extension of the concentration range of application of the FLK eq 1.

Registry No. LiCl, 7447-41-8; NaCl, 7647-14-5; NaBr, 7647-15-6; NaI, 7681-82-5; KF, 7789-23-3.

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High-Pressure Vapor–Liquid Equilibria for Binary Mixtures Containing a Light Paraffin and an Aromatic Compound or a Naphthene in the Range 313–473 K

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The experimental study summarized here represents a continuing effort to obtain phase equilibrium data on selected binary systems. The lighter components of the binaries are methane, ethane, and propane. The heavier components are toluene, *m*-xylene, mesitylene, *n*-propylbenzene, cyclohexane, methylcyclohexane, and *n*-propylcyclohexane. Three apparatuses based on a static method were used at three temperatures (ca. 313, 393, and 473 K) and pressures up to the critical one.

Introduction

This work is a contribution to the Gas Processors Association Project to establish a data bank of high-pressure vapor–liquid equilibria (VLE) between natural gas components and heavier hydrocarbons. Binary VLE were measured by using several experimental methods (*1–4*).

Consistency tests on our lowest pressure data have been presented for two binaries (*5*). Careful measurements at pressures close to atmospheric allow calculation of cross second and third virial coefficients, only if heavy-component vapor-phase composition is precise and exempt of systematic errors. The main interest of testing our data through the Prausnitz–Keeler (*6*) test was to find out that some of our previous data had systematic errors. New experimental measurements (*5*), coupled with data obtained with a specially developed new apparatus (dynamic type), made it possible to identify the unsatisfactory operating conditions of the capillary sampling system. When they were modified it became possible to obtain reliable new results. All the data presented in this paper satisfy the Prausnitz–Keeler test.

Experimental Section

Apparatus and Procedure. The three apparatuses used in this work are based on the static method with analysis of the equilibrium phases. They differ mainly by the sampling system. The first, apparatus 1, developed by Legret et al. (*7*), had detachable microcells to sample both phases between 1 and 100 MPa, at 233–433 K. This equipment is particularly suited for studies at temperatures that are low compared to the components' normal boiling temperatures. Sampling microcells are removed from the equilibrium cell and placed inside a special heated injection assembly to a gas–liquid chromatograph (GLC).

The second apparatus, apparatus 2, developed by Figuère et al. (*8*), uses two valves to perform microexpansion sampling between 0.5 and 40 MPa, at 333–673 K. The sampling valves are part of the equilibrium cell. The equilibrium temperature has to be higher than the bubble temperature of the heaviest component at GLC carrier gas pressure to ensure fast vaporization of liquid samples.

Apparatus 3, designed by Laugier and Richon (*9*) to combine the advantages of the two preceding apparatuses, uses sampling by capillaries. The capillaries limit the sample size by hydrodynamic slow flow and connect the sampling tip immersed in the temperature-controlled liquid bath where the equilibrium cell is immersed to the heated injector. In this way, the temperature of the on-line injection chamber has no effect on that of the equilibrium cell.

Since the volumes of the samples in each of the three apparatuses are sufficiently small (2×10^{-5}% to 2×10^{-4}%), compared to the cell volumes, sampling does not disturb the state of equilibrium.

Pressure P measurements were performed by using membrane pressure transducers calibrated with a dead-weight

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Table I. Vapor–Liquid Equilibrium Data, Temperature T, Pressure P, Liquid-Phase x and Vapor-Phase y Mole Fractions, and the Uncertainties σ, for the System Methane (1)–n-Propylbenzene (2)

T/K	$\sigma(T)$/K	P/MPa	σ(P)/MPa	x_1	$\sigma(x_1)/10^{-3}$	y_1	$\sigma(y_1)/10^{-3}$	T/K	$\sigma(T)$/K	P/MPa	σ(P)/MPa	x_1	$\sigma(x_1)/10^{-3}$	y_1	$\sigma(y_1)/10^{-3}$
313.2	0.1	1.00	0.01			0.9987	0.2[c]	392.7	0.1	35.4	0.1	0.635	8[a]	0.947	3[a]
313.2	0.1	1.55	0.01			0.9990	0.2[c]	392.7	0.1	37.9	0.1	0.687	8[a]	0.919	3[a]
313.2	0.1	1.98	0.01			0.9992	0.2[c]	392.7	0.1	39.0	0.1			0.902	3[a]
313.2	0.1	5.06	0.01			0.9993	0.2[c]	392.7	0.1	39.5	0.1	0.729	8[a]		
313.6	0.1	5.1	0.1	0.128	6[a]	0.9992	0.3[a]	392.7	0.1	39.9	0.1			0.875	4[a]
313.6	0.1	10.0	0.1	0.232	10[a]	0.9993	0.3[a]	392.7	0.1	40.3	0.1	0.769	8[a]	0.844	5[a]
313.6	0.1	14.9	0.1	0.316	14[a]	0.9991	0.3[a]								
313.6	0.1	19.8	0.1	0.397	17[a]	0.9984	0.3[a]	472.8	0.5	1.90	0.04			0.829	6[b]
313.6	0.1	24.9	0.1	0.461	20[a]	0.9962	0.5[a]	472.8	0.5	2.14	0.04	0.044	1[b]		
313.6	0.1	29.9	0.1	0.511	22[a]	0.9920	0.9[a]	472.8	0.5	3.13	0.04	0.067	2[b]		
313.6	0.1	35.0	0.1	0.555	25[a]	0.9853	0.9[a]	472.8	0.5	4.13	0.04			0.902	4[b]
313.6	0.1	39.8	0.1	0.610	10[a]	0.9794	0.5[a]	472.8	0.5	5.08	0.04	0.109	3[b]		
313.6	0.1	44.9	0.1			0.9708	0.5[a]	472.8	0.5	7.80	0.04			0.936	2[b]
313.6	0.1	45.1	0.1	0.673	11[a]			472.8	0.5	10.13	0.04	0.217	7[b]		
313.6	0.1	50.0	0.1			0.9368	0.7[a]	472.8	0.5	11.80	0.04			0.941	2[b]
313.6	0.1	52.7	0.1	0.805	10[a]			472.8	0.5	15.25	0.04	0.316	7[b]		
313.6	0.1	53.2	0.1			0.8686	1.0[a]	472.8	0.5	15.37	0.04			0.939	2[b]
								472.8	0.5	20.33	0.04	0.412	7[b]		
392.7	0.1	5.5	0.1	0.126	4[a]			472.8	0.5	21.00	0.04			0.933	5[b]
392.7	0.1	10.5	0.1	0.224	6[a]	0.9935	0.4[a]	472.8	0.5	25.18	0.04	0.514	10[b]		
392.7	0.1	14.6	0.1			0.9919	0.5[a]	472.8	0.5	27.79	0.04			0.872	4[b]
392.7	0.1	15.2	0.1	0.306	8[a]			472.8	0.5	28.60	0.04	0.594	7[b]		
392.7	0.1	20.3	0.1	0.389	8[a]	0.9900	0.4[a]	472.8	0.5	30.05	0.04			0.821	4[b]
392.7	0.1	25.5	0.1	0.472	8[a]			472.8	0.5	30.58	0.04	0.672	7[b]		
392.7	0.1	26.0	0.1	0.480	8[a]	0.985	1[a]	472.8	0.5	30.91	0.04	0.709	6[b]		
392.7	0.1	30.3	0.1	0.550	10[a]	0.974	1[a]								

[a] Apparatus 1 (*1*). [b] Apparatus 2 (*1*). [c] Apparatus 3 (present work).

