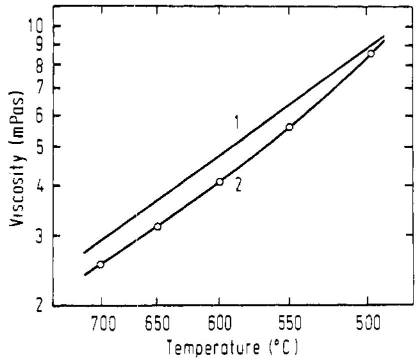

Figure 1. FLINAK viscosities (log mPa s vs. 1000/K): curve 1 according to Grimes et al.,[5] eq 4; curve 2 present results, eq 1.

(mean values) are given in Table I.

An exponential function of the second order in temperature T (K) was fitted to the entire experimental material:

$$\eta(\text{mPa s}) = 1.633 \exp(-2762.9T^{-1} + (3.1095 \times 10^{6})T^{-2}) \qquad (1)$$

The standard deviation (SD) of η in the fit was 0.27%.

The densities reported by Mellors and Senderoff[4] were adopted in calculating the viscosity. The following expression, where t is degree Celsius, was derived by us from their density diagram:

$$\rho(\text{kg/m}^3) = (2.395 - (6.1 \times 10^{-4})t)10^3 \qquad (2)$$

The present viscosities may be recalculated with different densities by using the relation

$$\Delta\eta = (a + 0.005(\Delta\rho))(\Delta\rho) \qquad (3)$$

$$a = 0.852 + 0.0391\eta - 0.00158\eta^2$$

where $\Delta\rho$ is the percentage deviation of the density from eq 2 and $\Delta\eta$ is the viscosity correction in percent.

FLINAK viscosities have been measured earlier by Grimes et al.[5] They report the Arrhenius equation

$$\eta(\text{mPa s}) = 0.0400 \exp(4170/T) \qquad (4)$$

which yields viscosities 16% higher than ours at 600-650 °C (the discrepancy increases with about 2% if the density data of Grimes et al.[5] are applied to the present results through eq 3). Both results are shown as Arrhenius plots in Figure 1. While a rigid adherence to the Arrhenius rule is typical for simple liquids such as molten NaF, the present trend toward too high viscosities at lower temperatures is often observed in complex mixtures.[2,6]

The accuracy of our method in routinely performed investigations is estimated to be 0.5-1% SD,[1,2] which in this work also includes the effect of a 1 °C uncertainty in the temperature.

Acknowledgment

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Liquid-Vapor Equilibria in Binary Systems Formed by Methylcyclohexane with Chlorobenzene, Fluorobenzene, and Thiophene

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Total vapor pressure at 348.15 K and liquid and vapor composition have been determined at 303.15 K by refractometry at points covering the whole range of molar concentrations for binary systems consisting of methylcyclohexane with either chlorobenzene, fluorobenzene, or thiophene. From these data the excess Gibbs free energy, G^E, for the three systems have been calculated.

As part of our systematic research on thermodynamic properties of the liquid state, we report in this paper excess Gibbs free energy values, G^E, for the three referred systems, calculated from vapor pressure data obtained at one and the same temperature for all systems. Determination of liquid and vapor composition at equilibrium was done through their refractive indexes n_D, using previously prepared calibration curves. The G^E values were determined from measurements of the four parameters, temperature, T, pressure, p, liquid-phase composition, x, and vapor-phase composition, y, and their thermodynamic consistency was checked analytically.

