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Excess Molar Isentropic Compressibilities, Excess Molar Volumes, and Excess Sound Speeds of the 1-Propanol + Diethyl Ether + 1-Octanol Ternary Mixture and Constituent Binary Mixtures at 298.15 K

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The sound speeds and densities of the 1-propanol + diethyl ether + 1-octanol ternary mixture and constituent binary mixtures, 1-propanol + diethyl ether, 1-propanol + 1-octanol, and diethyl ether + 1-octanol, have been measured at 298.15 K as a function of composition. Isentropic compressibilities, molar isentropic compressibilities, excess molar isentropic compressibilities, excess molar volumes, and excess sound speeds have been calculated from the experimental density and sound speed data. Excess molar volumes, excess molar isentropic compressibilities, and excess sound speeds of the binary mixtures were fitted to the Redlich–Kister equation. By using the free length theory (FLT), Schaaff's collision factor theory (CFT), Nomoto's relation (NR), Van Deal's ideal mixing relation (IMR), and Junjie's relation (JR), sound-speed values of the investigated mixtures were calculated. These values were compared with the experimental sound-speed results.

KEY WORDS: densities; diethyl ether; isentropic compressibilities; mixtures; 1-octanol; 1-propanol; sound speed.

1. INTRODUCTION

Most fuel oxygenates are used to enhance the octane rating of gasoline aimed at reducing air pollution. Ethers and alkanols are added to gasoline as oxygenates to replace lead based anti-knock agents. A knowledge of the acoustic properties of binary and ternary mixtures is useful in gasoline technology. Transport and acoustic properties of liquid mixtures containing ether and alkanols have been previously reported [1–5]. A study

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Table I. Physical Properties of the Pure Components at 298.15 K

Property	ρ (kg · m^{-3})	u (m · s^{-1})	$A_{p,i}$ (mm^3 · K^{-1} · mol^{-1})	$C_{p,i}$ (J · mol^{-1} · K^{-1})	$K_{S,i}$ (m^3 · PPa^{-1} · mol^{-1})
1-Propanol	Exp. 800.62				
	Lit. 799.982 [13]	Exp. 1208.1			
	799.60 [14]	Lit. 1207.1 [17]	76.57[a]	143.85 [23]	64.2449
	800.62 [15]	1205.42 [18]			
Diethyl-	Exp. 708.3				
ether	Lit. 707.7 [1]	Exp. 982.6			
	708.3 [5]	Lit. 980 [1]	173.91[b]	175.81 [21]	153.0130
1-Octanol	Exp. 821.72	Exp. 1347.9			
	Lit. 821.62 [16]	Lit. 1348 [19]	133.10[c]	305.25 [24]	106.1533
	821.72 [15]	1347.9 [15]			

[a]Derived from measured densities from this study and the isobaric expansivity $\alpha_{p,i}$ in Ref. 20.
[b]Derived from measured densities from this study and the isobaric expansivity $\alpha_{p,i}$ in Ref. 21.
[c]Derived from measured densities from this study and the isobaric expansivity $\alpha_{p,i}$ in Ref. 22.

of the densities of the 1-propanol + diethyl ether binary mixture has been published [6].

Acoustic properties give information about the nature of intermolecular interactions in binary and ternary mixtures. In this work, densities and sound speeds of the 1-propanol + diethyl ether + 1-octanol ternary mixture, and constituent binary mixtures have been measured. Isentropic compressibilities, κ_S, molar isentropic compressibilities, K_S, excess molar isentropic compressibilities, K_S^{E}, and excess molar volumes, $V_{\mathrm{m}}^{\mathrm{E}}$, have been calculated from the experimental densities and sound speeds. These results are used to discuss the nature and the extent of intermolecular interactions in the mixtures. Several theories for predictions of sound speeds have been evaluated based on comparisons of experimental sound speeds from this work with predicted values. These include the free length theory (FLT) [7,8], Schaaff's collision factor theory (CFT) [9], Nomoto's relation (NR) [10], Van Deal's ideal mixing relation (IMR) [11], and Junjie's relation (JR) [12].

