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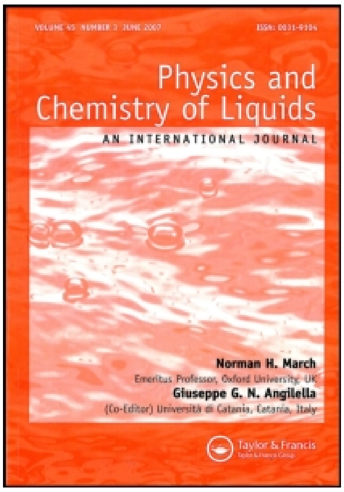

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Temperature and pressure dependence of the volumetric properties of binary liquid mixtures containing 1-propanol and dihaloalkanes

Vanesa Gil-Hernández[a]; Pilar García-Giménez[a]; José Muñoz Embid[a]; Manuela Artal[a]; Inmaculada Velasco[a]
[a] Facultad de Ciencias, Departamento de Química Orgánica - Química Física, Universidad de Zaragoza, Zaragoza - 50009, Spain

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Temperature and pressure dependence of the volumetric properties of binary liquid mixtures containing 1-propanol and dihaloalkanes

VANESA GIL-HERNÁNDEZ, PILAR GARCÍA-GIMÉNEZ,
JOSÉ MUÑOZ EMBID, MANUELA ARTAL
and INMACULADA VELASCO*

Facultad de Ciencias, Departamento de Química Orgánica – Química Física,
Universidad de Zaragoza, Zaragoza – 50009, Spain

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Densities of 1-propanol + dibromomethane, or +bromochloromethane, or +1,2-dichloroethane, or +1-bromo-2-chloroethane binary mixtures were measured at 288.15, 298.15 and 308.15 K, over the entire composition range. Thermal expansion coefficients, α, and excess molar volumes, V_m^E, were calculated. Moreover, densities at 298.15 K and pressures up to 2×10^7 Pa were determined for the same mixtures. Isothermal compressibilities, κ_T, of the pure liquids and their mixtures were obtained.

Keywords: Density; Excess volume; Thermal expansion coefficient; Isothermal compressibility

1. Introduction

Thermodynamic properties for suitably chosen binary mixtures have been studied for examining some theories of mixtures and for understanding the strength and nature of interactions among them. Experimental data of the thermodynamic properties of binary mixtures containing polyhaloalkanes with different halogen atoms in the same molecule are very scarce.

Following our study of the thermodynamic properties of different halogenated aliphatic compounds and their mixtures [1–7], we present here the densities of 1-propanol + dibromomethane, or +bromochloromethane, or +1,2-dichloroethane, or +1-bromo-2-chloroethane binary mixtures at 288.15, 298.15 and 308.15 K. Thermal expansion coefficients, α, and excess molar volumes, V_m^E, were calculated over the entire composition range.

Moreover, densities of the same mixtures at 298.15 K and pressures up to 2×10^7 Pa were determined. Isothermal compressibilities, κ_T, of the pure liquids and their

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*Corresponding author. Fax: 34 976 76 26 88. Tel.: 34 976 76 11 97. Email: curra@unizar.es

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Table 1. Densities, ρ, of the pure liquids at 298.15 K.

	ρ (kg m^{-3})	
Substance	Experimental	Literature [10,13]
Dibromomethane	2478.56	2484.20
Bromochloromethane	1924.88	1923.00
1,2-Dichloroethane	1246.59	1246.37
1-Bromo-2-chloroethane	1727.88	1730.15
1-Propanol	799.73	799.75

mixtures were calculated. There are only previous studies on the mixture 1-propanol + 1,2-dichloroethane [8,9]. As far as we know, there are no previous studies on the other mixtures.

2. Experimental

The liquids used were 1-propanol (> 99.5 mol%), dibromomethane (> 98.5 mol%) and 1,2-dichloroethane (> 99.5 mol%), obtained from Fluka AG Buchs, and bromochloromethane (> 99 mol%) and 1-bromo-2-chloroethane (> 98 mol%), obtained from Aldrich Chem Co. All the liquids were used without further purification. The densities of the pure liquids are listed in table 1.