Table II. Vapor–Liquid Equilibrium Data, Temperature T, Pressure P, Liquid-Phase x and Vapor-Phase y Mole Fractions, and the Uncertainties σ, for the System Methane (1)–Methylcyclohexane (2)

T/K	$\sigma(T)$/K	P/MPa	$\sigma(P)$/MPa	x_1	$\sigma(x_1)/10^{-3}$	y_1	$\sigma(y_1)/10^{-3}$	T/K	$\sigma(T)$/K	P/MPa	$\sigma(P)$/MPa	x_1	$\sigma(x_1)/10^{-3}$	y_1	$\sigma(y_1)/10^{-3}$
313.4	0.1	2.52	0.02	0.081	3[a]	0.9914	0.6[a]	393.1	0.5	22.07	0.02	0.538	7[b]	0.901	4[b]
313.4	0.1	5.02	0.02	0.153	3[a]	0.9932	0.5[a]	393.1	0.5	24.96	0.02	0.608	6[b]	0.872	3[b]
313.4	0.1	10.08	0.02	0.288	5[a]	0.9921	0.5[a]	393.1	0.5	26.00	0.02	0.644	7[b]	0.853	4[b]
313.4	0.1	15.07	0.02	0.412	7[a]	0.985	1[a]	393.1	0.5	27.00	0.02	0.678	5[b]	0.837	5[b]
313.4	0.1	20.06	0.02	0.530	7[a]	0.973	2[a]								
313.4	0.1	22.49	0.02	0.587	7[a]	0.960	3[a]	473.2	0.5	3.35	0.02	0.065	2[b]	0.654	6[b]
313.4	0.1	25.23	0.02	0.660	5[a]	0.945	3[a]	473.2	0.5	5.03	0.02	0.111	3[b]	0.743	5[b]
313.4	0.1	27.71	0.02	0.737	5[a]	0.910	5[a]	473.2	0.5	6.52	0.02	0.149	3[b]	0.775	5[b]
								473.2	0.5	8.94	0.02	0.212	4[b]	0.803	4[b]
393.1	0.5	2.89	0.02	0.071	2[b]	0.917	3[b]	473.2	0.5	11.52	0.02	0.281	4[b]	0.810	4[b]
393.1	0.5	8.05	0.02	0.199	3[b]	0.944	4[b]	473.2	0.5	14.04	0.02	0.346	5[b]	0.800	4[b]
393.1	0.5	13.03	0.02	0.319	5[b]	0.942	2[b]	473.2	0.5	16.53	0.02	0.410	7[b]	0.786	4[b]
393.1	0.5	18.00	0.02	0.428	7[b]	0.927	3[b]	473.2	0.5	18.02	0.02	0.462	7[b]	0.769	5[b]

[a] Apparatus 3 (*4*). [b] Apparatus 2 (*4*).

Table III. Vapor–Liquid Equilibrium Data, Temperature T, Pressure P, Liquid-Phase x and Vapor-Phase y Mole Fractions, and the Uncertainties σ, for the System Methane (1)–n-propylcyclohexane (2)

T/K	$\sigma(T)$/K	P/MPa	$\sigma(P)$/MPa	x_1	$\sigma(x_1)/10^{-3}$	y_1	$\sigma(y_1)/10^{-3}$	T/K	$\sigma(T)$/K	P/MPa	$\sigma(P)$/MPa	x_1	$\sigma(x_1)/10^{-3}$	y_1	$\sigma(y_1)/10^{-3}$
313.6	0.1	3.15	0.1	0.131	5[a]			393.1	0.5	32.50	0.04	0.679	10[b]	0.926	3[b]
313.6	0.1	5.20	0.1	0.179	5[a]	0.9986	0.5[a]	393.1	0.5	33.65	0.04			0.914	3[b]
313.6	0.1	7.45	0.1	0.234	5[a]	0.9986	0.5[a]	393.1	0.5	34.50	0.04			0.902	3[b]
313.6	0.1	10.50	0.1	0.303	5[a]	0.9982	0.5[a]	393.1	0.5	35.00	0.04	0.749	9[b]		
313.6	0.1	15.40	0.1	0.402	5[a]	0.9982	0.9[a]	393.1	0.5	35.50	0.04	0.763	7[b]	0.884	3[b]
313.6	0.1	20.50	0.1	0.486	6[a]	0.9962	0.5[a]								
313.6	0.1	25.50	0.1	0.554	7[a]	0.9937	0.9[a]	472.8	0.5	1.50	0.04	0.038	1[b]	0.754	7[b]
313.6	0.1	30.80	0.1	0.633	7[a]	0.987	2[a]	472.8	0.5	2.15	0.04	0.052	1[b]		
313.6	0.1	35.20	0.1	0.694	7[a]	0.977	4[a]	472.8	0.5	4.00	0.04	0.105	3[b]	0.895	4[b]
313.6	0.1	38.95	0.1	0.762	7[a]	0.960	3[a]	472.8	0.5	8.00	0.04	0.202	6[b]	0.928	3[b]
								472.8	0.5	12.00	0.04	0.296	7[b]	0.933	2[b]
393.1	0.5	2.50	0.04	0.073	2[b]	0.976	6[b]	472.8	0.5	15.90	0.04	0.384	8[b]	0.927	4[b]
393.1	0.5	5.15	0.04	0.141	4[b]	0.981	6[b]	472.8	0.5	20.10	0.04	0.477	9[b]	0.918	5[b]
393.1	0.5	10.10	0.04	0.256	6[b]	0.986	6[b]	472.8	0.5	23.90	0.04	0.575	9[b]	0.888	3[b]
393.1	0.5	15.10	0.04	0.359	7[b]	0.979	5[b]	472.8	0.5	25.90	0.04	0.639	8[b]	0.850	3[b]
393.1	0.5	20.00	0.04	0.452	9[b]	0.972	4[b]	472.8	0.5	26.40	0.04	0.658	7[b]	0.838	5[b]
393.1	0.5	25.00	0.04	0.539	8[b]	0.963	4[b]	472.8	0.5	27.00	0.04	0.712	6[b]	0.805	6[b]
393.1	0.5	30.00	0.04	0.626	10[b]	0.944	4[b]								

[a] Apparatus 1 (*1*). [b] Apparatus 2 (*1*).

Table IV. Vapor–Liquid Equilibrium Data, Temperature T, Pressure P, Liquid-Phase x and Vapor-Phase y Mole Fractions, and the Uncertainties σ, for the System Ethane (1)–Toluene (2)

T/K	$\sigma(T)$/K	P/MPa	$\sigma(P)$/MPa	x_1	$\sigma(x_1)/10^{-3}$	y_1	$\sigma(y_1)/10^{-3}$	T/K	$\sigma(T)$/K	P/MPa	$\sigma(P)$/MPa	x_1	$\sigma(x_1)/10^{-3}$	y_1	$\sigma(y_1)/10^{-3}$
313.1	0.1	0.63	0.01	0.084	2[a]			393.1	0.5	6.40	0.02	0.445	6[b]	0.945	3[b]
313.1	0.1	0.678	0.005			0.988	1.5[c]	393.1	0.5	7.76	0.02			0.936	2[b]
313.1	0.1	1.012	0.005			0.991	1[c]	393.1	0.5	7.82	0.02	0.546	7[b]		
313.1	0.1	1.29	0.01	0.178	4[a]	0.9923	0.3[a]	393.1	0.5	8.90	0.02	0.628	8[b]	0.921	2[b]
313.1	0.1	1.424	0.005			0.9930	0.6[c]	393.1	0.5	9.92	0.02	0.718	5[b]	0.896	3[b]
313.1	0.1	2.05	0.01	0.296	5[a]	0.9938	0.4[a]	393.1	0.5	10.19	0.02	0.742	7[b]		
313.1	0.1	2.89	0.01	0.458	7[a]	0.9945	0.2[a]								
313.1	0.1	3.38	0.01	0.557	7[a]	0.9946	0.3[a]	473.2	0.5	1.17	0.02	0.027	1[b]	0.361	20[b]
313.1	0.1	3.90	0.01	0.682	6[a]	0.9944	0.3[a]	473.2	0.5	1.75	0.02	0.056	1[b]	0.540	6[b]
313.1	0.1	4.35	0.01	0.805	6[a]	0.9940	0.4[a]	473.2	0.5	3.18	0.02	0.133	3[b]	0.687	6[b]
313.1	0.1	4.73	0.01			0.9932	0.4[a]	473.2	0.5	4.90	0.02			0.753	6[b]
313.1	0.1	4.77	0.01	0.905	2[a]			473.2	0.5	4.99	0.02	0.224	4[b]		
313.1	0.1	4.83	0.01			0.9938	0.3[a]	473.2	0.5	6.51	0.02	0.296	4[b]	0.765	5[b]
								473.2	0.5	8.27	0.02			0.755	7[b]
393.1	0.5	0.93	0.02	0.065	2[b]	0.855	7[b]	473.2	0.5	8.32	0.02	0.388	5[b]		
393.1	0.5	2.08	0.02			0.916	3[b]	473.2	0.5	9.92	0.02	0.478	5[b]	0.724	6[b]
393.1	0.5	2.16	0.02	0.158	4[b]	0.920	3[b]	473.2	0.5	11.17	0.02	0.563	5[b]	0.686	7[b]
393.1	0.5	3.46	0.02	0.253	4[b]	0.934	5[b]	473.2	0.5	11.48	0.02	0.604	5[b]	0.624	6[b]
393.1	0.5	5.12	0.02	0.361	5[b]	0.945	3[b]								

[a] Apparatus 3 (2). [b] Apparatus 2 (2). [c] Apparatus 3 (present work).