2. EXPERIMENTAL

Diethyl ether (>99.5 mass%), 1-propanol (>99 mass%), and 1-octanol (>99 mass%) were obtained from Merck. The purities of these compounds were checked by comparing measured densities and sound speeds with those reported in the literature [1,13–24]. These compounds were used (as received) without further purification. The pure compound densities,

sound speeds, and molar isentropic compressibilities at 298.15 are shown in Table I together with literature data [1, 13–24].

The mixtures in this study were prepared gravimetrically using an electronic balance (Scaltec, SBC22), accurate to 0.01 mg. The precision of the composition determination is estimated to be better than $\pm 1 \times 10^{-4}$ mole fraction. The densities and sound speeds of both pure liquids and liquid mixtures were measured using a vibrating-tube densimeter and sound analyzer, Anton Paar DSA-5000, automatically thermostated at ± 0.01 K. The calibration of the apparatus was carried out with air and deionized double-distilled water. The precision of the instrument is reported to be $3 \times 10^{-6}\,\mathrm{g \cdot cm^{-3}}$ for density and $0.1\,\mathrm{m \cdot s^{-1}}$ for sound speed.

3. RESULTS AND DISCUSSION

The values of the density, ρ, sound speed, u, isentropic compressibility, κ_s, molar isentropic compressibility K_S, excess molar volume, V_m^E, excess molar isentropic compressibility, K_S^E, and excess sound speed, u^E, for the 1-propanol + diethyl ether + 1-octanol ternary mixture and constituent binary mixtures, 1-propanol + diethyl ether, 1-propanol + 1-octanol, and diethyl ether + 1-octanol, at 298.15 K, and atmospheric pressure are given in Tables II and III. The density values for 1-propanol + diethyl ether obtained in this study are in agreement, within experimental uncertainty, with density values from the literature [6].

κ_S and K_S have been calculated from the following equations:

$$\kappa_S = \frac{1}{\rho u^2} \tag{1}$$

$$K_s = -(\partial V/\partial p)_S = V\kappa_S = \sum_{i=1}^{N} x_i M_i \Big/ \left(\rho u^2\right) \tag{2}$$

where ρ is the density, V is the molar volume, and x_i and M_i are the mole fraction and molar mass of component i in the mixture, respectively.

The excess molar volume, V^E, is calculated using the expression

$$V^E = \sum_{i=1}^{N} x_i M_i \left(\rho^{-1} - \rho_i^{-1}\right) \tag{3}$$

where ρ is the density of the mixture, ρ_i is the density of pure component i, M_i is the molar mass of component i, x_i is the mole fraction of component i, and N is the number of components.

Table II. Experimental Densities, ρ, and Sound Speeds, u, and Calculated K_s, V^E, K_s^E, and u^E for 1-Propanol + Diethyl Ether, 1-Propanol + 1-Octanol, and Diethyl Ether + 1-Octanol Binary Mixtures at 298.15 K