Experimental Section

Vapor pressure measurements were carried out by using a dynamical ebulliometer based on the work of Brown (*1*). A detailed scheme of the particular aparatus used in this work is given in ref 2. The liquids used and their source and quality were methylcyclohexane (Fluka purum), chlorobenzene (Fluka puriss), fluorobenzene (Fluka puriss), and thiophene (Fluka purum). They were further purified following conventional procedures (*3*), reaching 99.5% purity for methylcyclohexane and thiophene, 99.7% for fluorobenzene, and 99.8% for chlorobenzene. For comparison sake, in Tables I and II are included values of the

Table I. Density, ρ, Refractive Index, n_D, Virial Coefficients, B, and Molar Volumes, v

compd	ρ(298.15 K)/g cm^{-3}		n_D(303.15 K)		$-B$/cm^3 mol^{-1} (348.15 K)	v/cm^3 mol^{-1} (348.15 K)
	obsd	lit.	obsd	lit.		
methylcyclohexane	0.76498	0.76506^a	1.41820	1.41803^b	1463.8	136.234
chlorobenzene	1.10038	1.10037^b	1.51897	1.51837^b	1563.1	107.482
fluorobenzene	1.01665	1.0165^b	1.46053	1.46256^b	1183.5	100.649
thiophene	1.05808	1.05887^a	1.52215	1.52257^a	992.3	84.415

^{a} Reference 4. ^{b} Reference 5.

Table II. Vapor Pressures, p, of the Pure Compounds

	p/kPa							
	methylcyclohexane		chlorobenzene		fluorobenzene		thiophene	
T/K	obsd	lit.^{a}	obsd	lit.^{b}	obsd	lit.^{c}	obsd	lit.^{a}
313.15	12.175	12.208			20.328	20.424	20.745	20.726
318.15	15.017	15.063			24.989	25.089	25.488	25.470
323.15	18.448	18.440			30.481	30.585	31.089	31.063
328.15	22.375	22.411	7.161	7.147	37.098	37.021	37.627	37.611
333.15	27.060	27.050	8.553	8.845	44.344	44.508	45.286	45.232
338.15	32.395	32.433	10.875	10.919	53.038	53.166	54.135	54.047
343.15	38.634	38.649	13.401	13.373	62.985	63.124	64.275	64.188
348.15	45.791	45.783	16.311	16.268	74.395	74.514	75.935	75.790
353.15	53.893	53.931	19.650	19.657	87.442	87.475	89.122	88.995

^{a} Reference 4. ^{b} Reference 1. ^{c} Reference 6.

Table III. Values of Refractive Index n_D as a Function of the Mole Fraction x_1 at 303.15 K

chlorobenzene (1) + methylcyclohexane (2)		fluorobenzene (1) + methylcyclohexane (2)		thiophene (1) + methylcyclohexane (2)	
x_1	n_D	x_1	n_D	x_1	n_D
0.0000	1.41820	0.0000	1.41820	0.0000	1.41820
0.0606	1.42276	0.2057	1.42357	0.1678	1.42811
0.1055	1.42643	0.2632	1.42532	0.2542	1.43410
0.1402	1.42929	0.3385	1.42780	0.2894	1.43681
0.1791	1.43256	0.3395	1.42786	0.3323	1.44005
0.2378	1.43760	0.3489	1.42823	0.3360	1.44036
0.2845	1.44165	0.4047	1.43022	0.3572	1.44213
0.2852	1.44183	0.4876	1.43342	0.3682	1.44299
0.3472	1.44763	0.5374	1.43558	0.4266	1.44803
0.4161	1.45389	0.5450	1.43588	0.4821	1.45304
0.4246	1.45473	0.5999	1.43828	0.4923	1.45401
0.5195	1.46404	0.6603	1.44115	0.5311	1.45778
0.5542	1.46758	0.7344	1.44487	0.5668	1.46148
0.5655	1.46882	0.7611	1.44633	0.6000	1.46499
0.6380	1.47638	0.7840	1.44760	0.6791	1.47411
0.6748	1.48039	0.8013	1.44857	0.6972	1.47621
0.6971	1.48288	0.8457	1.45111	0.7765	1.48650
0.7255	1.48604	0.8624	1.45220	0.8170	1.49220
0.7577	1.48948	0.8757	1.45298	0.8453	1.49639
0.7890	1.49334	0.9316	1.45647	0.9218	1.50849
0.8640	1.50217	0.9472	1.45731	0.9364	1.51086
1.0000	1.51897	1.0000	1.46053	1.0000	1.52215

physical constants determined by us on these purified substances and those given in the literature.

