3956	
0.4001	0.7460	0.550	1.3880		1.0000	0.9116	1.281	1.4000	
0.5004	0.7656	0.609	1.3885						
2-Ethoxyethanol (1) + Nonane (2)									
298.15 K									
0.0000	0.7145	0.650	1.4034	1209	0.6010	0.8044	1.024	1.4024	1222
0.0980	0.7245	0.662	1.4025	1208	0.7022	0.8279	1.107	1.4024	1234
0.2031	0.7371	0.696	1.4020	1202	0.8034	0.8556	1.263	1.4027	1250
0.3023	0.7511	0.746	1.4014	1200	0.9003	0.8867	1.469	1.4038	1268
0.4074	0.7676	0.822	1.4018	1205	1.0000	0.9253	1.784	1.4054	1296
0.5050	0.7851	0.900	1.4015	1212					
303.15 K									
0.0000	0.7106	0.608	1.4004		0.6010	0.8001	0.929	1.3998	
0.0980	0.7203	0.620	1.3995		0.7022	0.8235	1.005	1.4000	
0.2031	0.7330	0.646	1.3995		0.8034	0.8511	1.137	1.4004	
0.3023	0.7468	0.690	1.3989		0.9003	0.8821	1.316	1.4019	
0.4074	0.7633	0.753	1.3992		1.0000	0.9208	1.587	1.4033	
0.5050	0.7807	0.821	1.3992						
308.15 K									
0.0000	0.7068	0.569	1.3985		0.6010	0.7956	0.853	1.3975	
0.0980	0.7162	0.577	1.3975		0.7022	0.8189	1.916	1.3978	
0.2031	0.7287	0.601	1.3970		0.8034	0.8465	1.034	1.3980	
0.3023	0.7425	0.640	1.3968		0.9003	0.8775	1.191	1.3995	
0.4074	0.7589	0.697	1.3967		1.0000	0.9161	1.427	1.4014	
0.5050	0.7761	0.757	1.3969						
313.15 K									
0.0000	0.7029	0.535	1.3965		0.6010	0.7912	0.778	1.3948	
0.0980	0.7121	0.537	1.3954		0.7022	0.8144	0.837	1.3956	
0.2031	0.7246	0.558	1.3942		0.8034	0.8420	0.939	1.3957	
0.3023	0.7382	0.596	1.3945		0.9003	0.8729	1.075	1.3969	
0.4074	0.7546	0.642	1.3942		1.0000	0.9116	1.281	1.4000	
0.5050	0.7718	0.698	1.3950						
2-Ethoxyethanol (1) + Decane (2)									
298.15 K									
0.0000	0.7266	0.832	1.4093	1238	0.5978	0.8062	1.128	1.4050	1237
0.0958	0.7347	0.828	1.4078	1231	0.6989	0.8280	1.223	1.4045	1244
0.2018	0.7458	0.851	1.4070	1224	0.7994	0.8541	1.345	1.4043	1256
0.2985	0.7578	0.905	1.4064	1221	0.8984	0.8851	1.512	1.4043	1274
0.4011	0.7719	0.962	1.4058	1224	1.0000	0.9253	1.784	1.4054	1296
0.4984	0.7877	1.046	1.4054	1229					
303.15 K									
0.0000	0.7229	0.774	1.4068		0.5978	0.8018	1.016	1.4026	
0.0958	0.7309	0.767	1.4055		0.6989	0.8238	1.108	1.4025	
0.2018	0.7418	0.785	1.4046		0.7994	0.8495	1.209	1.4025	
0.2985	0.7537	0.827	1.4038		0.8984	0.8806	1.354	1.4025	
0.4011	0.7678	0.879	1.4033		1.0000	0.9208	1.587	1.4033	
0.4984	0.7835	0.946	1.4031						
308.15 K									
0.0000	0.7190	0.721	1.4043		0.5978	0.7973	0.929	1.4003	
0.0958	0.7263	0.709	1.4029		0.6989	0.8191	1.001	1.4000	
0.2018	0.7377	0.725	1.4027		0.7994	0.8449	1.096	1.4001	
0.2985	0.7494	0.766	1.4017		0.8984	0.8759	1.223	1.4000	
0.4011	0.7634	0.806	1.4009		1.0000	0.9161	1.427	1.4014	
0.4984	0.7789	0.866	1.4005						
313.15 K									
0.0000	0.7153	0.673	1.4028		0.5978	0.7929	0.844	1.3977	
0.0958	0.7229	0.661	1.4006		0.6989	0.8147	0.921	1.3977	
0.2018	0.7338	0.681	1.4002		0.7994	0.8405	0.992	1.3977	
0.2985	0.7452	0.705	1.3993		0.8984	0.8714	1.103	1.3979	
0.4011	0.7596	0.744	1.3985		1.0000	0.9116	1.281	1.4000	
0.4984	0.7747	0.797	1.3980						