x_1	ρ (kg·m^{-3})	u (m·s^{-1})	K_s (m^3·PPa^{-1}·mol^{-1})	V^E (10^{-6} m^3·mol^{-1})	K_s^E (m^3·PPa^{-1}·mol^{-1})	u^E (m·s^{-1})
			1-Propanol + diethyl ether			
0.0577	713.7	995.5	145.430	−0.219	−3.058	8.2
0.1159	719.1	1008.2	138.108	−0.403	−5.655	16.1
0.2165	728.3	1028.9	126.745	−0.638	−8.725	27.1
0.3209	738.0	1050.4	115.980	−0.817	−10.705	36.6
0.438	748.7	1075.4	104.956	−0.894	−11.646	45.0
0.543	758.3	1098.8	95.864	−0.879	−11.476	49.9
0.6498	768.3	1124.2	87.197	−0.811	−10.496	51.9
0.7513	777.6	1148.3	79.788	−0.651	−8.509	48.0
0.8515	786.9	1172.6	73.051	−0.439	−5.739	37.2
0.942	795.2	1194.3	67.546	−0.183	−2.447	18.3
			1-Propanol + 1-octanol			
0.045	821.4	1344.4	104.209	−0.030	−0.076	0.2
0.1	821.0	1340.9	101.665	−0.060	−0.335	1.6
0.2098	819.6	1331.6	96.987	−0.036	−0.452	2.7
0.3104	818.1	1322.3	92.685	−0.016	−0.562	3.8
0.4086	816.5	1311.9	88.525	−0.005	−0.627	4.6
0.5096	814.7	1299.8	84.262	0.012	−0.671	5.2
0.6147	812.5	1285.5	79.862	0.017	−0.670	5.5
0.7111	810.3	1270.5	75.818	0.011	−0.665	5.5
0.8051	807.5	1253	72.060	0.026	−0.461	4.4
0.9117	804.1	1230.3	67.735	0.010	−0.272	2.6
			Diethyl ether + 1 octanol			
0.0503	819.2	1337.1	106.198	−0.253	−3.104	17.0
0.1511	813.0	1312	107.030	−0.597	−8.430	43.8
0.25	806.2	1285.4	108.229	−0.892	−13.050	63.5
0.3375	799.5	1260	109.701	−1.113	−16.513	75.8
0.4438	790.4	1226.6	112.110	−1.333	−19.793	84.4
0.5317	782.4	1196.6	114.604	−1.541	−21.709	86.1
0.5775	777.2	1179.3	116.531	−1.523	−21.959	84.4
0.6813	764.5	1139.8	121.272	−1.462	−21.806	77.7
0.8389	741.3	1071.4	131.981	−1.139	−16.959	52.6
0.8765	734.4	1052.7	135.763	−0.933	−14.338	43.0

The excess molar isentropic compressibilities, K_S^E, were estimated by means of the equation,

$$K_S^E = K_S - K_S^{id} \tag{4}$$

Table III. Experimental Densities, ρ, and Sound Speeds, u, and Calculated K_s, V^E, K_s^E, and u^E for 1-Propanol (1) + Diethyl Ether (2) + 1-Octanol (3) at 298.15 K