The precision involved in the parameters we determined is to ±7 Pa for vapor pressure, to $\pm 5 \times 10^{-4}$ for mole fraction, and to ±0.01 K for temperature.

Results

As pointed out above, determination of vapor- and liquid-phase composition at equilibrium was done through refractive index measurements. Of course the vapor phase was condensed prior to making the measurements. To that end calibrated curves of liquid refractive index against mole fractions were prepared ahead of time. For each system, values for 20 samples covering regularly the whole mole fraction range were plotted. The plot thus obtained was fit to a polynomial relationship of the type

$$n_D = \sum_{i=0}^{n} A_i x^i \tag{1}$$

Refractive indexes (±0.000 02) were measured with a Bausch & Lomb precision refractometer and the results are given in Table III. In Table IV the fitting coefficients A_i for each system are included, together with their standard deviations, σ, defined as $\sigma = (\sum \Delta_i^2/n)^{1/2}$.

Excess Gibbs free energy was calculated through the relationship

$$G^E = x_1\mu_1^E + x_2\mu_2^E \tag{2}$$

where x_1 and x_2 are the mole fractions and μ_1^E and μ_2^E are the chemical potentials for both components. The last ones were calculated by using the relationships

$$\mu_1^E = RT \ln \gamma_1 = RT \ln \frac{py_1}{x_1p_1^\circ} + (B_{11} - v_1^\circ)(p - p_1^\circ) + py_2^2\delta_{12} \tag{3}$$

$$\mu_2^E = RT \ln \gamma_2 = RT \ln \frac{py_2}{x_2p_2^\circ} + (B_{22} - v_2^\circ)(p - p_2^\circ) + py_1^2\delta_{12} \tag{4}$$

The pure component virial coefficients B_{11} and B_{22} and mole volumes v_1° and v_2°, all at 348.15 K, are given in Table I. The values of B for methylcyclohexane and chlorobenzene were calculated from their critical constants (*7*) and for fluorobenzene (*6*) and thiophene by literature data (*8*) interpolation. Calculation

Table IV. Coefficients A_i and Standard Deviation σ for $n_D = \Sigma_{i=0}{}^n A_i x_1{}^i$ at 303.15 K

	A_0	A_1	A_2	A_3	A_4	$10^5\sigma$
chlorobenzene (1) + methylcyclohexane (2)	1.418 12	0.076 89	0.020 47	0.003 51		7
fluorobenzene (1) + methylcyclohexane (2)	1.418 23	0.022 42	0.016 13	0.003 96		7
thiophene (1) + methylcyclohexane (2)	1.418 19	0.052 98	0.038 48	0.005 25	−0.017 75	3

Table V. Liquid-Phase Mole Fraction x_1, Vapor-Phase Mole Fraction y_1, Vapor Pressure p, Activity Coefficients γ_1 and γ_2, and Excess Gibbs Energy G^E, at 348.15 K for the System Chlorobenzene (1) + Methylcyclohexane (2)