Table 2 (Continued)

x_1	ϱ/(g·cm^{-3})	η/(mPa·s)	n	u/(m·s^{-1})	x_1	ϱ/(g·cm^{-3})	η/(mPa·s)	n	u/(m·s^{-1})
2-Ethoxyethanol (1) + Dodecane (2)									
298.15 K									
0.0000	0.7461	1.331	1.4190	1284	0.5996	0.8112	1.412	1.4110	1256
0.1001	0.7527	1.288	1.4176	1273	0.6933	0.8291	1.453	1.4099	1262
0.1987	0.7609	1.294	1.4159	1268	0.7988	0.8538	1.529	1.4077	1269
0.3009	0.7706	1.321	1.4152	1258	0.8984	0.8839	1.636	1.4056	1279
0.3972	0.7816	1.339	1.4137	1256	1.0000	0.9253	1.784	1.4054	1296
0.5014	0.7954	1.379	1.4125	1255					
303.15 K									
0.0000	0.7425	1.215	1.4168		0.5996	0.8071	1.284	1.4086	
0.1001	0.7489	1.171	1.4152		0.6933	0.8248	1.317	1.4074	
0.1987	0.7571	1.174	1.4142		0.7988	0.8495	1.387	1.4053	
0.3009	0.7666	1.195	1.4129		0.8984	0.8794	1.465	1.4036	
0.3972	0.7776	1.223	1.4118		1.0000	0.9208	1.587	1.4033	
0.5014	0.7913	1.256	1.4102						
308.15 K									
0.0000	0.7389	1.113	1.4149		0.5996	0.8027	1.166	1.4061	
0.1001	0.7451	1.075	1.4132		0.6933	0.8204	1.191	1.4052	
0.1987	0.7529	1.076	1.4120		0.7988	0.8450	1.254	1.4031	
0.3009	0.7626	1.090	1.4103		0.8984	0.8750	1.316	1.4018	
0.3972	0.7735	1.115	1.4093		1.0000	0.9161	1.427	1.4014	
0.5014	0.7872	1.138	1.4079						
313.15 K									
0.0000	0.7353	1.025	1.4128		0.5996	0.7985	1.063	1.4042	
0.1001	0.7414	0.986	1.4089		0.6933	0.8162	1.082	1.4028	
0.1987	0.7492	0.987	1.4102		0.7988	0.8406	1.139	1.4009	
0.3009	0.7590	0.997	1.4087		0.8984	0.8705	1.191	1.4000	
0.3972	0.7696	1.020	1.4083		1.0000	0.9116	1.281	1.4000	
0.5014	0.7830	1.045	1.4055						
2-Ethoxyethanol (1) + Cyclohexane (2)									
298.15 K									
0.0000	0.7737	0.877	1.4232	1266	0.5998	0.8545	1.211	1.4086	1248
0.0993	0.7840	0.864	1.4192	1257	0.6974	0.8708	1.341	1.4077	1269
0.2013	0.7970	0.910	1.4163	1246	0.8080	0.8908	1.496	1.4061	1272
0.2968	0.8095	0.961	1.4148	1242	0.9006	0.9078	1.714	1.4052	1286
0.4007	0.8242	1.035	1.4124	1241	1.0000	0.9253	1.784	1.4054	1296
0.4950	0.8381	1.112	1.4104	1241					
303.15 K									
0.0000	0.7691	0.804	1.4203		0.5998	0.8499	1.093	1.4061	
0.0993	0.7791	0.787	1.4163		0.6974	0.8662	1.200	1.4052	
0.2013	0.7921	0.827	1.4136		0.8080	0.8858	1.341	1.4037	
0.2968	0.8047	0.875	1.4116		0.9006	0.9032	1.527	1.4034	
0.4007	0.8194	0.938	1.4099		1.0000	0.9208	1.587	1.4033	
0.4950	0.8335	1.004	1.4078						
308.15 K									
0.0000	0.7643	0.737	1.4175		0.5998	0.8449	0.992	1.4038	
0.0993	0.7740	0.724	1.4139		0.6974	0.8612	1.085	1.4029	
0.2013	0.7870	0.755	1.4111		0.8080	0.8811	1.206	1.4020	
0.2968	0.7996	0.798	1.4092		0.9006	0.8965	1.371	1.4010	
0.4007	0.8145	0.852	1.4069		1.0000	0.9161	1.427	1.4014	
0.4950	0.8284	0.884	1.4052						
313.15 K									
0.0000	0.7596	0.682	1.4148		0.5998	0.8401	0.899	1.4019	
0.0993	0.7692	0.663	1.4109		0.6974	0.8564	0.977	1.4005	
0.2013	0.7822	0.696	1.4052		0.8080	0.8766	1.094	1.4000	
0.2968	0.7951	0.731	1.4070		0.9006	0.8930	1.231	1.3994	
0.4007	0.8097	0.786	1.4049		1.0000	0.9116	1.281	1.4000	
0.4950	0.8237	0.837	1.4031						
2-Ethoxyethanol (1) + 2,2,4-Trimethylpentane (2)									
298.15 K									
0.0000	0.6885	0.462	1.3884	1080	0.6001	0.7971	0.862	1.3951	1151
0.0991	0.7018	0.494	1.3888	1089	0.6976	0.8227	1.006	1.3973	1176
0.1991	0.7169	0.536	1.3895	1092	0.7979	0.8523	1.179	1.3993	1209
0.2975	0.7335	0.595	1.3905	1096	0.8986	0.8860	1.436	1.4019	1248
0.4347	0.7596	0.692	1.3925	1120	1.0000	0.9253	1.784	1.4054	1296
0.4972	0.7729	0.753	1.3934	1128					
303.15 K									
0.0000	0.6844	0.436	1.3860		0.6001	0.7924	0.797	1.3928	
0.0991	0.6975	0.466	1.3865		0.6976	0.8180	0.913	1.3949	
0.1991	0.7126	0.500	1.3873		0.7979	0.8476	1.086	1.3974	
0.2975	0.7291	0.552	1.3883		0.8986	0.8812	1.292	1.4001	
0.4347	0.7552	0.648	1.3900		1.0000	0.9208	1.587	1.4033	
0.4972	0.7684	0.694	1.3910						