x_1	x_2	ρ ($kg \cdot m^{-3}$)	u ($m \cdot s^{-1}$)	K_s ($m^3 \cdot PPa^{-1} \cdot mol^{-1}$)	V^E ($m^3 \cdot mol^{-1}$)	κ_s^E ($m^3 \cdot PPa^{-1} \cdot mol^{-1}$)	u^E ($m \cdot s^{-1}$)
0.0488	0.0105	820.8	1342.2	104.010	−0.077	−0.788	8.4
0.0636	0.0424	818.7	1333.4	103.545	−0.185	−2.617	18.7
0.0524	0.8581	732.5	1046.1	133.694	−0.874	−12.990	39.6
0.0498	0.891	725.8	1028.2	137.983	−0.623	−9.749	28.9
0.1056	0.0264	819.2	1334.1	101.601	−0.134	−1.818	14.4
0.1093	0.0643	816.8	1324.1	101.705	−0.271	−3.904	25.9
0.1167	0.1388	811.7	1303.8	102.025	−0.516	−7.787	45.7
0.1242	0.1895	807.9	1288.7	102.314	−0.671	−10.174	56.6
0.1115	0.3016	799.4	1256.7	104.557	−0.989	−14.847	74.4
0.1082	0.4386	786.8	1210.6	108.103	−1.251	−18.704	83.5
0.1074	0.573	772.0	1160.6	112.875	−1.388	−20.384	81.2
0.0858	0.7573	747.0	1085.1	124.502	−1.157	−17.191	57.8
0.089	0.8279	734.4	1050.1	130.540	−0.909	−13.265	41.3
0.1206	0.8097	734.3	1048.7	128.888	−0.868	−12.637	39.9
0.2117	0.0368	816.9	1321.3	97.272	−0.129	−2.368	18.0
0.2157	0.1487	809.1	1290.6	97.921	−0.540	−8.298	49.2
0.233	0.2159	803.3	1267.4	98.213	−0.730	−11.158	62.0
0.2167	0.325	794.3	1234.4	100.722	−1.048	−15.370	76.8
0.212	0.4581	780.3	1185.2	104.869	−1.236	−18.185	80.8
0.1968	0.5927	763.9	1131.9	111.339	−1.280	−18.491	72.3
0.2086	0.6906	747.0	1080.9	117.976	−1.024	−15.006	53.1
0.3246	0.0406	814.8	1308.6	92.527	−0.128	−2.628	20.0
0.3158	0.1524	806.4	1276.5	93.956	−0.511	−8.244	50.0
0.3538	0.2201	799.3	1248.0	93.571	−0.686	−10.850	61.8
0.3731	0.2324	797.4	1240.1	93.117	−0.700	−11.138	62.9
0.3272	0.4585	773.5	1158.4	101.643	−1.067	−16.113	72.3
0.3552	0.5317	761.0	1117.0	104.551	−1.036	−15.039	62.2
0.4179	0.0641	811.2	1290.8	88.766	−0.198	−3.886	27.9
0.4335	0.1502	803.6	1260.7	89.074	−0.499	−7.973	49.8
0.4578	0.2193	795.8	1230.3	89.554	−0.650	−10.303	59.8
0.4525	0.3444	781.3	1179.2	93.322	−0.864	−13.253	67.4
0.4478	0.452	766.6	1130.3	97.910	−0.965	−13.853	62.2
0.5205	0.1045	805.3	1263.1	84.929	−0.335	−5.777	39.1
0.5545	0.1455	800.2	1242.1	84.214	−0.450	−7.378	47.6
0.5425	0.2397	790.3	1205.9	86.728	−0.700	−10.516	60.2
0.5537	0.3471	775.5	1154.1	89.833	−0.866	−12.228	61.7
0.6429	0.0536	806.6	1260.9	79.425	−0.142	−3.128	24.2
0.6333	0.1583	795.9	1221.7	81.376	−0.472	−7.508	48.2
0.6512	0.248	783.5	1176.0	83.248	−0.645	−9.565	54.8
0.7296	0.0736	801.9	1237.6	76.091	−0.218	−3.920	29.1
0.748	0.1445	792.6	1202.0	76.752	−0.417	−6.382	42.2
0.8343	0.0559	800.0	1222.3	71.750	−0.151	−2.780	21.6

Table III. continued

x_1	x_2	ρ (kg · m^{-3})	u (m · s^{-1})	K_s (m^3 · PPa^{-1} · mol^{-1})	V^E (m^3 · mol^{-1})	κ_s^E (m^3 · PPa^{-1} · mol^{-1})	u^E (m · s^{-1})
0.8761	0.0248	802.1	1226.8	69.610	−0.043	−1.347	11.8
0.8711	0.0767	795.8	1203.7	70.685	−0.218	−3.422	25.3
0.9237	0.0203	800.9	1217.6	67.617	−0.041	−1.039	9.0
0.392	0.4566	769.7	1143.3	99.648	−1.009	−14.974	67.3

where the molar isentropic compressibilities for the ideal mixture, K_S^{id}, were calculated by the following relation [25,26]:

$$K_S^{id} = \sum_i x_i \left[K_{S,i} - T A_{p,i} \left\{ \left(\sum x_i A_{p,i} \Big/ \sum x_i C_{p,i} \right) - \left(A_{p,i} / C_{p,i} \right) \right\} \right] \quad (5)$$

where $A_{p,i}$ (the product of the molar volume V_i and the isobaric expansivity $\alpha_{p,i}$), $C_{p,i}$ (isobaric molar heat capacity), and $K_{S,i}$ (molar isentropic compressibility) are properties of the pure liquid component i.