The excess molar volumes V_m^E were calculated from the density measurement, at $T = 288.15$ K, $T = 298.15$ K and $T = 308.15$ K, obtained in a vibrating-tube digital densimeter (Anton-Paar model DMA 60) equipped with a DMA 602 cell. The densimeter calibration was performed, at atmospheric pressure, by using doubly distilled and degassed water, cyclohexane, and carbontetrachloride [10]. The vibrating-tube temperature was measured by means of an Anton-Paar DM 100-30 digital thermometer, and was regulated to better than ±0.01 K using a GRANT LT-D6G thermostat. The thermometer was previously checked [7] against the vapor pressure of benzene (Merck, >99.9%) along with the equation of Ambrose [11] relating temperature (T_{68}) with pressure by means of a sum of Chebyshev polynomials up to degree six (as recommended by IUPAC [12]).

The mixtures were prepared gravimetrically, and the mole-fraction error was estimated to be less than $\pm 10^{-4}$. Duplicate densities of the pure liquids and mixtures studied agreed to within 2×10^{-2} kg m^{-3}.

The densities (ρ) of the pure components and binary mixtures, over the complete composition range, were measured at $T = 298.15$ K and pressure range from 2×10^5 to 2×10^7 Pa, using the same vibrating-tube digital densimeter with a DMA 512 high pressure cell. High pressure was generated by a liquid pump (model LC-10 AT; Shimazdu). Pressure was measured with a pressure gauge (Gefran), and was calibrated with distilled water and nitrogen using another pressure gauge (Model DPI 145, Druck). The accuracy on measured pressures is about ±0.04%.

The vibrating-tube temperature was measured by means of an Anton-Paar DM 100-30 digital thermometer, and was regulated to better than ±0.01 K using a Neslab RTE-210 thermostat. The oscillation period (τ) of sample in the vibrating U tube was converted into density (ρ) via

$$\rho = A(\tau^2 - B) \tag{1}$$

where A and B are instrument constants determined, at high pressure, by using ethanol and 1,2-dichloroethane as standard fluids [10,13]. The values of parameters A and B, determined from the calibration, were treated as a function of pressure:

$$A = 654.19 - 1.20(10^{-7})P + 6.58(10^{-15})P^2$$

$$B = 15.1475 + 1.31(10^{-11})P + 8.18(10^{-18})P^2$$

The accuracy of the reported densities was estimated to be 0.1 $\mathrm{kg\,m^{-3}}$.

3. Results and discussion

The calculated values of the excess molar volume V_m^E for the studied mixtures are listed in table 2 and plotted againts x in figures 1 and 2. Each set of results was fitted by the ordinary (unweighted) least-squares method by a polynomial of the form:

$$V_\mathrm{m}^\mathrm{E}\ (10^{-6}\,\mathrm{m^3\,mol^{-1}}) = [x(1-x)\Sigma A_i(2x-1)^i] \tag{2}$$

where x is the mole fraction.

The values of the coefficients A_i and the standard deviations σ are given by:

$$\sigma\left(V_\mathrm{m}^\mathrm{E}\right) = \left[\frac{\sum\left(V^\mathrm{E} - V_\mathrm{exp}^\mathrm{E}\right)^2}{(N-M)}\right]^{1/2}, \tag{3}$$

where N is the number of experimental points and M is the number of fitting coefficients, the coefficients determined by the least-squares analysis are reported in table 3.

In order to obtain the thermal expansion coefficients of the pure liquids, the experimental values of densities of each system have been fitted to a polynomial function:

$$\frac{\rho}{1000}\ (\mathrm{kg\,m^{-3}}) = A_{ij}(T - T_0)^{j-1}x^{i-1} \tag{4}$$

where $T_0 = 278.15\,\mathrm{K}$. The coefficients A_{ij} and standard deviations are reported in table 4.

The thermal expansion coefficients α are therefore obtained by using the equation:

$$\alpha(\mathrm{K^{-1}}) = \frac{-1}{\rho}\left(\frac{\delta\rho}{\delta T}\right)_p \tag{5}$$

We have obtained the following values of α for pure liquids: α $(C_3H_8O) = 9.86 \times 10^{-4}\,\mathrm{K^{-1}}$; α $(CH_2Br_2) = 1.047 \times 10^{-3}\,\mathrm{K^{-1}}$; α $(CH_2BrCl) = 1.195 \times 10^{-3}\,\mathrm{K^{-1}}$; α $(ClC_2H_4Cl) = 1.178 \times 10^{-3}\,\mathrm{K^{-1}}$; α $(BrC_2H_4Cl) = 1.120 \times 10^{-3}\,\mathrm{K^{-1}}$. Figure 3 shows the calculated values of α for the studied systems at 298.15 K.