x_1	y_1	p/kPa	γ_1	γ_2	G^E/J mol^{-1}
0.0000		45.791			
0.0468	0.0269	44.840	1.5549	1.0002	60.37
0.0727	0.0405	44.332	1.4903	1.0026	90.86
0.1112	0.0610	43.508	1.4409	1.0051	130.62
0.1437	0.0773	42.838	1.3917	1.0097	161.40
0.1790	0.0960	42.089	1.3639	1.0141	194.15
0.2179	0.1158	41.259	1.3255	1.0212	225.23
0.2467	0.1309	40.605	1.3029	1.0260	244.86
0.2766	0.1451	39.981	1.2687	1.0352	262.90
0.3025	0.1584	39.403	1.2486	1.0420	277.35
0.3233	0.1693	38.935	1.2341	1.0478	288.22
0.3406	0.1784	38.526	1.2217	1.0525	295.13
0.3582	0.1877	38.139	1.2102	1.0587	303.71
0.3725	0.1939	37.813	1.1921	1.0655	304.72
0.3944	0.2064	37.296	1.1825	1.0724	313.78
0.4221	0.2217	36.625	1.1659	1.0827	320.37
0.4246	0.2232	36.564	1.1650	1.0835	321.20
0.4456	0.2349	36.053	1.1523	1.0924	324.66
0.4871	0.2587	35.017	1.1282	1.1119	327.47
0.5255	0.2813	34.031	1.1057	1.1330	324.30
0.5669	0.3092	32.921	1.0906	1.1549	322.81
0.6207	0.3464	31.409	1.0655	1.1914	306.33
0.6646	0.3815	30.074	1.0502	1.2217	288.54
0.6872	0.4019	29.334	1.0441	1.2361	277.64
0.7164	0.4299	28.432	1.0389	1.2603	268.96
0.7403	0.4535	27.611	1.0304	1.2817	250.70
0.7809	0.5001	26.196	1.0228	1.3195	226.83
0.8106	0.5393	25.046	1.0166	1.3458	201.38
0.8336	0.5733	24.142	1.0134	1.3683	183.22
0.8614	0.6184	23.002	1.0086	1.4006	156.46
0.8854	0.6630	21.966	1.0052	1.4294	131.86
0.9188	0.7363	20.446	1.0022	1.4706	96.51
0.9316	0.7691	19.840	1.0022	1.4838	84.00
0.9654	0.8658	18.208	1.0010	1.5263	46.24
0.9939	0.9740	16.653	1.0004	1.5754	9.09
1.0000		16.311			

Table VI. Liquid-Phase Mole Fraction x_1, Vapor-Phase Mole Fraction y_1, Vapor Pressure p, Activity Coefficients γ_1 and γ_2, and Excess Gibbs Energy G^E, at 348.15 K for the System Fluorobenzene (1) + Methylcyclohexane (2)

x_1	y_1	p/kPa	γ_1	γ_2	G^E/J mol^{-1}
0.0000		45.791			
0.1024	0.2081	52.386	1.4452	1.0057	123.79
0.1287	0.2492	53.802	1.4133	1.0080	148.97
0.1583	0.2914	55.335	1.3810	1.0120	176.99
0.1894	0.3324	56.877	1.3523	1.0168	204.45
0.2148	0.3635	58.073	1.3307	1.0211	225.12
0.2454	0.3973	59.380	1.3010	1.0280	247.26
0.2710	0.4257	60.495	1.2853	1.0324	264.16
0.3014	0.4557	61.687	1.2608	1.0405	282.43
0.3307	0.4833	62.783	1.2398	1.0486	297.74
0.3677	0.5168	64.079	1.2162	1.0578	312.75
0.3967	0.5406	65.057	1.1967	1.0705	325.14
0.4275	0.5659	66.013	1.1790	1.0811	332.94
0.4577	0.5892	66.884	1.1612	1.0937	338.68
0.4899	0.6131	67.777	1.1435	1.1092	343.23
0.5222	0.6362	68.608	1.1265	1.1266	344.88
0.5717	0.6695	69.742	1.1001	1.1600	341.87
0.6066	0.6940	70.498	1.0861	1.1815	334.81
0.6441	0.7188	71.211	1.0698	1.2118	323.57
0.6950	0.7528	72.091	1.0507	1.2578	302.00
0.7453	0.7873	72.843	1.0350	1.3090	272.80
0.8010	0.8271	73.491	1.0205	1.3735	229.76
0.8559	0.8690	74.003	1.0101	1.4468	179.04
0.9041	0.9060	74.273	1.0005	1.5654	125.72
0.9473	0.9481	74.389	1.0008	1.5752	71.39
0.9824	0.9844	74.393	1.0020	1.4178	23.47
1.0000		74.395			