The excess sound speed, u^E, of each sample with respect to ideal behavior is defined by the equation,

$$u^E = u - u^{id} = u - \left(\rho^{id} \kappa_S^{id} \right)^{-1/2} \quad (6)$$

where u is the sound speed of the mixture, $\rho^{id} = \sum_{i=1} \phi_i \rho_i$ is the density of the corresponding ideal mixture [27], and ρ_i is the density of pure component i. ϕ_i is defined by the relation,

$$\phi_i = \frac{x_i V_i}{\left(\sum_i x_i V_i \right)} \quad (7)$$

The excess molar volumes, V^E, excess molar isentropic compressibilities, K_S^E, and excess sound speeds, u^E, of the binary mixtures were fitted with a Redlich–Kister equation [28];

$$R_{ij} = x_i x_j \sum_{k=0}^{m} A_k (x_i - x_j)^k \quad (8)$$

where R_{ij} is V^E, K_S^E, and u^E, x_i is the mole faction of component i, A_k is the polynomial coefficient, k is the number of polynomial coefficients, and

Table IV. Values of the Parameter A_i of the Redlich–Kister Equation and C_i of Cibulka's Equation, and Corresponding Standard Deviations, σ, at 298.15 K

	A_0	A_1	A_2	A_3	σ
		1-Propanol + diethyl ether			
V^E (10^{-6} m$^3 \cdot$ mol^{-1})	−3.598	0.247	−0.140	0.113	0.005
u^E (m $\cdot$ s^{-1})	193.2	92.3	65.3	11.7	0.1
K_s^E (m$^3 \cdot$ PPa$^{-1} \cdot$ mol^{-1})	−46.722	4.053	−5.587	3.679	0.032
		1-Propanol + 1-octanol			
V^E (10^{-6} m$^3 \cdot$ mol^{-1})	0.044	0.133	−0.361	0.533	0.006
u^E (m $\cdot$ s^{-1})	20.9	9.9	4.1	1.1	0.2
K_s^E (m$^3 \cdot$ PPa$^{-1} \cdot$ mol^{-1})	−2.696	−0.643	−0.776	0.925	0.035
Diethyl ether + 1-octanol					
V^E (10^{-6} m$^3 \cdot$ mol^{-1})	−5.762	−2.833	−1.570	0.419	0.030
u^E (m $\cdot$ s^{-1})	342.6	24.2	48.9	20.6	0.3
K_s^E (m$^3 \cdot$ PPa$^{-1} \cdot$ mol^{-1})	−83.843	−37.053	−25.777	−13.549	0.122
		1-Propanol + diethyl ether + 1-octanol			
	C_1	C_2	C_3		
V^E (10^{-6} m$^3 \cdot$ mol^{-1})	1.699	2.126	0.469		0.025
u^E (m $\cdot$ s^{-1})	472.4	−111.1	−316.9		1.3
K_s^E (m$^3 \cdot$ PPa$^{-1} \cdot$ mol^{-1})	9.818	4.056	0.854		0.135

m is the number of parameters. The coefficients A_k of Eq. (8) are presented in Table IV.

The excess molar volumes, V^E, excess molar isentropic compressibilities, K_S^E, and excess sound speeds, u^E, of the ternary mixture have been fitted with Cibulka's equation [29]:

$$R = R_{\text{bin}} + x_1 x_2 x_3 (C_1 + C_2 x_1 + C_3 x_2) \tag{9}$$

where R is V^E/m$^3 \cdot$ mol^{-1}, K_S^E/m$^3 \cdot$ PPa$^{-1} \cdot$ mol^{-1}, or u^E/m $\cdot$ s^{-1}. $R_{\text{bin}} = R_{12} + R_{13} + R_{23}$ (with R_{ij} defined by Eq. (8)), and C_i's are adjustable coefficients. C_i was obtained by the method of least squares along with the corresponding root-mean-square deviation, σ. Adjustable coefficients, C_i, of Eq. (9) are presented in Table IV.