Table 2. Densities, ρ, and excess molar volumes, V_m^E, for the studied mixtures.

	288.15 K		298.15 K		308.15 K	
x	ρ ($kg\,m^{-3}$)	V_m^E ($10^{-9}\,m^3\,mol^{-1}$)	ρ ($kg\,m^{-3}$)	V_m^E ($10^{-9}\,m^3\,mol^{-1}$)	ρ ($kg\,m^{-3}$)	V_m^E ($10^{-9}\,m^3\,mol^{-1}$)
$(1-x)$ 1-Propanol + (x) dibromomethane						
0.0000	807.41	0.0	799.73	0.0	790.96	0.0
0.1079	978.80	39.3	969.34	52.0	958.89	39.7
0.2096	1141.78	121.3	1130.65	140.9	1118.14	152.1
0.3051	1296.17	218.2	1283.66	231.8	1268.79	284.8
0.4036	1457.08	318.2	1443.19	325.4	1426.31	388.0
0.5094	1632.52	396.4	1617.12	396.7	1598.41	451.7
0.6051	1794.80	397.9	1777.88	398.5	1757.91	429.3
0.7087	1974.67	336.9	1955.64	352.2	1934.06	368.5
0.8100	2154.03	254.1	2133.15	274.1	2109.77	285.0
0.9046	2323.88	187.8	2301.59	200.3	2275.78	230.1
1.0000	2501.88	0.0	2478.56	0.0	2451.74	0.0
$(1-x)$ 1-Propanol + (x) bromochloromethane						
0.0000	807.41	0.0	799.73	0.0	790.96	0.0
0.0970	906.27	67.0	897.51	70.0	886.84	131.5
0.2123	1025.97	167.4	1015.82	178.7	1003.91	215.7
0.2908	1109.09	230.3	1097.88	250.4	1084.97	283.2
0.3979	1224.60	316.5	1212.30	323.0	1197.90	352.1
0.5090	1347.74	369.4	1333.59	399.6	1317.83	413.1
0.5938	1443.93	398.7	1428.77	420.0	1411.70	434.2
0.6994	1567.84	362.7	1551.05	388.7	1532.45	393.4
0.7954	1683.47	320.7	1666.10	309.3	1645.26	339.1
0.9032	1819.53	164.5	1799.54	187.1	1777.50	184.8
1.0000	1945.94	0.0	1924.88	0.0	1900.86	0.0
$(1-x)$ 1-Propanol + (x) 1,2-dichloroethane						
0.0000	807.41	0.0	799.73	0.0	790.96	0.0
0.0982	855.64	−138.0	847.18	−120.6	837.58	−104.7
0.1998	902.14	−28.5	892.86	12.2	882.66	25.4
0.3013	947.36	129.4	937.35	182.3	926.76	177.2
0.3963	988.95	285.8	978.76	310.9	967.41	321.3
0.5069	1038.01	364.8	1027.23	386.4	1015.20	395.2
0.6145	1086.54	339.0	1075.08	362.1	1062.15	385.3
0.7052	1127.43	290.6	1115.34	319.3	1101.86	336.8
0.8506	1193.05	161.9	1180.18	180.6	1165.51	208.8
0.9098	1219.37	120.7	1206.26	130.6	1191.43	141.5
1.0000	1260.13	0.0	1246.59	0.0	1231.27	0.0
$(1-x)$ 1-Propanol + (x) 1-bromo-2-chloroethane						
0.0000	807.41	0.0	799.73	0.0	790.96	0.0
0.1012	911.85	−66.4	902.89	−42.7	892.89	−34.8
0.2014	1011.59	−3.5	1001.74	15.7	990.54	31.5
0.2991	1106.39	82.1	1095.84	86.5	1083.42	115.4
0.4042	1206.74	130.6	1195.25	134.4	1181.47	179.3
0.4985	1295.06	163.5	1282.68	171.4	1267.66	231.9
0.6025	1390.52	198.5	1377.30	202.3	1361.17	263.6
0.7004	1479.46	181.4	1465.04	205.5	1448.08	255.9
0.7980	1566.70	153.3	1551.67	166.0	1534.06	197.0
0.9071	1663.16	83.8	1646.80	116.4	1628.48	127.7
1.0000	1744.36	0.0	1727.88	0.0	1708.86	0.0