Table 2 (Continued)

x_1	ϱ/(g·cm^{-3})	η/(mPa·s)	n	u/(m·s^{-1})	x_1	ϱ/(g·cm^{-3})	η/(mPa·s)	n	u/(m·s^{-1})
				308.15 K					
0.0000	0.6801	0.412	1.3833		0.6001	0.7879	0.738	1.3904	
0.0991	0.6933	0.439	1.3836		0.6976	0.8134	0.839	1.3926	
0.1991	0.7083	0.475	1.3849		0.7979	0.8429	0.993	1.3952	
0.2975	0.7247	0.517	1.3858		0.8986	0.8765	1.167	1.3978	
0.4347	0.7507	0.601	1.3875		1.0000	0.9161	1.427	1.4014	
0.4972	0.7640	0.642	1.3887						
				313.15 K					
0.0000	0.6760	0.391	1.3807		0.6001	0.7834	0.677	1.3878	
0.0991	0.6891	0.415	1.3817		0.6976	0.8089	0.767	1.3905	
0.1991	0.7040	0.445	1.3825		0.7979	0.8383	0.901	1.3931	
0.2975	0.7204	0.483	1.3836		0.8986	0.8719	1.066	1.3956	
0.4347	0.7462	0.560	1.3854		1.0000	0.9116	1.281	1.4000	
0.4972	0.7596	0.597	1.3867						

Table 3. Coefficients and Standard Errors of Eq 1

property	a_0	a_1	b_0	b_1	b_2	b_3	σ
			2-Ethoxyethanol (1) + Hexane (2)				
ϱ/(g·cm^{-3})	0.0183	−0.0024	48.558	27.918	11.928	7.535	0.0007
η/(mPa·s)	0.2258	−0.0181	83.052	727.31	−2846.2	4515.7	0.0570
n	0.0235	−0.0001	82.969	2.771	1.488	−0.1392	0.0029
			2-Ethoxyethanol (1) + Heptane (2)				
ϱ/(g·cm^{-3})	0.0183	−0.0023	49.957	22.912	6.850	13.380	0.0007
η/(mPa·s)	0.2985	−0.0174	81.468	505.148	−1845.1	2710.1	0.0609
n	0.0501	−0.0007	46.578	0.3499	1.169	−0.0501	0.0005
			2-Ethoxyethanol (1) + Octane (2)				
ϱ/(g·cm^{-3})	0.0567	−0.0023	16.793	6.540	0.4261	5.797	0.0008
η/(mPa·s)	0.2079	−0.0175	205.23	586.28	−1844.4	3210.8	0.0600
n	0.0090	−0.0007	261.57	−0.1437	0.9816	3.607	0.0005
			2-Ethoxyethanol (1) + Nonane (2)				
ϱ/(g·cm^{-3})	0.0550	−0.0022	17.651	5.896	−0.8946	7.001	0.0009
η/(mPa·s)	0.1120	−0.0191	−1046.6	−1214.6	2811.8	−7220.3	0.0610
n	−0.0096	−0.0007	−249.98	2.514	−2.210	−1.276	0.0004
			2-Ethoxyethanol (1) + Decane (2)				
ϱ/(g·cm^{-3})	0.0544	−0.0022	18.386	5.489	−2.145	8.105	0.0011
η/(mPa·s)	0.0738	−0.0179	−1769.6	−672.25	810.98	−5465.3	0.0674
n	0.0079	−0.0007	304.55	−4.747	1.852	1.431	0.0004
			2-Ethoxyethanol (1) + Dodecane (2)				
ϱ/(g·cm^{-3})	0.0353	−0.0020	28.989	7.537	−6.874	14.882	0.0015
η/(mPa·s)	0.3931	−0.0202	1623.6	−192.88	275.85	1071.3	0.0720
n	0.0211	−0.0006	114.64	−1.542	−1.621	1.018	0.0006
			2-Ethoxyethanol (1) + Cyclohexane (2)				
ϱ/(g·cm^{-3})	0.0412	−0.0023	28.749	7.680	5.284	−0.4175	0.0005
η/(mPa·s)	0.0234	−0.0165	3804.6	382.57	5680.0	5866.6	0.0823
n	0.0229	−0.0007	109.16	−5.380	3.835	−0.965	0.0008
			2-Ethoxyethanol (1) + 2,2,4-Trimethylpentane (2)				
ϱ/(g·cm^{-3})	0.0335	−0.0023	27.964	11.618	1.415	9.672	0.0006
η/(mPa·s)	0.4285	−0.0184	110.29	395.45	−1156.9	2049.1	0.0551
n	0.0081	−0.0007	290.59	2.670	2.254	2.630	0.0003

shift slightly toward 2-ethoxyethanol-rich region of the mixtures from hexane to decane.