The values of the excess molar volume, V^E, the excess molar isentropic compressibility, K_s^E and the excess sound speed, u^E, have been plotted against mole fraction for 1-propanol + diethyl ether, 1-propanol + 1-octanol, and diethyl ether + 1-octanol in Figs. 1 to 3, respectively. Isolines from Cibulka's equation for the ternary system are shown in Figs. 4 to 6, respectively.

The excess molar volumes, V^E, of the ternary mixture and the constituent binary mixtures examined in this study, are negative over the

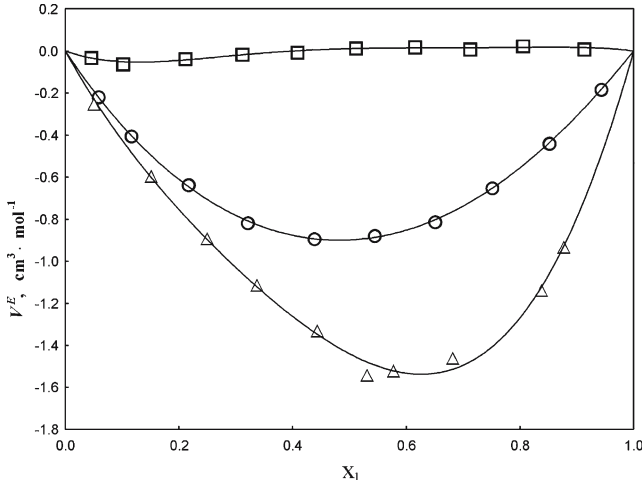

Fig. 1. Excess molar volume, V^{E}, for the binary mixtures at 298.15 K: 1-propanol (1) + diethyl ether (2) (O), 1-propanol (1) + 1-octanol (3) (□), diethyl ether (2) + 1-octanol (3) (Δ), and Redlich–Kister correlations (—).

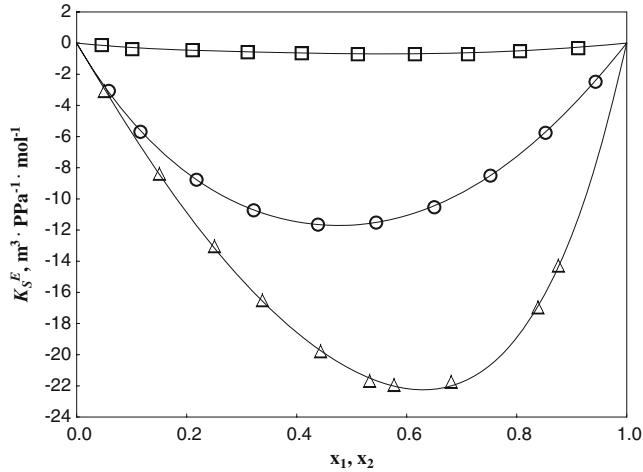

Fig. 2. Excess molar isentropic compressibilities, K_s^{E}, for the binary mixtures at 298.15 K: 1-propanol (1) + diethyl ether (2) (O), 1-propanol (1) + 1-octanol (3) (□), diethyl ether (2) + 1-octanol (3) (Δ), and Redlich–Kister correlations (—).

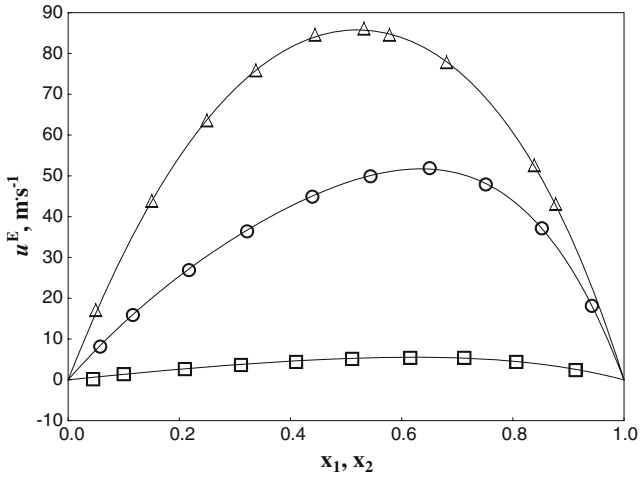

Fig. 3. Excess sound speeds, u^E, for the binary mixtures at 298.15 K: 1-propanol (1) + diethyl ether (2) (O), 1-propanol (1) + 1-octanol (3) (∼), diethyl ether (2) + 1-octanol (3) (Δ), and Redlich–Kister correlations (—).