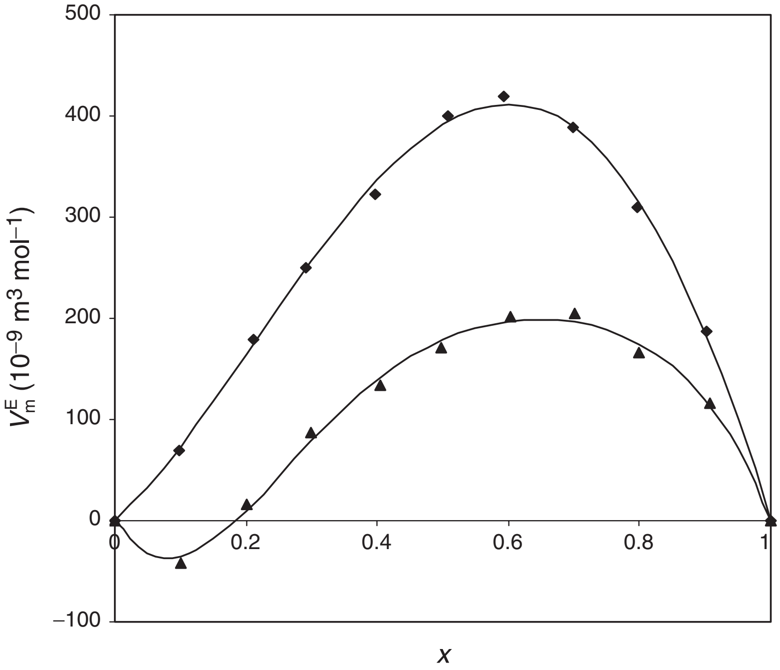

Figure 1. Excess molar volumes, V_m^E, as a function of mole fraction: $(1-x)$ 1-propanol + (x) bromochloromethane: (black diamonds) at 298.15 K. $(1-x)$ 1-propanol + (x) 1-bromo-2-chloroethane: (black triangles) at 298.15 K.

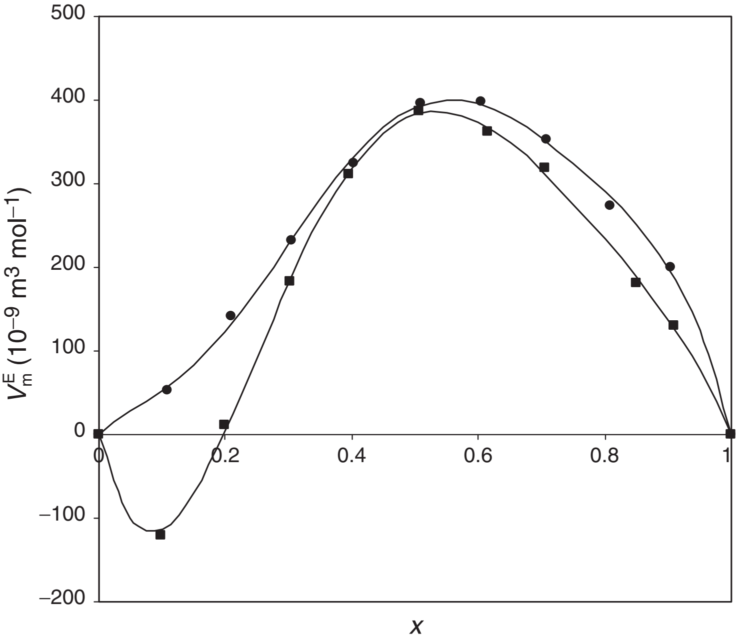

Figure 2. Excess molar volumes, V_m^E, as a function of mole fraction: $(1-x)$ 1-propanol + (x) dibromomethane: (black circles) at 298.15 K. $(1-x)$ 1-propanol + (x) 1,2-dichloroethane: (black squares) at 298.15 K.

Table 3. Parameters A_i of equation (2) for studied mixtures and standard deviations $\sigma\left(V_m^E\right)$ ($10^{-9}\,m^3\,mol^{-1}$).