Table V. Vapor–Liquid Equilibrium Data, Temperature T, Pressure P, Liquid-Phase x and Vapor-Phase y Mole Fractions, and the Uncertainties σ, for the System Ethane (1)–*m*-Xylene (2)

T/K	$\sigma(T)$/K	P/MPa	$\sigma(P)$/MPa	x_1	$\sigma(x_1)/10^{-3}$	y_1	$\sigma(y_1)/10^{-3}$	T/K	$\sigma(T)$/K	P/MPa	$\sigma(P)$/MPa	x_1	$\sigma(x_1)/10^{-3}$	y_1	$\sigma(y_1)/10^{-3}$
313.1	0.1	0.51	0.01	0.071	2[a]	0.9947	0.4[a]	393.1	0.5	10.96	0.02	0.791	6[b]	0.891	4[b]
313.1	0.1	1.22	0.01	0.183	3[a]	0.9973	0.2[a]	393.1	0.5	11.21	0.02	0.817	5[b]	0.859	3[b]
313.1	0.1	1.96	0.01	0.300	5[a]	0.9975	0.2[a]								
313.1	0.1	2.73	0.01	0.434	7[a]	0.9977	0.2[a]	473.1	0.5	1.01	0.02	0.036	1[b]	0.549	6[b]
313.1	0.1	3.28	0.01	0.540	7[a]	0.9979	0.2[a]	473.1	0.5	1.74	0.02	0.076	2[b]		
313.1	0.1	4.10	0.01	0.726	5[a]	0.9976	0.2[a]	473.1	0.5	2.12	0.02	0.101	3[b]	0.766	6[b]
313.1	0.1	4.67	0.01	0.867	4[a]	0.9967	0.2[a]	473.1	0.5	3.42	0.02	0.169	4[b]	0.825	4[b]
313.1	0.1	4.93	0.01	0.925	3[a]	0.9964	0.2[a]	473.1	0.5	4.81	0.02			0.852	5[b]
								473.1	0.5	4.96	0.02	0.250	4[b]		
393.1	0.5	0.80	0.02	0.063	1[b]	0.908	3[b]	473.1	0.5	6.59	0.02	0.330	6[b]		
393.1	0.5	1.50	0.02	0.115	2[b]	0.941	2[b]	473.1	0.5	6.92	0.02			0.863	3[b]
393.1	0.5	3.01	0.02	0.227	4[b]	0.958	2[b]	473.1	0.5	8.09	0.02	0.403	5[b]		
393.1	0.5	5.02	0.02	0.367	5[b]	0.963	2[b]	473.1	0.5	8.57	0.02	0.424	6[b]	0.857	3[b]
393.1	0.5	6.96	0.02	0.499	6[b]	0.954	3[b]	473.1	0.5	9.54	0.02	0.474	6[b]		
393.1	0.5	8.98	0.02	0.626	6[b]	0.940	3[b]	473.1	0.5	10.19	0.02	0.498	6[b]		
393.1	0.5	9.91	0.02	0.699	5[b]	0.925	3[b]	473.1	0.5	10.42	0.02	0.515	6[b]	0.840	3[b]
393.1	0.5	10.39	0.02	0.734	6[b]	0.920	3[b]	473.1	0.5	11.36	0.02	0.569	6[b]	0.813	3[b]
393.1	0.5	10.68	0.02	0.760	6[b]	0.905	4[b]	473.1	0.5	11.61	0.02	0.582	5[b]	0.810	3[b]
393.1	0.5	10.80	0.02	0.773	7[b]			473.1	0.5	11.98	0.02	0.618	5[b]	0.782	4[b]

[a] Apparatus 3 (2). [b] Apparatus 2 (2).

Table VI. Vapor–Liquid Equilibrium Data, Temperature T, Pressure P, Liquid-Phase x and Vapor-Phase y Mole Fractions, and the Uncertainties σ, for the System Ethane (1)–Mesitylene (2)

T/K	$\sigma(T)$/K	P/MPa	$\sigma(P)$/MPa	x_1	$\sigma(x_1)/10^{-3}$	y_1	$\sigma(y_1)/10^{-3}$	T/K	$\sigma(T)$/K	P/MPa	$\sigma(P)$/MPa	x_1	$\sigma(x_1)/10^{-3}$	y_1	$\sigma(y_1)/10^{-3}$
313.1	0.1	0.50	0.01	0.075	5[a]	0.9980	0.2[a]	402.8	0.5	10.56	0.02	0.691	7[b]	0.915	7[b]
313.1	0.1	1.27	0.01	0.204	4[a]	0.9988	0.1[a]	402.8	0.5	11.12	0.02	0.741	8[b]	0.872	7[b]
313.1	0.1	2.07	0.01	0.317	6[a]	0.9989	0.1[a]								
313.1	0.1	2.89	0.01	0.468	7[a]	0.9989	0.1[a]	473.0	0.5	0.91	0.02	0.038	1[b]	0.701	6[b]
313.1	0.1	3.70	0.01	0.627	7[a]	0.9986	0.2[a]	473.0	0.5	1.51	0.02	0.070	1[b]	0.793	4[b]
313.1	0.1	4.52	0.01	0.813	6[a]	0.9981	0.2[a]	473.0	0.5	2.19	0.02			0.846	5[b]
313.1	0.1	4.92	0.01	0.910	4[a]	0.9975	0.2[a]	473.0	0.5	3.01	0.02	0.145	2[b]	0.872	8[b]
313.1	0.1	5.06	0.01	0.944	3[a]	0.9971	0.2[a]	473.0	0.5	4.94	0.02	0.244	4[b]	0.896	5[b]
								473.0	0.5	7.13	0.02	0.349	4[b]	0.901	3[b]
402.8	0.5	1.03	0.02	0.073	2[b]	0.950	4[b]	473.0	0.5	9.09	0.02	0.444	5[b]	0.892	4[b]
402.8	0.5	2.14	0.02	0.151	3[b]	0.969	3[b]	473.0	0.5	9.56	0.02	0.468	5[b]		
402.8	0.5	3.85	0.02	0.266	4[b]	0.975	2[b]	473.0	0.5	10.30	0.02	0.503	6[b]		
402.8	0.5	5.54	0.02	0.373	6[b]	0.974	1[b]	473.0	0.5	11.16	0.02	0.554	6[b]	0.866	3[b]
402.8	0.5	7.03	0.02	0.464	6[b]	0.970	1[b]	473.0	0.5	11.70	0.02	0.589	6[b]		
402.8	0.5	8.11	0.02	0.530	6[b]	0.962	2[b]	473.0	0.5	12.43	0.02	0.640	6[b]	0.819	7[b]
402.8	0.5	9.57	0.02	0.624	6[b]	0.938	3[b]	473.0	0.5	12.82	0.02			0.736	8[b]

[a] Apparatus 3 (2). [b] Apparatus 2 (2).