The V^E results of 2-ethoxyethanol + 2,2,4-trimethylpentane mixtures are smaller than those of 2-ethoxyethanol + octane mixtures. This suggests that though 2,2,4-trimethylpentane and octane contain eight carbon atoms, the presence of bulky methyl groups in 2,2,4-trimethylpentane might lead to higher interactions, giving lower positive V^E than water + octane mixtures. On the other hand, the cyclic molecule, viz., cyclohexane with six carbon atoms, exhibits higher V^E than the linear hexane molecule having the same number of carbons. In view of the nonavailability of the V^E data for the present mixtures, we could not directly compare our V^E values with the literature findings. However, considerable work has been published on the thermodynamic properties of binary systems formed by mixing various types of alkanols with alkanes (*36, 37*). In these studies, the positive values of V^E were attributed to the breaking of hydrogen bonds between alkanol and alkane molecules.

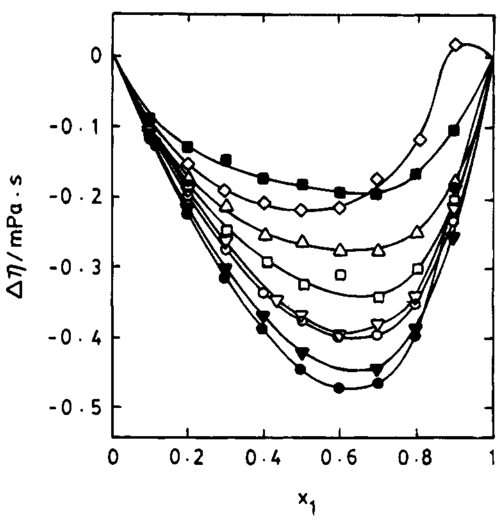

Figure 2. Deviations in viscosity at 298.15 K for the binary mixtures given in Figure 1.