System	T (K)	A_0	A_1	A_2	A_3	A_4	σ (V_m^E)
$(1-x)$ C_3H_8O +	288.15	1.567 ± 0.03	0.696 ± 0.09	−1.921 ± 0.29	0.476 ± 0.23	2.273 ± 0.52	9
(x) CH_2Br_2	298.15	1.565 ± 0.02	0.672 ± 0.08	−1.408 ± 0.26	0.543 ± 0.20	1.809 ± 0.46	8
	308.15	1.794 ± 0.03	0.309 ± 0.09	−2.044 ± 0.30	1.572 ± 0.23	2.422 ± 0.53	10
$(1-x)$ C_3H_8O +	288.15	1.483 ± 0.02	0.776 ± 0.04	−0.156 ± 0.10	–	–	9
(x) $BrClCH_2$	298.15	1.568 ± 0.02	0.785 ± 0.04	−0.204 ± 0.09	–	–	8
	308.15	1.639 ± 0.02	0.795 ± 0.08	−0.097 ± 0.24	−0.573 ± 0.20	0.573 ± 0.42	8
$(1-x)$ C_3H_8O +	288.15	1.439 ± 0.03	0.606 ± 0.08	−2.762 ± 0.30	1.869 ± 0.20	0.693 ± 0.50	9
(x) ClC_2H_4Cl	298.15	1.530 ± 0.02	0.485 ± 0.07	−2.182 ± 0.08	1.970 ± 0.17	–	8
	308.15	1.566 ± 0.02	0.649 ± 0.06	−1.971 ± 0.07	1.722 ± 0.16	–	7
$(1-x)$ C_3H_8O +	288.15	0.677 ± 0.02	0.517 ± 0.07	−0.154 ± 0.24	0.853 ± 0.19	−1.126 ± 0.42	8
(x) BrC_2H_4Cl	298.15	0.717 ± 0.02	0.571 ± 0.09	−0.387 ± 0.10	0.794 ± 0.22	–	9
	308.15	0.947 ± 0.02	0.735 ± 0.08	−0.604 ± 0.10	0.577 ± 0.22	–	9

Table 4. Coefficients A_{ij} of equation (4) and standard deviations (σ).

	j		
i	1	2	3
	$(1-x)$ 1-Propanol + (x) dibromomethane		
1	0.81708	-6.36×10^{-4}	-4.70×10^{-6}
2	1.54883	-6.35×10^{-4}	-2.86×10^{-5}
3	0.15371	-6.30×10^{-4}	1.75×10^{-5}
		$\sigma=1.2\times10^{-3}$	
	$(1-x)$ 1-Propanol + (x) bromochloromethane		
1	0.81601	-5.52×10^{-4}	-7.20×10^{-6}
2	0.99860	-2.70×10^{-3}	5.26×10^{-5}
3	0.16044	-4.53×10^{-4}	7.70×10^{-6}
		$\sigma=1.0\times10^{-3}$	
	$(1-x)$ 1-Propanol + (x) 1,2-dichloroethane		
1	0.81645	-6.32×10^{-4}	-5.00×10^{-6}
2	0.46229	-7.11×10^{-4}	1.40×10^{-6}
3	−0.00764	2.77×10^{-4}	-6.00×10^{-6}
		$\sigma=5.9\times10^{-4}$	
	$(1-x)$ 1-Propanol + (x) 1-bromo-2-chloroethane		
1	0.82120	−0.00142	2.13×10^{-5}
2	1.02955	−0.00116	-2.59×10^{-5}
3	−0.07840	-4.78×10^{-4}	1.84×10^{-5}
		$\sigma=6.2\times10^{-4}$	

The measured densities for the pure liquids and binary mixtures at 298.15 K and pressure range from 2×10^5 to 2×10^7 Pa are reported in tables 5 and 6. The isothermal compressibilities,

$$\kappa_T=\rho^{-1}(\delta\rho/\delta P)_T,$$

were obtained at 298.15 K, and are reported in table 7.

The "excess" compressibility, defined as

$$\kappa^E=-V^{-1}\left(\frac{\delta V^E}{\delta P}\right)_T=\kappa-\phi_1\kappa_1-\phi_2\kappa_2 \tag{6}$$