Table VII. Vapor–Liquid Equilibrium Data, Temperature T, Pressure P, Liquid-Phase x and Vapor-Phase y Mole Fractions, and the Uncertainties σ, for the System Ethane (1)–*n*-Propylbenzene (2)

T/K	$\sigma(T)$/ K	P/ MPa	$\sigma(P)$/ MPa	x_1	$\sigma(x_1)$/ 10^{-3}	y_1	$\sigma(y_1)$/ 10^{-3}	T/K	$\sigma(T)$/ K	P/ MPa	$\sigma(P)$/ MPa	x_1	$\sigma(x_1)$/ 10^{-3}	y_1	$\sigma(y_1)$/ 10^{-3}
313.2	0.1	0.38	0.005			0.9964	0.4[c]	403.2	0.5	2.50	0.02	0.183	3[b]		
313.2	0.1	0.49	0.01	0.081	4[a]	0.9979	0.2[a]	403.2	0.5	3.72	0.02	0.266	4[b]	0.972	1[b]
313.2	0.1	0.65	0.005			0.9978	0.2[c]	403.2	0.5	5.24	0.02	0.363	7[b]	0.973	1[b]
313.2	0.1	0.90	0.005			0.9982	0.2[c]	403.2	0.5	6.79	0.02	0.453	7[b]	0.970	2[b]
313.2	0.1	1.15	0.005			0.9985	0.3[c]	403.2	0.5	8.30	0.02	0.539	6[b]	0.967	2[b]
313.2	0.1	1.23	0.01	0.200	4[a]	0.9988	0.1[a]	403.2	0.5	9.74	0.02	0.626	7[b]		
313.2	0.1	1.51	0.005			0.9987	0.2[c]	403.2	0.5	10.71	0.02	0.682	6[b]		
313.2	0.1	1.99	0.01	0.311	6[a]	0.9989	0.1[a]	403.2	0.5	10.94	0.02	0.691	6[b]	0.942	4[b]
313.2	0.1	2.00	0.005			0.9988	0.2[c]	403.2	0.5	12.00	0.02	0.745	5[b]	0.919	3[b]
313.2	0.1	2.80	0.01	0.451	7[a]	0.9989	0.1[a]	403.2	0.5	12.25	0.02	0.764	6[b]		
313.2	0.1	2.97	0.01			0.9988	0.2[c]								
313.2	0.1	3.62	0.01	0.605	8[a]	0.9987	0.1[a]	473.1	0.5	1.00	0.02	0.033	1[b]	0.640	6[b]
313.2	0.1	4.18	0.01			0.9983	0.3[c]	473.1	0.5	1.77	0.02	0.074	2[b]	0.801	6[b]
313.2	0.1	4.29	0.01	0.753	5[a]	0.9983	0.2[a]	473.1	0.5	2.87	0.02			0.871	6[b]
313.2	0.1	4.80	0.01	0.879	4[a]	0.9980	0.2[a]	473.1	0.5	3.63	0.02	0.167	3[b]		
313.2	0.1	5.00	0.01			0.9971	0.4[c]	473.1	0.5	5.01	0.02	0.237	4[b]	0.903	4[b]
313.2	0.1	5.12	0.01	0.945	2[a]	0.9972	0.2[a]	473.1	0.5	7.10	0.02	0.335	5[b]	0.904	4[b]
								473.1	0.5	9.05	0.02	0.428	6[b]	0.896	3[b]
403.2	0.5	0.45	0.02	0.034	2[b]	0.873	5[b]	473.1	0.5	11.02	0.02	0.529	6[b]	0.872	3[b]
403.2	0.5	0.49	0.02	0.040	2[b]			473.1	0.5	11.95	0.02	0.583	6[b]	0.856	4[b]
403.2	0.5	1.25	0.02	0.099	3[b]	0.942	3[b]	473.1	0.5	13.00	0.02	0.667	7[b]	0.804	4[b]
403.2	0.5	2.28	0.02	0.168	4[b]	0.959	2[b]	473.1	0.5	13.28	0.02	0.701	6[b]		

[a] Apparatus 3 (2). [b] Apparatus 2 (2). [c] Apparatus 3 (this work).

Table VIII. Vapor–Liquid Equilibrium Data, Temperature T, Pressure P, Liquid-Phase x and Vapor-Phase y Mole Fractions, and the Uncertainties σ, for the System Ethane (1)–Methylcyclohexane (2)

T/K	$\sigma(T)$/ K	P/ MPa	$\sigma(P)$/ MPa	x_1	$\sigma(x_1)$/ 10^{-3}	y_1	$\sigma(y_1)$/ 10^{-3}	T/K	$\sigma(T)$/ K	P/ MPa	$\sigma(P)$/ MPa	x_1	$\sigma(x_1)$/ 10^{-3}	y_1	$\sigma(y_1)$/ 10^{-3}
313.1	0.1	0.60	0.01	0.135	3[a]	0.980	2[a]	393.1	0.5	6.55	0.02	0.527	6[b]	0.917	2[b]
313.1	0.1	1.06	0.01	0.234	5[a]	0.986	1[a]	393.1	0.5	7.77	0.02	0.623	5[b]	0.901	5[b]
313.1	0.1	1.53	0.01	0.327	6[a]	0.9884	0.8[a]	393.1	0.5	8.30	0.02	0.667	5[b]		
313.1	0.1	1.99	0.01	0.414	6[a]	0.9908	0.3[a]	393.1	0.5	8.77	0.02	0.710	4[b]	0.886	7[b]
313.1	0.1	2.49	0.01	0.508	8[a]	0.9926	0.5[a]	393.1	0.5	9.18	0.02	0.759	4[b]	0.869	7[b]
313.1	0.1	2.98	0.01	0.604	7[a]	0.9933	0.5[a]								
313.1	0.1	3.45	0.01	0.690	7[a]	0.9931	0.5[a]	473.0	0.5	2.05	0.02	0.072	2[b]	0.490	5[b]
313.1	0.1	3.98	0.01	0.791	4[a]	0.9933	0.3[a]	473.0	0.5	3.08	0.02	0.133	3[b]	0.602	5[b]
313.1	0.1	4.42	0.01	0.869	4[a]	0.9933	0.3[a]	473.0	0.5	4.03	0.02	0.185	3[b]	0.660	4[b]
313.1	0.1	4.77	0.01	0.923	3[a]	0.9932	0.6[a]	473.0	0.5	5.90	0.02	0.298	5[b]	0.721	3[b]
								473.0	0.5	6.93	0.02	0.357	5[b]	0.725	5[b]
393.1	0.5	1.03	0.02	0.080	2[b]	0.790	9[b]	473.0	0.5	7.80	0.02	0.420	5[b]	0.728	4[b]
393.1	0.5	2.16	0.02	0.180	3[b]	0.879	3[b]	473.0	0.5	8.86	0.02	0.506	6[b]	0.684	5[b]
393.1	0.5	2.92	0.02	0.244	4[b]	0.902	2[b]	473.0	0.5	9.06	0.02	0.519	6[b]		
393.1	0.5	4.12	0.02	0.343	5[b]	0.916	2[b]	473.0	0.5	9.25	0.02			0.642	5[b]
393.1	0.5	5.26	0.02	0.429	5[b]	0.916	3[b]	473.0	0.5	9.36	0.02	0.561	7[b]		

[a] Apparatus 3 (2). [b] Apparatus 2 (2).

Table IX. Vapor–Liquid Equilibrium Data, Temperature T, Pressure P, Liquid-Phase x and Vapor-Phase y Mole Fractions, and the Uncertainties σ, for the System Ethane (1)–*n*-Propylcyclohexane (2)