Table VII. Liquid-Phase Mole Fraction x_1, Vapor-Phase Mole Fraction y_1, Vapor Pressure p, Activity Coefficients γ_1 and γ_2, and Excess Gibbs Energy G^E, at 348.15 K for the System Thiophene (1) + Methylcyclohexane (2)

x_1	y_1	p/kPa	γ_1	γ_2	G^E/J mol^{-1}
0.0000		45.791			
0.0931	0.1957	51.820	1.4475	1.0003	100.48
0.1155	0.2346	53.200	1.4352	1.0013	124.04
0.1384	0.2722	54.611	1.4257	1.0026	148.47
0.1699	0.3186	56.417	1.4033	1.0055	179.77
0.2067	0.3675	58.428	1.3769	1.0104	214.99
0.2385	0.4051	60.003	1.3500	1.0158	241.70
0.2747	0.4445	61.712	1.3219	1.0233	270.18
0.3078	0.4769	63.137	1.2943	1.0322	293.28
0.3436	0.5092	64.567	1.2652	1.0436	315.06
0.3821	0.5412	65.957	1.2346	1.0579	333.74
0.4259	0.5745	67.414	1.2011	1.0785	351.40
0.4574	0.5979	68.378	1.1802	1.0932	359.20
0.4916	0.6222	69.322	1.1580	1.1108	363.37
0.5433	0.6566	70.697	1.1271	1.1454	367.59
0.5905	0.6883	71.783	1.1033	1.1767	360.85
0.6452	0.7237	72.913	1.0779	1.2221	346.09
0.7006	0.7600	73.925	1.0566	1.2747	321.90
0.7422	0.7879	74.562	1.0426	1.3192	296.32
0.7855	0.8179	75.130	1.0302	1.3713	263.64
0.8648	0.8768	75.880	1.0128	1.4861	186.94
0.9058	0.9102	75.960	1.0049	1.5563	133.28
0.9421	0.9422	75.960	1.0001	1.6299	82.11
1.0000		75.962			

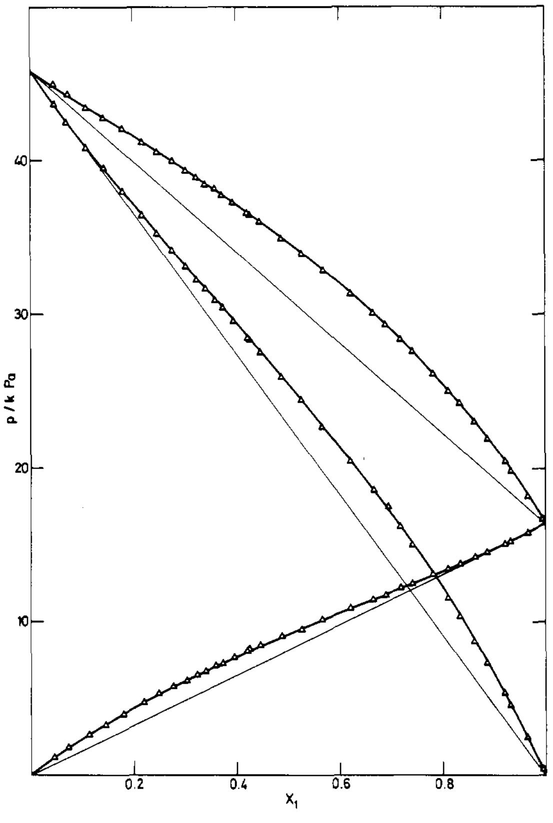

Figure 1. Total vapor pressure, p, and partial vapor pressures, p_1 and p_2, plotted against mole fraction, x_1, of chlorobenzene at 348.15 K.

of δ_{12} was done by the relationship $\delta_{12} = B_{11} + B_{22} - 2B_{12}$, where B_{12} is evaluated as $B_{12} = \{(B_{11}{}^{1/3} + B_{22}{}^{1/3})/2\}^3$. Values of $v_i{}^\circ$ for each substance were calculated from density literature data (*9*).