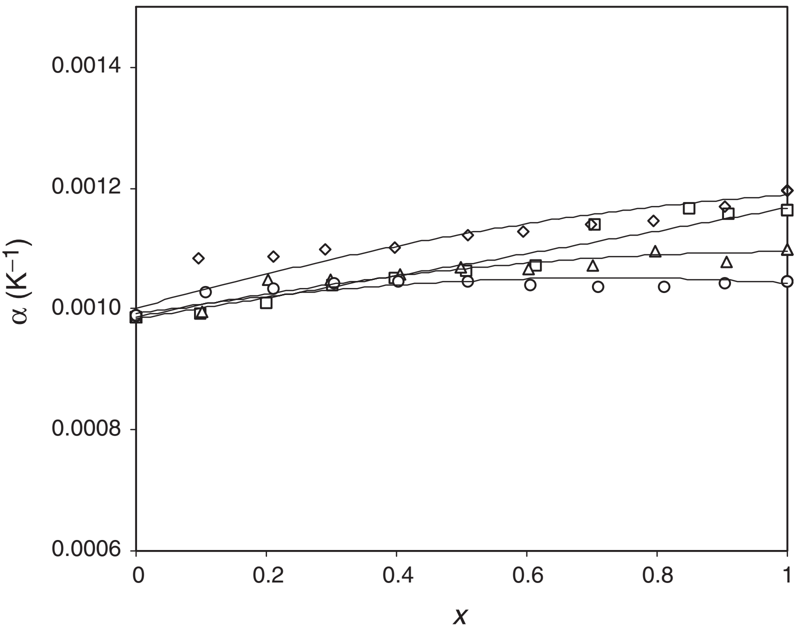

Figure 3. Thermal expansion coefficient, α, as a function of mole fraction at 298.15 K: $(1-x)$ 1-propanol + (x) dibromomethane (circles), + (x) bromochloromethane (diamonds), + (x) 1,2-dichloroethane (squares), + (x) 1-bromo-2-chloroethane (triangles).

Table 5. Densities, ρ (kg m^{-3}), as a function of pressure (10^5 Pa), for the pure liquid at 298.15 K.

CH_2Br_2		$BrClCH_2$		ClC_2H_4Cl		BrC_2H_4Cl		C_3H_8O	
P	ρ	P	ρ	P	ρ	P	ρ	P	ρ
193	2508.8	196	1953.2	197	1264.3	194	1749.5	197	813.5
192	2508.7	178	1950.3	177	1262.4	176	1747.1	196	813.5
177	2505.7	157	1947.0	157	1260.5	156	1744.5	177	812.1
159	2502.5	139	1944.2	139	1258.8	139	1742.5	157	810.8
158	2502.3	118	1940.8	120	1257.0	117	1739.6	137	809.5
137	2498.6	98	1937.8	101	1255.2	96	1737.2	118	808.0
118	2495.0	88	1936.4	89	1254.0	87	1736.1	98	806.7
98	2492.6	80	1934.9	80	1253.1	80	1735.1	88	805.2
88	2490.9	70	1933.4	71	1252.3	68	1733.7	79	806.2
80	2489.5	59	1932.0	61	1251.2	60	1732.8	69	804.6
69	2487.8	49	1930.5	51	1250.3	48	1731.4	59	803.8
59	2486.3	38	1928.8	41	1249.5	41	1730.6	49	803.0
50	2484.8	29	1927.6	31	1248.5	29	1729.1	39	802.3
41	2483.5	21	1926.2	20	1247.4	20	1728.2	29	801.5
30	2481.9	10	1924.6	11	1246.5	9	1726.9	20	800.8
21	2480.4	5	1923.9	5	1246.0	5	1726.5	10	800.0
10	2478.9	2	1923.5	2	1245.7	2	1726.1	5	799.6
6	2478.4	–	–	–	–	–	–	2	799.3
3	2477.9	–	–	–	–	–	–	–	–
2	2477.6	–	–	–	–	–	–	–	–

Table 6. Densities, ρ ($\mathrm{kg\,m^{-3}}$), for the studied mixtures at 298.15 K.

(1 − x) 1-Propanol + (x) dibromomethane

$x = 0.3137$		$x = 0.4951$		$x = 0.6915$	
P (10^5 Pa)	ρ ($\mathrm{kg\,m^{-3}}$)	P (10^5 Pa)	ρ ($\mathrm{kg\,m^{-3}}$)	P (10^5 Pa)	ρ ($\mathrm{kg\,m^{-3}}$)
196	1319.3	197	1624.0	196	1978.8
178	1317.3	177	1621.2	176	1975.4
158	1315.2	157	1618.1	157	1972.5
138	1313.0	137	1615.3	147	1971.0
137	1313.0	117	1612.4	137	1969.4
119	1310.8	99	1609.7	117	1966.4
101	1308.7	88	1608.1	98	1963.5
99	1308.5	80	1606.2	88	1962.2
89	1307.5	69	1604.7	78	1960.6
80	1306.4	59	1603.4	68	1959.2
70	1305.4	49	1602.2	59	1958.0
61	1304.4	39	1600.9	49	1956.5
50	1303.3	28	1599.6	39	1955.1
40	1302.1	20	1598.6	29	1953.8
30	1301.2	10	1597.3	19	1952.4
21	1300.1	5	1596.7	11	1951.2
11	1299.1	2	1596.4	5	1950.6
6	1298.5	–	–	2	1950.1
2	1298.0	–	–	–	–