T/K	$\sigma(T)$/ K	P/ MPa	$\sigma(P)$/ MPa	x_1	$\sigma(x_1)$/ 10^{-3}	y_1	$\sigma(y_1)$/ 10^{-3}	T/K	$\sigma(T)$/ K	P/ MPa	$\sigma(P)$/ MPa	x_1	$\sigma(x_1)$/ 10^{-3}	y_1	$\sigma(y_1)$/ 10^{-3}
313.1	0.1	0.91	0.01	0.187	5[a]	0.9983	0.2[a]	393.0	0.5	9.60	0.02	0.708	4[b]		
313.1	0.1	1.60	0.01	0.319	6[a]	0.9987	0.1[a]	393.0	0.5	10.49	0.02	0.783	5[b]	0.926	2[b]
313.1	0.1	2.29	0.01	0.440	7[a]	0.9991	0.1[a]	393.0	0.5	10.86	0.02	0.846	7[b]	0.884	2[b]
313.1	0.1	3.00	0.01	0.569	7[a]	0.9992	0.1[a]								
313.1	0.1	3.71	0.01	0.700	5[a]	0.9989	0.1[a]	472.9	0.5	1.10	0.02	0.052	1[b]	0.709	5[b]
313.1	0.1	4.42	0.01	0.827	4[a]	0.9985	0.1[a]	472.9	0.5	2.08	0.02	0.109	2[b]	0.822	3[b]
313.1	0.1	4.97	0.01	0.914	3[a]	0.9981	0.2[a]	472.9	0.5	3.00	0.02	0.160	3[b]	0.859	3[b]
313.1	0.1	5.12	0.01	0.954	2[a]	0.9979	0.2[a]	472.9	0.5	4.02	0.02	0.216	4[b]	0.879	3[b]
								472.9	0.5	5.72	0.02	0.311	5[b]	0.893	2[b]
393.0	0.5	0.76	0.02	0.067	1[b]	0.935	2[b]	472.9	0.5	7.19	0.02	0.386	5[b]	0.894	3[b]
393.0	0.5	1.52	0.02	0.133	2[b]	0.961	1[b]	472.9	0.5	8.99	0.02	0.473	6[b]	0.884	3[b]
393.0	0.5	3.25	0.02	0.271	4[b]	0.975	0.8[b]	472.9	0.5	10.55	0.02	0.561	5[b]	0.861	3[b]
393.0	0.5	4.74	0.02	0.379	5[b]	0.976	0.8[b]	472.9	0.5	11.52	0.02			0.826	3[b]
393.0	0.5	6.25	0.02	0.483	6[b]	0.976	0.9[b]	472.9	0.5	11.77	0.02	0.654	5[b]	0.804	4[b]
393.0	0.5	7.73	0.02	0.579	6[b]	0.967	1[b]								

[a] Apparatus 3 (3). [b] Apparatus 2 (3).

Table X. Vapor–Liquid Equilibrium Data, Temperature T, Pressure P, Liquid-Phase x and Vapor-Phase y Mole Fractions, and the Uncertainties σ, for the System Propane (1)–Toluene (2)

T/K	$\sigma(T)$/K	P/MPa	$\sigma(P)$/MPa	x_1	$\sigma(x_1)/10^{-3}$	y_1	$\sigma(y_1)/10^{-3}$	T/K	$\sigma(T)$/K	P/MPa	$\sigma(P)$/MPa	x_1	$\sigma(x_1)/10^{-3}$	y_1	$\sigma(y_1)/10^{-3}$
312.8	0.1	0.250	0.003	0.121	3[a]			394.0	0.5	0.63	0.02	0.082	2[b]	0.744	6[b]
313.1	0.1	0.310	0.003			0.9751	1.0[c]	394.0	0.5	1.15	0.02	0.171	3[b]	0.851	3[b]
313.1	0.1	0.320	0.003			0.9752	1.0[c]	394.0	0.5	1.79	0.02	0.295	5[b]	0.904	3[b]
312.8	0.1	0.400	0.003	0.208	5[a]			394.0	0.5	2.38	0.02	0.406	6[b]	0.923	3[b]
313.1	0.1	0.460	0.003			0.9836	0.8[c]	394.0	0.5	3.02	0.02	0.541	5[b]	0.937	3[b]
313.1	0.1	0.525	0.003			0.9855	0.8[c]	394.0	0.5	3.63	0.02	0.660	5[b]	0.942	2[b]
312.8	0.1	0.549	0.003	0.304	5[a]			394.0	0.5	4.20	0.02	0.766	5[b]	0.947	2[b]
313.1	0.1	0.651	0.003			0.9887	0.6[c]	394.0	0.5	4.83	0.02	0.870	4[b]	0.939	4[b]
312.8	0.1	0.700	0.003	0.418	6[a]			473.2	0.5	1.22	0.02	0.043	1[b]	0.331	5[b]
313.1	0.1	0.793	0.003			0.9913	0.6[c]	473.2	0.5	2.00	0.02	0.116	2[b]	0.556	5[b]
312.8	0.1	0.850	0.003	0.541	6[a]			473.2	0.5	2.87	0.02	0.198	3[b]	0.652	5[b]
313.1	0.1	0.997	0.003			0.9944	0.5[c]	473.2	0.5	3.61	0.02	0.269	4[b]	0.705	5[b]
312.8	0.1	1.007	0.003	0.703	5[a]			473.2	0.5	4.43	0.02	0.350	6[b]	0.735	5[b]
312.8	0.1	1.152	0.003	0.844	4[a]			473.2	0.5	5.26	0.02	0.439	5[b]	0.747	5[b]
313.1	0.1	1.178	0.003			0.9960	0.6[c]	473.2	0.5	6.06	0.02	0.528	6[b]	0.746	3[b]
312.8	0.1	1.299	0.003	0.957	1[a]			473.2	0.5	6.63	0.02	0.603	6[b]	0.710	6[b]

[a] Apparatus 3 (4). [b] Apparatus 2 (4). [c] Apparatus 3 (this work).

Table XI. Vapor–Liquid Equilibrium Data, Temperature T, Pressure P, Liquid-Phase x and Vapor-Phase y Mole Fractions, and the Uncertainties σ, for the System Propane (1)–*m*-Xylene (2)

T/K	$\sigma(T)$/K	P/MPa	$\sigma(P)$/MPa	x_1	$\sigma(x_1)/10^{-3}$	y_1	$\sigma(y_1)/10^{-3}$	T/K	$\sigma(T)$/K	P/MPa	$\sigma(P)$/MPa	x_1	$\sigma(x_1)/10^{-3}$	y_1	$\sigma(y_1)/10^{-3}$
313.3	0.1	0.252	0.003	0.140	3[a]			393.7	0.5	0.41	0.02	0.060	1[b]	0.826	6[b]
313.3	0.1	0.298	0.003	0.166	4[a]			393.7	0.5	1.09	0.02	0.182	3[b]	0.924	6[b]
313.2	0.1	0.350	0.005			0.9930	0.4[c]	393.7	0.5	1.81	0.02	0.313	5[b]	0.945	2[b]
313.2	0.1	0.400	0.005			0.9936	0.3[c]	393.7	0.5	2.43	0.02	0.432	6[b]	0.955	2[b]
313.3	0.1	0.401	0.003	0.232	4[a]			393.7	0.5	3.17	0.02	0.576	6[b]	0.961	2[b]
313.2	0.1	0.485	0.005			0.9948	0.3[c]	393.7	0.5	3.86	0.02	0.712	6[b]	0.963	2[b]
313.2	0.1	0.546	0.005			0.9952	0.3[c]	393.7	0.5	4.40	0.02	0.810	4[b]	0.966	2[b]
313.3	0.1	0.552	0.003	0.327	6[a]			393.7	0.5	4.82	0.02	0.879	3[b]	0.968	2[b]
313.2	0.1	0.702	0.005			0.9963	0.2[c]	473.2	0.5	0.79	0.02	0.034	2[b]	0.395	15[b]
313.3	0.1	0.703	0.003	0.439	6[a]	0.9962	0.3[a]	473.2	0.5	1.78	0.02	0.129	3[b]	0.680	13[b]
313.3	0.1	0.850	0.003	0.559	6[a]	0.9972	0.2[a]	473.2	0.5	2.83	0.02	0.230	4[b]	0.787	5[b]
313.3	0.1	0.992	0.003	0.687	6[a]	0.9979	0.2[a]	473.2	0.5	3.83	0.02	0.326	5[b]	0.822	3[b]
313.2	0.1	1.007	0.005			0.9978	0.2[c]	473.2	0.5	4.81	0.02	0.422	6[b]	0.833	3[b]
313.3	0.1	1.153	0.003	0.837	4[a]	0.9986	0.1[a]	473.2	0.5	5.74	0.02	0.513	6[b]	0.833	3[b]
313.2	0.1	1.278	0.005			0.9992	0.1[c]	473.2	0.5	6.78	0.02	0.629	5[b]	0.807	3[b]
313.3	0.5	1.300	0.003	0.949	2[a]	0.9994	0.1[a]	473.2	0.5	7.21	0.02	0.709	5[b]	0.726	5[b]

[a] Apparatus 3 (4). [b] Apparatus 2 (4). [c] Apparatus 3 (this work).