Fig. 4. Isolines from Cibulka's Eq. (9) for the excess molar volume, V^E (in 10^{-6} m^3 · mol^{-1}) of 1-propanol + diethyl ether + 1-octanol at 298.15 K.

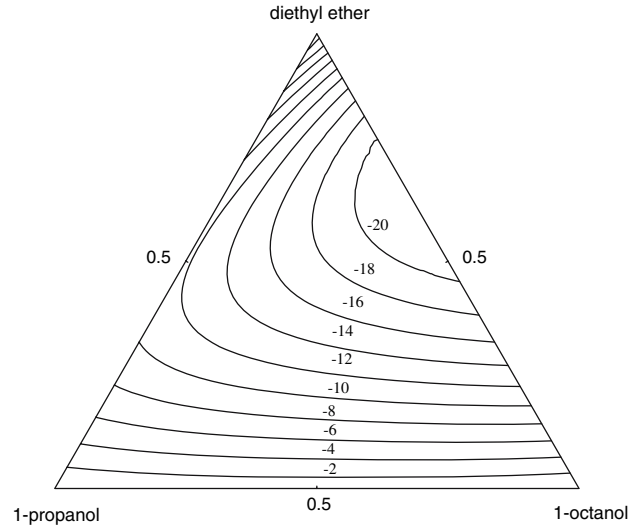

Fig. 5. Isolines from Cibulka's Eq. (9) for the excess molar isentropic compressibility, K_s^E (in $m^3 \cdot PPa^{-1} \cdot mol^{-1}$) of 1-propanol + diethyl ether + 1-octanol at 298.15 K.

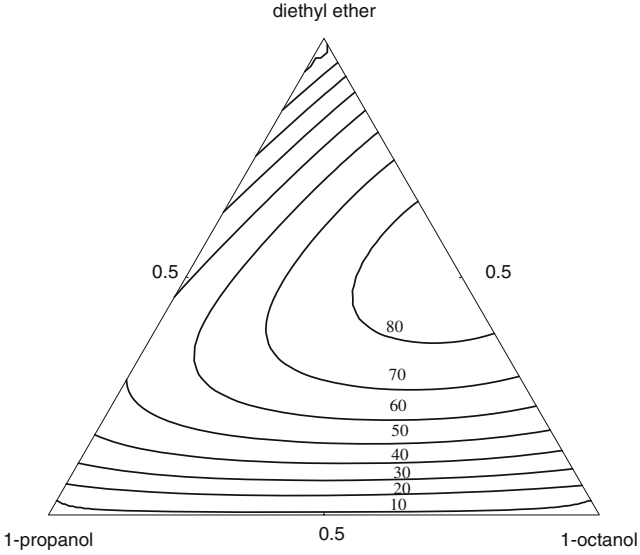

Fig. 6. Isolines from Cibulka's Eq. (9) for excess sound speed, u^E (in $m \cdot s^{-1}$) of 1-propanol + diethyl ether + 1-octanol at 298.15 K.

complete composition range except for 1-propanol + 1-octanol. The excess molar isentropic compressibilities, K_s^E, show negative values over the complete composition range. The excess molar volumes, V^E, for 1-propanol + 1-octanol are negative over the complete composition range except for the mixture with a high mole fraction of 1-octanol. The excess sound speeds, u^E are positive over the whole composition range for all the binary mixtures and the ternary mixture. For all binary liquid mixtures, u^E curves show similar behavior while V^E and K_s^E show an opposite trend (Figs. 1–3).