(1 − x) 1-Propanol + (x) bromochloromethane

$x = 0.2991$		$x = 0.4943$		$x = 0.6993$	
P (10^5 Pa)	ρ ($\mathrm{kg\,m^{-3}}$)	P (10^5 Pa)	ρ ($\mathrm{kg\,m^{-3}}$)	P (10^5 Pa)	ρ ($\mathrm{kg\,m^{-3}}$)
196	1126.8	197	1341.4	197	1576.2
177	1124.8	177	1339.0	195	1575.9
158	1122.9	158	1336.8	178	1573.2
137	1120.9	138	1334.6	156	1570.4
132	1120.2	118	1332.2	137	1568.0
118	1118.8	99	1330.0	118	1565.3
98	1116.8	88	1328.8	98	1562.7
88	1115.9	78	1327.6	88	1561.5
81	1114.2	69	1326.5	79	1560.1
69	1113.0	60	1325.4	69	1559.1
59	1112.2	49	1324.3	59	1557.7
50	1111.2	41	1323.4	49	1556.3
40	1110.4	29	1322.0	39	1555.1
29	1109.1	21	1320.9	29	1553.9
20	1108.3	10	1319.7	20	1552.6
11	1107.4	5	1319.2	12	1551.7
4	1106.8	2	1318.8	5	1550.8
2	1106.5	–	–	2	1550.4

(1 − x) 1-Propanol + (x) 1,2-dichloroethane

$x = 0.3030$		$x = 0.5042$		$x = 0.6856$	
P (10^5 Pa)	ρ ($\mathrm{kg\,m^{-3}}$)	P (10^5 Pa)	ρ ($\mathrm{kg\,m^{-3}}$)	P (10^5 Pa)	ρ ($\mathrm{kg\,m^{-3}}$)
197	954.5	197	1044.2	197	1125.5
179	953.1	179	1042.6	178	1123.7
159	951.5	161	1041.2	156	1121.6
137	949.9	138	1039.2	137	1120.1
119	948.3	122	1037.8	121	1118.5
100	946.9	100	1036.0	103	1117.1
88	945.7	89	1035.0	94	1116.3

(*Continued*)

Table 6. Continued.

$(1-x)$ 1-Propanol + (x) 1,2-dichloroethane					
$x=0.3030$		$x=0.5042$		$x=0.6856$	
P (10^5 Pa)	ρ (kg m^{-3})	P (10^5 Pa)	ρ (kg m^{-3})	P (10^5 Pa)	ρ (kg m^{-3})
79	944.9	76	1033.8	80	1115.0
68	944.1	68	1033.1	68	1113.9
59	943.3	57	1032.2	60	1113.1
50	942.5	48	1031.5	49	1112.2
39	941.7	38	1030.6	40	1111.4
29	940.8	29	1029.8	30	1110.5
20	940.0	21	1029.1	21	1109.7
10	939.2	10	1028.1	10	1108.7
5	938.7	6	1027.8	5	1108.2
2	938.5	2	1027.4	2	1108.0

$(1-x)$ 1-Propanol + (x) 1-bromo-2-chloroethane					
$x=0.2992$		$x=0.5058$		$x=0.7030$	
P (10^5 Pa)	ρ (kg m^{-3})	P (10^5 Pa)	ρ (kg m^{-3})	P (10^5 Pa)	ρ (kg m^{-3})
195	1109.4	193	1308.3	194	1487.7
177	1107.7	179	1306.8	175	1485.5
157	1106.0	156	1304.5	155	1483.3
137	1104.2	136	1302.5	136	1480.9
118	1102.4	118	1300.5	118	1479.1
98	1100.6	99	1298.6	99	1476.9
87	1099.6	87	1297.5	89	1476.0
79	1098.7	80	1296.5	80	1474.8
69	1097.9	71	1295.7	67	1473.4
59	1096.9	59	1294.6	58	1472.4
49	1096.2	48	1293.5	50	1471.6
39	1095.2	41	1292.7	41	1470.7
29	1094.3	28	1291.5	28	1469.3
19	1093.4	19	1290.5	21	1468.4
10	1092.6	11	1289.7	12	1467.4
5	1092.0	5	1289.1	7	1466.8
2	1091.8	2	1288.8	2	1466.5