Table XII. Vapor–Liquid Equilibrium Data, Temperature T, Pressure P, Liquid-Phase x and Vapor-Phase y Mole Fractions, and the Uncertainties σ, for the System Propane (1)–Mesitylene (2)

T/K	$\sigma(T)$/K	P/MPa	$\sigma(P)$/MPa	x_1	$\sigma(x_1)/10^{-3}$	y_1	$\sigma(y_1)/10^{-3}$	T/K	$\sigma(T)$/K	P/MPa	$\sigma(P)$/MPa	x_1	$\sigma(x_1)/10^{-3}$	y_1	$\sigma(y_1)/10^{-3}$
313.1	0.1	0.297	0.003			0.9967	0.3[c]	403.1	0.5	1.88	0.02	0.301	5[b]	0.966	1[b]
313.1	0.1	0.349	0.003	0.185	5[a]	0.9973	0.2[c]	403.1	0.5	2.49	0.02	0.394	7[b]	0.971	1[b]
313.1	0.1	0.509	0.003	0.295	7[a]	0.9979	0.2[c]	403.1	0.5	3.34	0.02	0.533	7[b]	0.973	1[b]
313.1	0.1	0.657	0.003	0.397	7[a]			403.1	0.5	4.09	0.02	0.663	6[b]	0.973	1[b]
313.1	0.1	0.666	0.003			0.9982	0.2[c]	403.1	0.5	4.72	0.02	0.774	5[b]	0.966	1[b]
313.1	0.1	0.821	0.003	0.530	8[a]			403.1	0.5	5.10	0.02	0.838	5[b]	0.941	2[b]
313.1	0.1	0.828	0.003			0.9985	0.3[c]	473.0	0.5	0.96	0.02	0.071	2[b]	0.716	5[b]
313.1	0.1	0.963	0.003	0.660	8[a]			473.0	0.5	1.60	0.02	0.132	3[b]	0.808	4[b]
313.1	0.1	0.970	0.003			0.9989	0.2[c]	473.0	0.5	3.10	0.02	0.271	5[b]	0.872	3[b]
313.1	0.1	1.102	0.003	0.781	6[a]	0.9991	0.1[c]	473.0	0.5	4.58	0.02	0.409	6[b]	0.887	3[b]
313.1	0.1	1.204	0.003			0.9995	0.1[c]	473.0	0.5	5.07	0.02	0.454	6[b]	0.883	3[b]
313.1	0.1	1.216	0.003	0.881	5[a]			473.0	0.5	5.98	0.02	0.541	7[b]	0.878	4[b]
313.1	0.1	1.306	0.003	0.963	3[a]	0.9998	0.1[c]	473.0	0.5	7.04	0.02	0.653	5[b]	0.843	4[b]
403.1	0.5	0.67	0.02	0.103	3[b]	0.929	2[b]	473.0	0.5	7.43	0.02	0.715	5[b]	0.803	5[b]
403.1	0.5	1.30	0.02	0.208	4[b]	0.957	1[b]	473.0	0.5	7.55	0.02	0.770	5[b]	0.796	5[b]

[a] Apparatus 3 (3). [b] Apparatus 2 (3). [c] Apparatus 3 (this work).

Table XIII. Vapor–Liquid Equilibrium Data, Temperature T, Pressure P, Liquid-Phhase x and Vapor-Phase y Mole Fractions, and the Uncertainties σ, for the System Propane (1)–Propylbenzene (2)

T/K	$\sigma(T)$/ K	P/ MPa	$\sigma(P)$/ MPa	x_1	$\sigma(x_1)$/ 10^{-3}	y_1	$\sigma(y_1)$/ 10^{-3}	T/K	$\sigma(T)$/ K	P/ MPa	$\sigma(P)$/ MPa	x_1	$\sigma(x_1)$/ 10^{-3}	y_1	$\sigma(y_1)$/ 10^{-3}
313.2	0.1	0.325	0.005			0.9966	0.5[c]	393.2	0.5	1.51	0.02	0.282	4[b]	0.966	2[b]
313.3	0.1	0.350	0.003	0.202	4[a]			393.2	0.5	2.19	0.02	0.412	6[b]	0.975	3[b]
313.3	0.1	0.499	0.003	0.305	5[a]			393.2	0.5	2.75	0.02	0.513	6[b]	0.976	2[b]
313.2	0.1	0.525	0.005			0.9977	0.2[c]	393.2	0.5	3.30	0.02	0.615	5[b]	0.975	3[b]
313.3	0.1	0.638	0.003	0.400	7[a]			393.2	0.5	3.77	0.02	0.708	5[b]	0.973	3[b]
313.2	0.1	0.700	0.005			0.9985	0.2[c]	393.2	0.5	4.11	0.02	0.774	6[b]	0.964	3[b]
313.3	0.1	0.799	0.003	0.522	8[a]			393.2	0.5	4.39	0.02	0.829	5[b]	0.948	3[b]
313.2	0.1	0.820	0.005			0.9987	0.2[c]								
313.3	0.1	0.942	0.003	0.643	8[a]			473.2	0.5	0.83	0.02	0.059	1[b]	0.626	6[b]
313.2	0.1	0.955	0.005			0.9990	0.1[c]	473.2	0.5	1.90	0.02	0.163	3[b]	0.815	4[b]
313.3	0.1	1.100	0.003	0.769	5[a]			473.2	0.5	3.04	0.02	0.275	5[b]	0.859	3[b]
313.2	0.1	1.110	0.005			0.9992	0.1[c]	473.2	0.5	4.14	0.02	0.380	5[b]	0.873	4[b]
313.2	0.1	1.210	0.005			0.9995	0.1[c]	472.3	0.5	5.24	0.02	0.482	5[b]	0.879	4[b]
313.3	0.1	1.256	0.003	0.909	4[a]	0.9995	0.2[a]	473.2	0.5	6.32	0.02	0.586	5[b]	0.868	5[b]
313.3	0.1	1.309	0.003	0.949	4[a]	0.9997	0.2[a]	473.2	0.5	6.76	0.02	0.635	6[b]	0.851	6[b]
								473.2	0.5	6.97	0.02	0.654	6[b]	0.838	7[b]
393.2	0.5	0.50	0.02	0.093	2[b]	0.923	3[b]	473.2	0.5	7.27	0.02	0.700	5[b]	0.810	7[b]
393.2	0.5	0.97	0.02	0.183	4[b]	0.955	2[b]								

[a] Apparatus 3 (3). [b] Apparatus 2 (3). [c] Apparatus 3 (this work).

Table XIV. Vapor–Liquid Equilibrium Data, Temperature T, Pressure P, Liquid-Phase x and Vapor-Phase y Mole Fractions, and the Uncertainties σ, for the System Propane (1)–Cyclohexane (2)