In Tables V–VII are collected the liquid- and vapor-phase mole fractions at equilibrium, the total pressure, the activity coeffi-

Table VIII. Coefficients C_i and Standard Deviation σ, for the Relation between Excess Gibbs Energy and Mole Fraction at 348.15 K

	C_0	C_1	C_2	C_3	C_4	σ/J mol^{-1}
chlorobenzene (1) + methylcyclohexane (2)	1299.53	−46.33	59.00	82.60		2.19
fluorobenzene (1) + methylcyclohexane (2)	1373.07	134.06	109.03	−109.28	−144.14	0.95
thiophene (1) + methylcyclohexane (2)	1457.47	209.16	52.85	26.51	−286.81	1.43

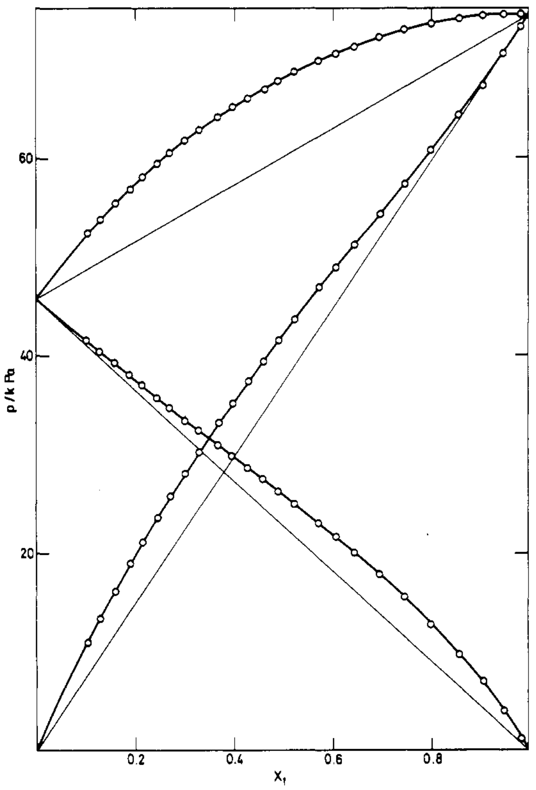

Figure 2. Total vapor pressure, p, and partial vapor pressures, p_1 and p_2, plotted against mole fraction, x_1, of fluorobenzene at 348.15 K.

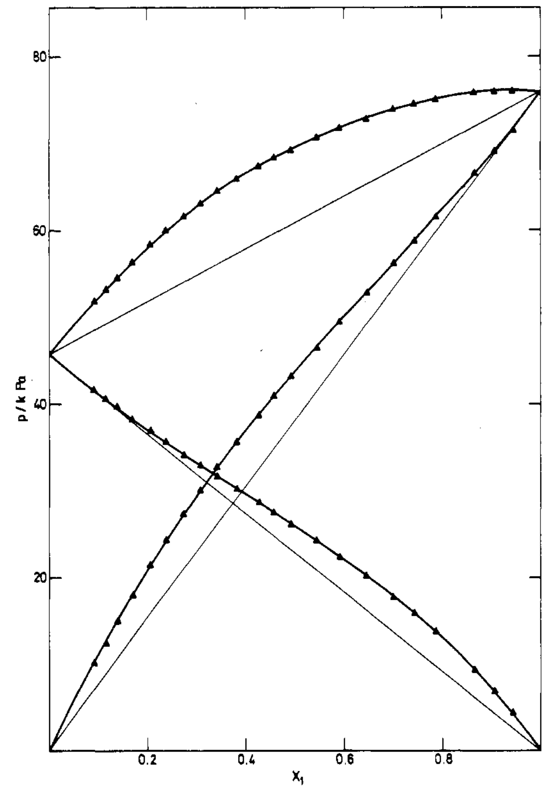

Figure 3. Total vapor pressures, p, and partial vapor pressures, p_1 and p_2, plotted against mole fraction, x_1, of thiophene at 348.15 K.

cients, and the excess Gibbs energy.