Table 7. Isothermal compressibility, κ_T (TPa^{-1}), for studied mixtures at 298.15 K.

	x				
System	0.00	0.30	0.50	0.70	1.00
$(1-x)$ $C_3H_8O + (x)$ CH_2Br_2	995	864	777	689	561
$(1-x)$ $C_3H_8O + (x)$ $BrClCH_2$	995	925	876	826	749
$(1-x)$ $C_3H_8O + (x)$ ClC_2H_4Cl	995	910	860	816	762
$(1-x)$ $C_3H_8O + (x)$ BrC_2H_4Cl	995	850	782	734	700

where ϕ_1 and ϕ_2 are the volume fractions, is widely used. The values of κ^E of the studied systems are plotted against x in figure 4.

As shown in figure 3 and table 7, dibromomethane exhibits the minima values of thermal expansion coefficient and isothermal compressibility, and bromochloromethane and 1,2-dichloroethane show similar α and κ_T values. On the other hand,

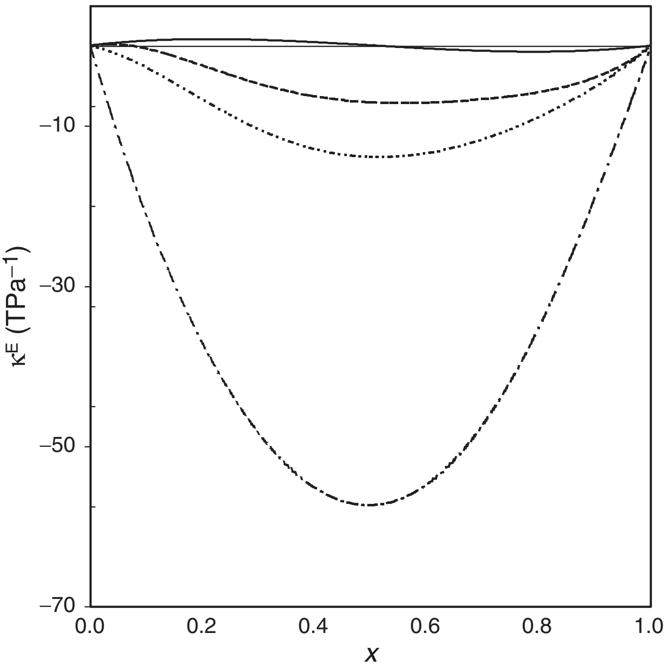

Figure 4. Excess isothermal compressibility, κ^E, as a function of mole fraction at 298.15 K: $(1-x)$ 1-propanol + (x) dibromomethane (large lines discontinuous), +(x) bromochloromethane (continuous line), + (x) 1,2-dichloroethane (discontinuous line), +(x) 1-bromo-2-chloroethane (small and large lines discontinuous).

except for 1-bromo-2-chloroethane, the density of these haloalkanes seems to change in opposite direction to that of isothermal compressibility showing that any increase in the density of the haloalkane could decrease the intermolecular free space and thereby the ability to be compressed.

The excess molar volumes V_m^E for all the studied mixtures are positive and increase following the sequence: 1-propanol + 1-bromo-2-chloroethane < +1,2-dichloroethane < +dibromomethane < +bromochloromethane. Taking into account the V_m^E of the corresponding dihaloalkane + n-alkane [14] and 1-alkanol + n-alkane mixtures [15], we can conclude that the contribution to V_m^E due to the strong specific interaction halogen atom–hydroxyl group is more important than the geometrical ("free volume") effects in the mixture. The excess isothermal compressibilities, κ^E, however, are negative and the mixtures 1-propanol + 1-bromo-2-chloroethane and 1-propanol + bromochloromethane show the maxima and minima deviation of the ideality, respectively. The explanation of this behaviour is difficult with only this kind of measurements, given the variety and complexity of the interactional and geometrical effects present in the pure dihaloalkanes.

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