Table 4. Estimated Parameters of Excess Functions

function	T/K	A_0	A_1	A_2	A_3	A_4	σ	function	T/K	A_0	A_1	A_2	A_3	A_4	σ
2-Ethoxyethanol (1) + Hexane (2)															
V^E/(cm^3·mol^{-1})	298.15	1.471	0.890	0.624	0.502	−0.024	0.007	Δu/(m·s^{-1})	298.15	−265.50	21.34	108.86	−7.69	−59.26	3.313
	303.15	1.410	1.333	0.134	0.576	1.750	0.038	Δk_s/TPa^{-1}	298.15	7.70	−211.20	−73.20	121.76	33.48	5.358
	308.15	1.350	1.192	0.151	0.657	2.129	0.036	ΔR/(cm^3·mol^{-1})	298.15	−1.466	0.154	0.036	−0.540	0.084	0.020
	313.15	1.394	1.538	−0.821	−0.760	5.235	0.037		303.15	−1.621	0.272	0.277	−0.332	−0.755	0.021
$\Delta\eta$/(mPa·s)	298.15	−1.770	1.031	−0.943	−0.819	1.611	0.012		308.15	−1.578	0.514	−0.334	−0.733	0.131	0.004
	303.15	−1.514	0.877	−0.881	−0.829	1.662	0.013		313.15	−1.462	−0.024	−1.215	0.650	2.147	0.011
	308.15	−1.319	0.764	−0.757	−0.862	1.565	0.012								
	313.15	−1.135	0.607	−0.656	−0.656	1.371	0.011								
2-Ethoxyethanol (1) + Heptane (2)															
V^E/(cm^3·mol^{-1})	298.15	2.539	0.415	0.910	1.495	0.793	0.016	Δu/(m·s^{-1})	298.15	−223.36	−13.63	101.57	118.46	−149.59	0.817
	303.15	2.614	0.561	0.905	1.107	0.820	0.006	Δk_s/TPa^{-1}	298.15	26.0	−202.80	88.8	206.5	−40.1	1.376
	308.15	2.732	0.587	0.798	1.609	1.516	0.004	ΔR/(cm^3·mol^{-1})	298.15	−4.275	1.068	1.010	−0.268	−2.207	0.024
	313.15	2.908	0.913	0.500	1.286	2.543	0.012		303.15	−4.223	1.163	0.498	0.216	−1.382	0.026
$\Delta\eta$/(mPa·s)	298.15	−1.763	1.084	−0.178	−0.396	−0.376	0.027		308.15	−4.226	0.520	0.171	0.721	0.502	0.047
	303.15	−1.514	0.872	−0.148	−0.251	−0.368	0.020		313.15	−4.269	0.667	−0.063	0.624	−0.208	0.042
	308.15	−1.317	0.741	−0.159	−0.221	−0.226	0.015								
	313.15	−1.138	0.597	−0.136	−0.142	−0.258	0.010								
2-Ethoxyethanol (1) + Octane (2)															
V^E/(cm^3·mol^{-1})	298.15	2.833	0.285	0.668	0.913	1.867	0.019	Δu/(m·s^{-1})	298.15	−198.92	8.56	46.22	8.89	−19.58	1.446
	303.15	3.031	0.159	0.786	1.169	1.582	0.017	Δk_s/TPa^{-1}	298.15	59.40	−157.56	84.32	23.37	−83.71	2.280
	308.15	3.168	0.073	0.784	1.778	1.596	0.014	ΔR/(cm^3·mol^{-1})	298.15	−7.736	1.856	−0.648	0.272	0.063	0.019
	313.15	3.365	−0.206	−0.154	2.684	3.443	0.010		303.15	−7.853	1.868	−0.255	0.715	−1.163	0.026
$\Delta\eta$/(mPa·s)	298.15	−1.501	0.688	−0.520	0.194	−0.128	0.001		308.15	−7.895	1.985	−0.117	0.158	−1.297	0.024
	303.15	−1.300	0.581	−0.438	0.096	−0.042	0.002		313.15	−7.897	2.294	−0.595	−1.308	0.054	0.063
	308.15	−1.134	0.509	−0.402	0.093	−0.054	0.001								
	313.15	−0.987	0.441	−0.293	−0.047	−0.033	0.004								
2-Ethoxyethanol (1) + Nonane (2)															
V^E/(cm^3·mol^{-1})	298.15	3.224	−0.010	1.545	1.129	0.144	0.012	Δu/(m·s^{-1})	298.15	−165.68	27.37	55.91	24.08	−22.56	0.891
	303.15	3.423	0.162	1.483	1.045	0.758	0.006	Δk_s/TPa^{-1}	298.15	58.26	−120.91	76.49	55.46	−139.0	1.234
	308.15	3.659	0.240	1.337	1.460	1.473	0.014	ΔR/(cm^3·mol^{-1})	298.15	−11.648	3.466	−2.175	0.568	1.660	0.020
	313.15	3.904	0.352	1.542	1.481	1.409	0.014		303.15	−11.593	3.274	−1.751	0.899	1.687	0.016
$\Delta\eta$/(mPa·s)	298.15	−1.243	0.400	−0.830	0.540	0.222	0.013		308.15	−11.660	3.336	−2.136	0.642	1.926	0.007
	303.15	−1.083	0.325	−0.670	0.510	0.163	0.011		313.15	−11.789	3.251	−2.300	0.602	1.296	0.028
	308.15	−0.943	0.284	−0.634	0.393	0.186	0.010								
	313.15	−0.829	0.243	−0.531	0.296	0.074	0.007								
2-Ethoxyethanol (1) + Decane (2)															
V^E/(cm^3·mol^{-1})	298.15	3.505	0.096	1.156	0.647	1.685	0.021	Δu/(m·s^{-1})	298.15	−151.91	−8.62	−84.94	50.36	113.2	0.848
	303.15	3.679	0.246	1.429	0.331	1.500	0.016	Δk_s/TPa^{-1}	298.15	73.95	−71.86	197.30	−166.32	−204.6	1.084
	308.15	4.005	−0.067	0.134	2.174	5.026	0.028	ΔR/(cm^3·mol^{-1})	298.15	−16.436	5.440	−1.977	0.871	−0.287	0.006
	313.15	4.193	0.107	1.488	1.119	1.834	0.023		303.15	−16.073	6.007	−3.726	−0.210	1.828	0.049
$\Delta\eta$/(mPa·s)	298.15	−1.056	0.272	−0.678	0.380	−0.068	0.004		308.15	−16.369	5.708	−2.062	−0.250	0.403	0.012
	303.15	−0.940	0.215	−0.481	0.324	−0.187	0.003		313.15	−16.664	5.841	−1.561	−0.006	−1.873	0.027
	308.15	−0.834	0.215	−0.445	0.185	−0.163	0.004								
	313.15	−0.734	0.157	−0.277	0.242	−0.319	0.005								
2-Ethoxyethanol (1) + Dodecane (2)															
V^E/(cm^3·mol^{-1})	298.15	3.593	−0.183	1.117	−0.383	1.681	0.017	Δu/(m·s^{-1})	298.15	−143.19	10.49	40.37	32.04	−84.56	1.411
	303.15	3.876	−0.066	0.994	−0.274	2.475	0.026	Δk_s/TPa^{-1}	298.15	111.27	−113.83	110.90	−9.87	−27.71	1.957
	308.15	4.071	0.048	2.125	0.093	0.613	0.014	ΔR/(cm^3·mol^{-1})	298.15	−27.080	10.776	−4.673	1.588	−1.227	0.028
	313.15	4.333	−0.390	0.898	0.935	3.010	0.017		303.15	−27.150	10.767	−3.913	1.329	−1.769	0.012