On Figures 1, 2, and 3 the experimental values for p, p_1, and p_2 were plotted vs. the mole fraction x_1, of each system.

The G^E values were fit to a polynomial of the type

$$G^E/\mathrm{J\ mol^{-1}} = x_1x_2\sum_{i=0}^{n} C_i(x_1 - x_2)^i \qquad (5)$$

The fitting coefficients C_i, for each system and their corresponding standard deviations, σ, are given in Table VIII.

The agreement of experimental vapor compositions with those calculated from p–x data with Barker's (*10*) calculation technique suggests thermodynamic consistency of the data. In what follows we give the standard deviation of the differences between the experimental value and the analytically calculated value for the mole fraction, Δy, the total pressure, Δp, and the excess Gibbs free energy, ΔG^E: for chlorobenzene (1) + methylcyclohexane (2) $\sigma(\Delta y) = 6 \times 10^{-4}$, $\sigma(\Delta p/\mathrm{kPa}) = 0.11$, and $\sigma(\Delta G^E/\mathrm{J\ mol^{-1}}) = 1.90$; for fluorobenzene (1) + methylcyclohexane (2) $\sigma(\Delta y) = 9 \times 10^{-4}$, $\sigma(\Delta p/\mathrm{kPa}) = 0.013$, and $\sigma(\Delta G^E/\mathrm{J\ mol^{-1}}) = 0.67$; and for thiophene (1) + methylcyclohexane (2) $\sigma(\Delta y) = 4 \times 10^{-4}$, $\sigma(\Delta p/\mathrm{kPa}) = 0.044$, and $\sigma(\Delta G^E/\mathrm{J\ mol^{-1}}) = 1.67$.

Glossary

A_i	coefficients for eq 1
B_{ij}	second virial coefficient due to interaction of molecules i and j (i,j = 1, 2), cm^3 mol^{-1}
C_i	coefficients for eq 5
G^E	excess Gibbs free energy, J mol^{-1}
n_D	refractive index
p	total pressure, kPa
p_i°	vapor pressure of pure species i, kPa
p_i	partial pressure of component i, kPa
R	universal gas constant, J mol^{-1} K^{-1}
T	absolute temperature, K
v_i°	molar volume of pure species i, cm^3 mol^{-1}
x_i	liquid-phase mole fraction of i
y_i	vapor-phase mole fraction of i

Greek Symbols

δ_{12}	$= B_{11} + B_{22} - 2B_{12}$
Δ	difference between experimental and calculated values
γ_i	activity coefficients of compound i at temperature T
μ_i^E	excess chemical potentials of compound i at temperature T
σ	standard deviation
ρ	density, g cm^{-3}

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Vapor–Liquid Equilibria of the System 2-Butanol–Chlorobenzene

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Isobaric vapor–liquid equilibrium data for the system 2-butanol + chlorobenzene are measured at 760 ± 1 mmHg pressure and reported. The system is nonideal and shows positive deviations from Raoult's law. Equilibrium temperature and liquid composition are correlated by the Danciu equation and the vapor and liquid compositions are correlated by the Norrish–Twigg equation.