T/K	$\sigma(T)$/ K	P/ MPa	$\sigma(P)$/ MPa	x_1	$\sigma(x_1)$/ 10^{-3}	y_1	$\sigma(y_1)$/ 10^{-3}	T/K	$\sigma(T)$/ K	P/ MPa	$\sigma(P)$/ MPa	x_1	$\sigma(x_1)$/ 10^{-3}	y_1	$\sigma(y_1)$/ 10^{-3}
313.0	0.1	0.255	0.003	0.152	4[a]	0.906	3[a]	393.0	0.5	2.17	0.02	0.395	6[b]	0.855	3[b]
313.0	0.1	0.405	0.003	0.262	5[a]	0.944	1[a]	393.0	0.5	2.64	0.02	0.491	6[b]	0.881	3[b]
313.0	0.1	0.554	0.003	0.378	6[a]	0.962	1[a]	393.0	0.5	3.37	0.02	0.637	5[b]	0.902	3[b]
313.0	0.1	0.701	0.003	0.492	6[a]	0.9732	0.7[a]	393.0	0.5	3.88	0.02	0.731	5[b]	0.908	5[b]
313.0	0.1	0.855	0.003	0.615	7[a]	0.9813	0.8[a]	393.0	0.5	4.06	0.02	0.761	5[b]	0.903	5[b]
313.0	0.1	1.004	0.003	0.732	5[a]	0.9868	0.5[a]								
313.0	0.1	1.160	0.003	0.847	4[a]	0.9922	0.5[a]	473.0	0.5	1.80	0.02	0.054	2[b]	0.232	5[b]
313.0	0.1	1.236	0.003	0.916	4[a]	0.9957	0.3[a]	473.0	0.5	2.29	0.02	0.104	2[b]	0.370	6[b]
313.0	0.1	1.318	0.003	0.970	1[a]	0.9983	0.2[a]	473.0	0.5	2.90	0.02	0.175	4[b]	0.490	7[b]
								473.0	0.5	3.50	0.02	0.238	4[b]	0.555	6[b]
393.0	0.5	0.68	0.02	0.084	2[b]	0.557	7[b]	473.0	0.5	4.14	0.02	0.307	5[b]	0.595	5[b]
393.0	0.5	0.93	0.02	0.138	3[b]	0.680	6[b]	473.0	0.5	4.76	0.02	0.372	6[b]	0.619	5[b]
393.0	0.5	1.26	0.02	0.208	4[b]	0.757	4[b]	473.0	0.5	5.33	0.02	0.436	6[b]	0.627	6[b]
393.0	0.5	1.63	0.02	0.287	5[b]	0.812	4[b]	473.0	0.5	5.90	0.02	0.515	8[b]	0.608	6[b]

[a] Apparatus 3 (3). [b] Apparatus 2 (3).

Table XV. Vapor–Liquid Equilibrium Data, Temperature T, Pressure P, Liquid-Phase x and Vapor-Phase y Mole Fractions, and the Uncertainties σ, for the System Propane (1)–Methylcyclohexane (2)

T/K	$\sigma(T)$/ K	P/ MPa	$\sigma(P)$/ MPa	x_1	$\sigma(x_1)$/ 10^{-3}	y_1	$\sigma(y_1)$/ 10^{-3}	T/K	$\sigma(T)$/ K	P/ MPa	$\sigma(P)$/ MPa	x_1	$\sigma(x_1)$/ 10^{-3}	y_1	$\sigma(y_1)$/ 10^{-3}
313.3	0.1	0.194	0.003	0.144	3[a]	0.938	2[a]	393.2	0.5	2.91	0.02	0.556	5[b]	0.927	3[b]
313.3	0.1	0.257	0.003	0.191	4[a]	0.9526	0.9[a]	233.2	0.5	3.37	0.02	0.642	6[b]	0.933	3[b]
313.3	0.1	0.400	0.003	0.299	5[a]	0.9717	0.6[a]	393.2	0.5	3.76	0.02	0.712	5[b]	0.938	3[b]
313.3	0.1	0.550	0.003	0.411	5[a]	0.9803	0.7[a]	393.2	0.5	4.23	0.02	0.786	5[b]	0.920	5[b]
313.3	0.1	0.700	0.003	0.521	6[a]	0.9860	0.6[a]								
313.3	0.1	0.827	0.003	0.613	6[a]	0.9894	0.4[a]	472.9	0.5	1.74	0.02	0.098	2[b]	0.429	6[b]
313.3	0.1	1.001	0.003	0.747	5[a]	0.9935	0.3[a]	472.9	0.5	2.60	0.02	0.191	4[b]	0.585	6[b]
313.3	0.1	1.155	0.003	0.856	5[a]	0.9960	0.2[a]	472.9	0.5	3.44	0.02	0.278	4[b]	0.665	8[b]
313.3	0.1	1.301	0.003	0.953	3[a]	0.9985	0.1[a]	472.9	0.5	4.12	0.02	0.351	5[b]	0.695	6[b]
								472.9	0.5	4.83	0.02	0.427	5[b]	0.708	6[b]
393.2	0.5	0.77	0.02	0.126	3[b]	0.757	5[b]	472.9	0.5	5.38	0.02	0.488	6[b]	0.714	5[b]
393.2	0.5	1.26	0.02	0.227	4[b]	0.845	4[b]	472.9	0.5	5.69	0.02	0.523	5[b]	0.703	6[b]
393.2	0.5	1.81	0.02	0.341	5[b]	0.894	3[b]	472.9	0.5	6.15	0.02	0.603	6[b]	0.662	6[b]
393.2	0.5	2.33	0.02	0.452	6[b]	0.917	3[b]								

[a] Apparatus 3 (4). [b] Apparatus 2 (4).

gauge. Pressure accuracy depends on the transducer and its range. The uncertainties $\sigma(P)$ are given in Tables I–XVI.

Temperature T measurements are always carried out with thermocouples, which are calibrated against a platinum probe. Estimated temperature uncertainties $\sigma(T)$ are also reported in Tables I–XVI.

Vapor-phase and liquid-phase mole fractions z_i, where $z = x$ for liquid and $z = y$ for vapor, were obtained through GLC determinations. Detector calibration was carried out by injecting known amounts of pure components. The uncertainties reported in Tables I–XVI take into account the uncertainty on detector calibrations, and the reproducibility $\sigma(A_i)$ of the chromatographic ratio areas A_i on at least five samples, corresponding to the same equilibrium. The number of moles N_i of

Table XVI. Vapor–Liquid Equilibrium Data, Temperature T, Pressure P, Liquid-Phase x and Vapor-Phase y Mole Fractions, and the Uncertainties σ, for the System Propane (1)–n-Propylcyclohexane (2)

T/K	$\sigma(T)$/K	P/MPa	$\sigma(P)$/MPa	x_1	$\sigma(x_1)/10^{-3}$	y_1	$\sigma(y_1)/10^{-3}$
313.1	0.1	0.272	0.003			0.9950	0.4[c]
313.1	0.1	0.349	0.003			0.9963	0.3[c]
313.1	0.1	0.357	0.003	0.258	5[a]		
313.1	0.1	0.499	0.003	0.364	6[a]	0.9974	0.2[c]
313.1	0.1	0.654	0.003	0.472	8[a]	0.9981	0.2[c]
313.1	0.1	0.803	0.003	0.576	6[a]	0.9986	0.1[c]
313.1	0.1	0.956	0.003	0.689	6[a]	0.9990	0.1[c]
313.1	0.1	1.105	0.003	0.797	5[a]	0.9993	0.1[c]
313.1	0.1	1.228	0.003			0.9996	0.1[c]
313.1	0.1	1.238	0.003	0.895	5[a]		
313.1	0.1	1.306	0.003	0.948	2[a]	0.9998	0.1[c]
393.1	0.5	0.50	0.02	0.113	2[b]	0.907	3[b]
393.1	0.5	0.96	0.02	0.206	3[b]	0.950	2[b]
393.1	0.5	2.01	0.02	0.414	5[b]	0.9717	0.9[b]
393.1	0.5	3.04	0.02	0.602	5[b]	0.9784	0.6[b]
393.1	0.5	3.06	0.02	0.699	4[b]	0.9785	0.7[b]
393.1	0.5	4.14	0.02	0.787	4[b]	0.9789	0.9[b]
393.1	0.5	4.36	0.02	0.819	4[b]		
393.1	0.5	4.45	0.02	0.833	3[b]	0.979	1[b]
393.1	0.5	4.54	0.02	0.844	3[b]	0.976	1[b]
393.1	0.5	4.79	0.02	0.884	3[b]	0.957	2[b]
473.1	0.5	1.00	0.02	0.087	2[b]	0.671	6[b]
473.1	0.5	1.99	0.02	0.196	3[b]	0.812	5[b]
473.1	0.5	3.00	0.02	0.299	5[b]	0.851	5[b]
473.1	0.5	4.05	0.02	0.402	5[b]		
473.1	0.5	4.08	0.02	0.406	5[b]	0.874	4[b]
473.1	0.5	5.00	0.02	0.491	6[b]	0.881	4[b]
473.1	0.5	5.98	0.02	0.583	5[b]	0.873	4[b]
473.1	0.5	6.50	0.02	0.634	5[b]	0.861	4[b]
473.1	0.5	6.62	0.02	0.646	5[b]	0.859	4[b]
473.1	0.5	6.74	0.02	0.659	5[b]		
473.1	0.5	7.00	0.02	0.691	6[b]	0.846	8[b]

[a] Apparatus 3 (3). [b] Apparatus 2 (3). [c] Apparatus 3 (this work).