$\Delta\eta$/(mPa·s)	298.15	−0.728	0.290	−0.502	−0.299	−0.001	0.003		308.15	−27.207	10.884	−4.656	1.758	−0.188	0.019
	303.15	−0.593	0.163	−0.491	−0.258	0.004	0.004		313.15	−27.506	11.052	0.644	−0.086	−11.75	0.108
	308.15	−0.528	0.135	−0.385	−0.152	−0.068	0.005								
	313.15	−0.446	0.098	−0.419	−0.196	0.074	0.006								
2-Ethoxyethanol (1) + Cyclohexane (2)															
V^E/(cm^3·mol^{-1})	298.15	3.180	0.498	−0.643	3.028	0.609	0.018	Δu/(m·s^{-1})	298.15	−154.71	−71.11	137.44	64.79	−133.38	4.255
	303.15	3.261	0.588	−0.062	3.162	0.569	0.021	Δk_s/TPa^{-1}	298.15	164.87	−143.58	136.40	97.76	143.91	4.824
	308.15	3.416	1.160	−1.722	1.002	5.664	0.043	ΔR/(cm^3·mol^{-1})	298.15	−0.598	−0.138	0.086	−0.356	−1.327	0.018
	313.15	3.511	0.655	−1.227	3.078	3.742	0.022		303.15	−0.598	−0.165	−0.280	−0.235	−0.289	0.013
$\Delta\eta$/(mPa·s)	298.15	−0.844	0.204	−0.426	−1.426	1.495	0.017		308.15	−0.648	−0.089	−0.040	−0.283	0.167	0.011
	303.15	−0.737	0.184	−0.376	−1.326	1.264	0.013		313.15	−0.526	−0.135	−2.099	0.680	1.957	0.076
	308.15	−0.706	0.127	0.042	−1.056	0.577	0.017								
	313.15	−0.565	0.170	−0.370	−1.122	1.013	0.007								
2-Ethoxyethanol (1) + 2,2,4-Trimethylpentane (2)															
V^E/(cm^3·mol^{-1})	298.15	1.725	0.941	−0.162	−0.137	1.232	0.002	Δu/(m·s^{-1})	298.15	−233.18	30.54	−75.81	92.18	175.1	1.878
	303.15	1.866	0.860	0.004	−0.346	1.324	0.006	Δk_s/TPa^{-1}	298.15	−80.23	−111.95	279.22	15.63	−476.4	5.290
	308.15	1.902	0.954	0.004	−0.510	1.205	0.002	ΔR/(cm^3·mol^{-1})	298.15	−7.909	1.938	−0.657	0.260	−0.004	0.008
	313.15	2.005	0.952	−0.059	−0.680	1.391	0.009		303.15	−7.935	2.144	−0.273	−0.058	−0.115	0.002
$\Delta\eta$/(mPa·s)	298.15	−1.475	0.679	−0.414	0.181	0.000	0.004		308.15	−7.957	2.087	0.166	−0.106	−1.141	0.013
	303.15	−1.252	0.541	−0.343	0.090	0.078	0.005		313.15	−7.989	2.010	0.132	−0.572	−0.904	0.021
	308.15	−1.094	0.435	−0.143	0.156	−0.187	0.006								
	313.15	−0.943	0.415	−0.301	−0.033	0.253	0.003								

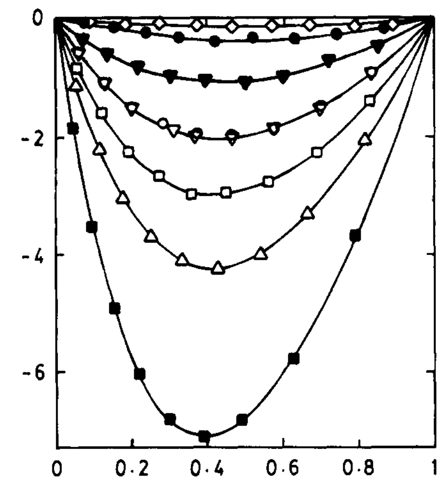

Figure 3. Deviations in molar refractivity at 298.15 K for the binary mixtures given in Figure 1.

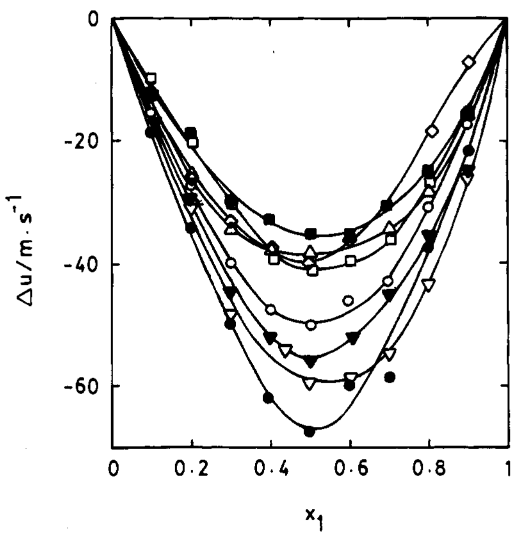

Figure 4. Deviations in speed of sound at 298.15 K for the binary mixtures given in Figure 1.