Some alcohol–chlorobenzene systems exhibit azeotropic behavior (*3*) and form symmetrical solutions. Vapor–liquid equilibrium data of chlorobenzene with methanol (*4*, *7*), 1-propanol, 1-butanol (*10*), 2-propanol, 2-butanol (*5*), 2-methyl-2-propanol (*8*), and 3-methyl-1-butanol (*9*) have been reported. So far vapor–liquid equilibrium data on 2-butanol–chlorobenzene is not studied. Hence vapor–liquid equilibrium data for the system 2-butanol–chlorobenzene are obtained at 760 mmHg pressure with a view to study its behavior in comparison with the aforementioned systems.

Experimental Section

Analytical reagent grade 2-butanol and chlorobenzene are used after double distillation in a laboratory packed distillation column. The physical properties (refractive index and boiling point) of the chemicals are presented in Table I along with the literature values for comparison (*12*).

The equilibrium still used in the present work is of the type designed by Jones, Schoenborn, and Colburn as modified by Ward (*11*). Equilibrium condition is attained in 45 min. However, the vapor and liquid samples are withdrawn for analysis after maintaining the equilibrium condition for 2 h. The equilibrium temperature is measured with a mercury-in-glass thermometer having an accuracy of 0.1 °C.

Vapor and liquid samples are analyzed by refractive index measurements at 30 °C. The composition in mole percent of each component of the binary mixture is determined by a standard calibration chart of refractive index vs. composition prepared earlier. Refractive index measurements are taken for sodium light using Abbe's refractometer having a precision of 0.001 and the last significant digit in the refractive index value is determined through eye approximation.

Results and Discussion

The liquid-phase activity coefficients for the components are determined from the equation

$$\gamma_i = Z_i \pi y_i / P^\circ_i x_i$$

where

$$Z_i = \exp[(\pi - P^\circ_i)(B_i - V_i)/RT]$$

Table I. Physical Properties of Chemicals

	bp, °C		refractive index at 25 °C	
chemical	exptl	lit.[12]	exptl	lit.[12]
2-butanol	99.5	99.53	1.3952	1.3953[a]
chlorobenzene	132.0	131.687	1.4750	1.4750 (24.6 °C)

[a] Calculated using dn/dt.

Table II. Experimental Data of the System 2-Butanol + Chlorobenzene

				exptl	
no.	temp, °C	x_1	y_1	γ_1	γ_2
1	122.7	0.041	0.231	2.56	1.03
2	119.4	0.054	0.280	2.61	1.08
3	117.8	0.112	0.403	1.90	0.99
4	112.8	0.137	0.443	2.02	1.11
5	111.6	0.162	0.466	1.87	1.14
6	102.9	0.501	0.663	1.17	1.59
7	101.7	0.581	0.699	1.11	1.76
8	100.9	0.660	0.748	1.08	1.86
9	100.0	0.766	0.814	1.04	2.06
10	99.7	0.814	0.846	1.03	2.16
11	99.8	0.910	0.920	1.00	2.32

Table III. Correlating Equations

1. Danciu Equation

$$\log X_2 = 0.92 + (1.05 \log \theta_1)$$

where $X_2 = x_2/x_1$ and $\theta_1 = (t - t_1)/(t_2 - t)$, t_1 and t_2 are boiling points of pure components and t is the boiling point of a binary mixture

2. Norrish–Twigg Equation

$$\log \frac{y_1}{x_1}\left[\frac{x_2}{y_2}\right]^K = 2.6875 - 2.5x_1$$

where K, the ratio of molar heats of vaporization of the lower boiling component to that of the higher boiling component, = 3.0652.

The second virial coefficients for both the components are calculated by using Wohl's (*13*) generalized correlation and molar volumes by the expansion factor method of Hala et al. (*2*). The following equations are used to calculate the pure-component vapor pressures: 2-butanol

$$\log P = 46.42483 - 4261.0/T - 12.4877 \log T$$

chlorobenzene

$$\log P = 7.18473 - 1556.6/(230 + t)$$

The experimental vapor–liquid equilibrium data along with activity coefficients are presented in Table II and the t–($x - y$)

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