Table XVII. Refractive Index n_D and Liquid Density ρ of the Compounds Used

compound	n_D(293.15 K) this work	n_D(293.15 K) lit.	ρ(293.15 K)/(g cm^{-3}) this work	ρ(293.15 K)/(g cm^{-3}) lit.
toluene	1.494 91	1.496 93[a]	0.866 98	0.866 83[a]
m-xylene	1.497 58	1.497 22[a]	0.864 34	0.864 36[a]
mesitylene	1.498 5	1.499 37[a]	0.865 8	0.865 18[a]
n-propylbenzene	1.492 3	1.492 02[b]	0.862 1	0.862 0[b]
cyclohexane			0.778 35	0.778 55[a]
methylcyclohexane	1.423 1	1.423 12[a]	0.769 39	0.769 39[a]
n-propylcyclohexane	1.436 9	1.437 05[b]	0.793 6	0.793 60[b]

[a] Reference 10. [b] Reference 11.

component i was computed from

$$N_i = A_i R_i \tag{1}$$

where A_i is given by the calibration curve and R_i is the response coefficient of the detector for component i.

Thus, for a binary mixture, the $\sigma(z_1)$ uncertainty is given by

$$\frac{\sigma(z_1)}{z_1} = z_2\left[\frac{\sigma(A_1)}{A_1} + \frac{\sigma(R_1)}{R_1} + \frac{\sigma(A_2)}{A_2} + \frac{\sigma(R_2)}{R_2)}\right] \tag{2}$$

where $\sigma(R_i)$ is the uncertainty of R_i.

Sources and Purities of Chemicals. Methane, ethane, and propane were provided by Messer-Griesheim, with stated purities of 99.995, 99.95, and 99.95 vol %, respectively. Cyclohexane, toluene, *m*-xylene, and *n*-propylbenzene were from Merck, with stated GLC purities of 99.7, 99.5, 98.5, and 99.0 mol %, respectively. Mesitylene from Fluka had a minimum GLC purity of 99 mol %. Methylcyclohexane was supplied by Janssen, with a specified purity of >99%; *n*-propylcyclohexane, from Sigma, had a purity of >99%. Refractive indices n_D and densities ρ of the liquid components were measured with a prism refractometer fitted with a sodium vapor lamp (Carl Zeiss), uncertainty 2×10^{-5}, or a vibrating-tube densimeter (ANTON PAAR, Model DMA 46), uncertainty 3×10^{-5} g cm^{-3}. They are given in Table XVII, along with the corresponding literature data. All the chemicals were used without further purification except for careful degassing of the liquids.

Experimental Results. Vapor–liquid equilibrium results are listed in Tables I–XVI.

Prausnitz–Keeler Test. It is possible to demonstrate (*6*) that the logarithm of the fugacity coefficient of the less volatile component can be obtained both from the experimental data, neglecting the Poynting correction, the activity coefficient in the liquid phase, and the fugacity coefficient in the reference state, and from a virial development reduced to two terms, neglecting smaller terms

$$A = \ln\left(\frac{x_2 P \varphi_2^S Z^V}{y_2 P}\right) = \frac{2y_1}{v^V}\left(B_{12} + \frac{3}{4}\frac{y_1}{v^V}C_{112}\right) \tag{3}$$

where 2 represents the less volatile component, P_2^S is its saturation pressure, P is the total pressure, Z^V is the compressibility factor, v^V is the molar volume of the vapor phase, and B_{12} and C_{112} are the second and third molar virial coefficients.

In a plot of A against y_i/v^V, the points calculated from experimental data should be close to a straight line of slope $2B_{12}$ for low values of P.

This test was applied to our data at the lower temperature where enough points are available at low P. Some of our earlier data (*1–4*) were found inconsistent with respect of this test, as explained by Renon et al. (*5*), due to a malfunction of the apparatus because of the capillary sampling system. After modification of the experimental procedure, new data consistent with the tests were obtained, as indicated in the footnotes of Tables I–XVI.

An example of the test is given in Figure 1, where the first five points only have been used. The second virial coefficient found by linear regression is $B_{12} = -0.27$ dm^3 mol^{-1}.

Estimation of the third virial coefficient, $C_{112} = 0.015$ dm^6

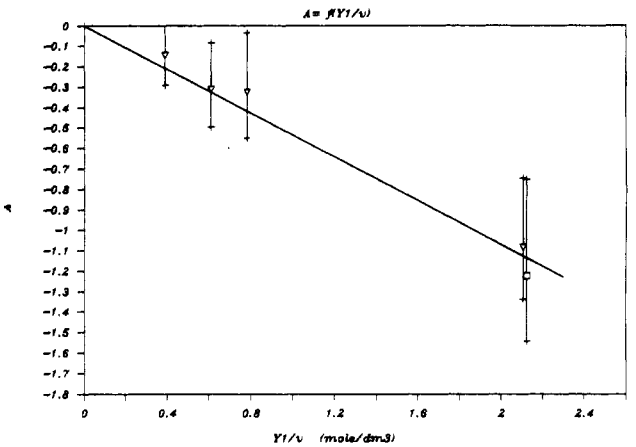

Figure 1. Consistency test on low-pressure experimental data for the methane (1)–*n*-propylbenzene (2) system at 313 K (eq 3). The straight line has a slope equal to $2B_{12}$, where $B_{12} = -0.27$ dm^3 mol^{-1} is the second virial coefficient: □, old data (*1*); ▽, new data (this work).

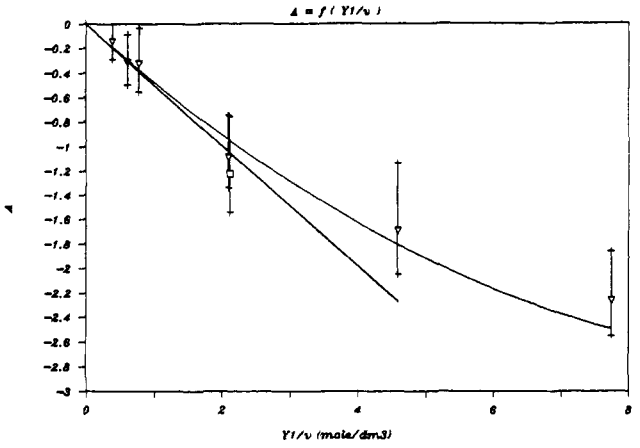

Figure 2. Influence of the third virial coefficient, eq 3, for the methane (1) + *n*-propylbenzene (2) system at 313 K: □, old data (*1*); ▽, new data (this work). The straight line is the plot assuming B_{12} = 0.27 dm^3 mol^{-1}; the curve is the plot using B_{12} = −0.25 dm^3 mol^{-1} and C_{112} = 0.015 dm^6 mol^{-2}.

mol^{-2} (simultaneously with the second B_{12} = −0.25 dm^3 mol^{-1}) is possible by regression according to eq 3 of all the experimental points below 15 MPa, as shown in Figure 2. The third virial coefficient has a nonnegligible effect for $y_1/v^V > 2$ mol dm^{-3} ($P > 4$ MPa).

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Glossary

A	defined by eq 3
A_i	GLC peak area for component i
B_{12}	second cross molar virial coefficient, dm^3 mol^{-1}
C_{122}	third cross molar virial coefficient, dm^6 mol^{-2}
P	pressure, MPa
T	temperature, K
v	molar volume, dm^3 mol^{-1}
x	liquid mole fraction
y	vapor mole fraction
z	mole fraction (either x or y)
Z	compressibility factor

Greek Letters

σ	uncertainty

Superscripts

S	at saturation
V	vapor phase

Subscripts

1	more volatile component
2	less volatile component

Registry No. Methane, 74-82-8; ethane, 74-84-0; propane, 74-98-6; toluene, 108-88-3; *m*-xylene, 108-38-3; mesitylene, 108-67-8; *n*-propylbenzene, 103-65-1; cyclohexane, 110-82-7; methylcyclohexane, 108-87-2; propylcyclohexane, 1678-92-8.

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