The observed values of V^E, u^E, and K_s^E (Figs. 1–3) can be evaluated qualitatively in terms of some factors that influence these excess functions. Such factors include (i) the mutual disruption of structural components present in pure liquids (self-associated 1-propanol, 1-octanol, and diethyl ether); (ii) the formation of new hydrogen bonds between dissimilar molecules; and (iii) the geometrical fitting of component molecules into each other's structures. The first one contributes to positive deviations in V^E and K_s^E, indicating weak interactions, while leading to negative deviations in u^E. The last two factors lead to negative deviations in V^E and K_s^E which suggest quite strong and specific interactions, while leading to positive deviations in u^E.

For the ternary mixture the observed values of excess molar isentropic compressibilities, K_s^E excess molar volumes, V^E, and the excess sound speeds, u^E could be explained in terms of the same effects as a function of the mole fraction of the components.

4. THEORETICAL

The empirical and semi-empirical theories of Jacobson, Schaaffs, Nomoto, Van Deal, and Junjie have been used to obtain speeds of sound in binary liquid mixtures.

4.1. Jacobson's Free Length Theory (FLT) [7,8]

$$u = \frac{K}{L\rho_m^{1/2}} \tag{10}$$

where K is a temperature-dependent constant whose value at 298.15 K is 625, ρ_m is the density of the mixture, and L is the free length of the mixture as defined in Refs. 7 and 8.

4.2. Schaaff's CFT [9]

$$u = u_\infty \frac{\left(\sum_{i=1}^{N} x_i s_i\right)\left(\sum_{i=1}^{N} x_i B_i\right)}{V} \tag{11}$$

where $u_\infty = 1600\,\mathrm{m}\cdot\mathrm{s}^{-1}$ and s_i is the space filling factor of component i in the mixture. x_i is the mole fraction. B_i is the actual volume of the molecule per mole of component i.

4.3. Nomoto's Relation [10]

$$u = \left[\frac{\sum_{i=1}^{N} x_i R_i}{\sum_{i=1}^{N} x_i V_i}\right]^3 \tag{12}$$

where R_i and V_i stand for the molar sound speed and molar volume of component i in the mixture, respectively.

4.4. Van Deal's Ideal Mixing Relation [11]

$$\left[\frac{1}{\sum_{i=1}^{N} x_i M_i}\right]\frac{1}{u^2} = \sum_{i=1}^{N} \frac{x_i}{M_i u_i^2} \tag{13}$$

where M_i and $u_i$are the molar mass and speed of sound of component i, respectively.

4.5. Junjie's Relation [12]

$$u = \frac{\sum_{i=1}^{N} (x_i V_i)}{\sum_{i=1}^{N} (x_i M_i)^{1/2}\left[\sum_{i=1}^{N} \frac{x_i V_i}{\rho_i u_i^2}\right]^{1/2}} \tag{14}$$

Table V gives the root-mean-square deviations relative to the sound speeds calculated by Jacobson's FLT, Schaaffs CFT, NR, Van Deal's IMR, and JR. NR gives the best results for all studied mixtures except for 1-propanol + diethyl ether. IMR gives the best results for 1-propanol + diethyl ether. The values predicted by FLT show maximum deviations for 1-propanol + diethyl ether and 1-propanol + 1-octanol systems. This is expected for mixtures containing self-associated liquids, such as 1-propanol in the present systems.

Table V. Root-Mean-Square Deviations Relative to the Predicted Sound Speeds by Means of FLT, CFT, NR, IMR, and JR Theories

	$RMSD_r$ (%)				
	u_{FLT}	u_{CFT}	u_{NR}	u_{IMR}	u_{JR}
1-Propanol + diethyl ether	6.9	1.1	1.2	0.4	2.5
1-Propanol + 1-octanol	5	1.4	0.2	8.1	0.3
Diethyl ether + 1-octanol	2.3	1.8	1.0	11.1	4.2
1-Propanol + diethyl ether + 1-octanol	4.8	1.3	0.9	8.9	3.2

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