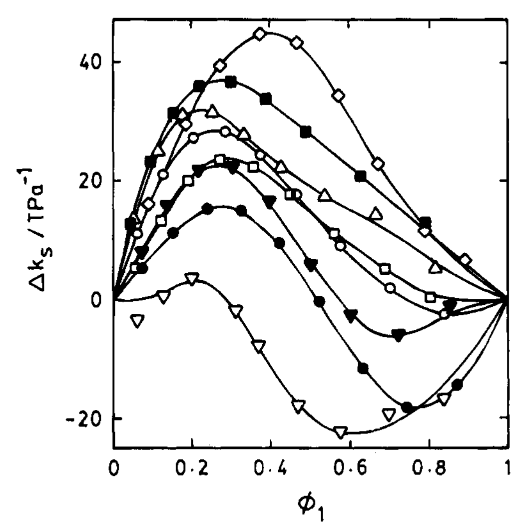

Figure 5. Deviations in isentropic compressibility at 298.15 K for the binary mixtures given in Figure 1.

Deviations in viscosity at 298.15 K for all the binary mixtures are presented in Figure 2. The values of $\Delta\eta$ are negative in all the mixtures and increase with increasing length of n-alkanes. In the case of the 2-ethoxyethanol +

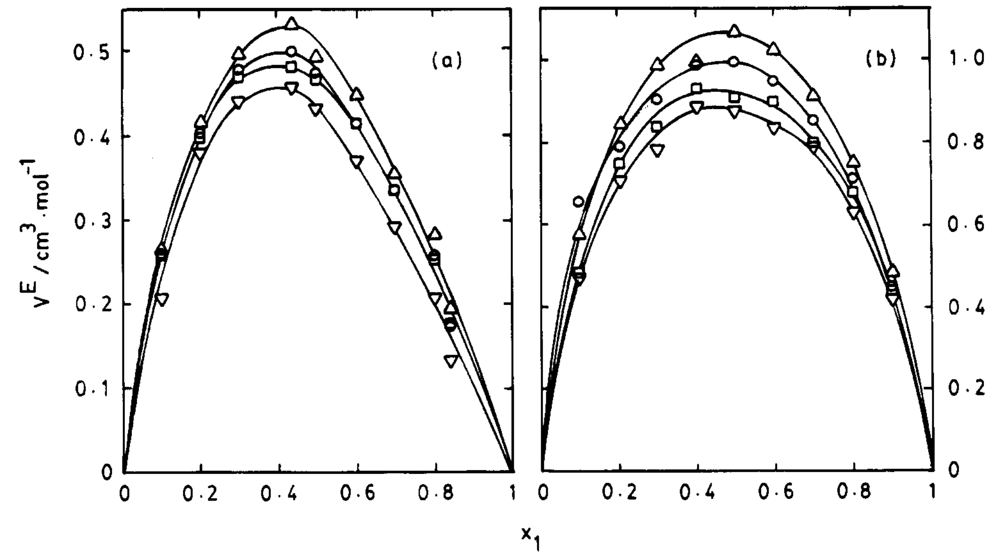

Figure 6. Excess molar volume for 2-ethoxyethanol + (a) 2,2,4-trimethylpentane and (b) decane mixtures at (▽) 298.15 K, (□) 303.15 K, (○) 308.15 K, and (▼) 313.15 K.

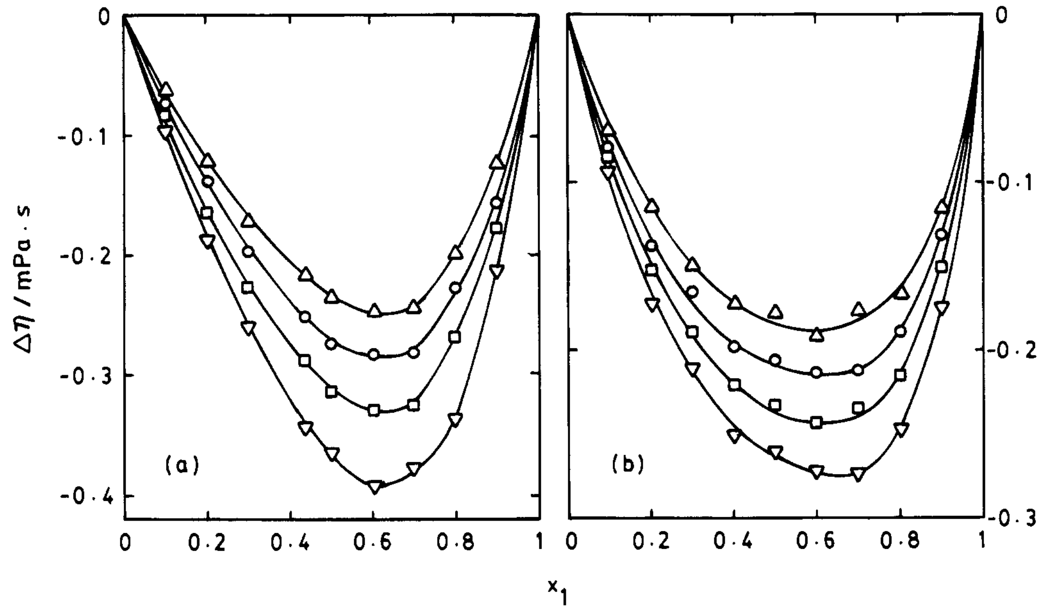

Figure 7. Deviations in viscosity for 2-ethoxyethanol + (a) 2,2,4-trimethylpentane and (b) decane mixtures at the temperature given in Figure 6.

cyclohexane mixture, the $\Delta\eta$ values are higher when compared to 2-ethoxyethanol + hexane mixtures. This further supports the V^E results discussed above for these mixtures, i.e., different behaviors in the transport properties of cyclohexane and hexane molecules in the presence of 2-ethoxyethanol. On the other hand, the shapes of $\Delta\eta$ versus x_1 curves for mixtures of 2-ethoxyethanol with octane or 2,2,4-trimethylpentane are almost identical.

Deviations in molar refractivity, which represent the changes in optical behavior of liquid mixtures due to electronic perturbations during mixing, are presented as a function of volume fraction at 298.15 K in Figure 3. For all mixtures, these values are negative and increase with an increase in chain length of n-alkanes. The values of ΔR for the 2-ethoxyethanol + cyclohexane mixture are close to zero and are higher than those for other mixtures. However, the dependence of ΔR on x_1 for mixtures of 2-ethoxyethanol + 2,2,4-trimethylpentane or + octane is similar over the whole range of mixture composition as shown by a common curve for both these mixtures. This suggests that the presence of side methyl groups in 2,2,4-trimethylpentane does not drastically alter the changes in optical properties even though the same number of carbon atoms are present in both 2,2,4-trimethylpentane and octane molecules. Another noticeable effect in Figure 3 is the large differences in ΔR values between mixtures of 2-ethoxyethanol with decane and dodecane. Such differences in the values of ΔR are small in mixtures containing lower alkanes. This further suggests that the deviations in optical properties become significant as the length of the alkane molecule increases.

Deviations in the speed of sound at 298.15 K are presented in Figure 4. These values are negative for all mixtures and show a systematic trend of increase with increasing size of the n-alkanes. On the whole, the trends in the behavior of Δu versus x_1 curves are quite identical to those of the $\Delta\eta$ versus x_1 curves presented in Figure 2. Here also, the values of Δu for mixtures containing octane are higher than those of the mixtures containing 2,2,4-trimethylpentane. Similarly, the Δu values of 2-ethoxyethanol + cyclohexane mixtures are quite higher than those of 2-ethoxyethanol + hexane mixtures.

The results of deviations in isentropic compressibility versus volume fraction are presented in Figure 5. Sigmoidal shapes are observed for all the mixtures except cyclohexane, decane, and dodecane. For mixtures of 2-ethoxyethanol with 2,2,4-trimethylpentane, hexane, heptane, and octane, the variation of Δk_s with ϕ_1 shows sign inversions. With mixtures containing nonane, decane, and dodecane, the values of Δk_s are positive over the entire composition and the curves are somewhat skewed when compared to the curves for lower n-alkanes. The sigmoidal shapes observed in mixtures of 2-ethoxyethanol with lower n-alkanes (2,2,4-trimethylpentane, hexane, heptane, and octane) result from a shifting imbalance between a relatively large positive contribution due to breaking of the hydrogen-bond structure and a negative contribution from the interstitial accommodation of n-alkane molecules into 2-ethoxyethanol. On the other hand, the interstitial accommodation of n-alkanes into 2-ethoxyethanol multimer structure becomes less effective when the size of the n-alkane is large and the positive contribution from the breaking of hydrogen bonds becomes more predominant, giving positive Δk_s values over the entire volume fraction range for these mixtures. However, a quantitative description of such effects may be found in the extended real associated solution (ERAS) model (*38*).

In the present work, while the effect of temperature on V^E and $\Delta\eta$ values is systematic, the ΔR values are not greatly affected within the temperature interval of 298.15−313.15 K. The V^E results show an increase with increasing temperature in all mixtures except 2-ethoxyethanol + hexane. The effect of V^E on temperature is displayed typically in Figure 6 for mixtures of 2-ethoxyethanol + 2,2,4-trimethylpentane and + decane. The increase in V^E values over the interval of 298.15−313.15 K is more significant with higher alkanes than the lower alkanes, showing the net effect of chain length on ΔV^E values. The temperature variation of $\Delta\eta$ values for mixtures of 2-ethoxyethanol with 2,2,4-trimethylpentane and decane is presented in Figure 7. Here also, we observe a systematic increase in $\Delta\eta$ values with increasing temperature. On the other hand, the ΔR values do not show any dependence on temperature, and hence, these plots are not displayed.

Conclusion

Density, viscosity, refractive index, and speed of sound values for binary mixtures of 2-ethoxyethanol with n-alkanes (C_6 to C_{12}), 2,2,4-trimethylpentane, and cyclohexane are presented as a function of mixture composition at 298.15, 303.15, 308.15, and 313.15 K. These results are used to calculate excess molar volume and deviations in viscosity, molar refractivity, speed of sound, and isentropic compressibility. The results are fitted to the Redlich−Kister polynomial to estimate the adjustable parameters and standard deviations between the observed and fitted quantities. The excess molar volumes are positive and deviations in viscosity, refractivity, and speed of sound are negative over the whole mixture composition at all temperatures. The values of these quantities increase with increasing chain length of the n-alkanes. The deviations in isentropic compressibility show sigmoidal trends with lower n-alkanes. Due to the insolubility of higher alkanes, i.e., tetradecane (C_{14}) and hexadecane (C_{16}), in 2-ethoxyethanol, experiments for these mixtures were not performed.

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