

Short Communication

VAPOUR—LIQUID EQUILIBRIA IN THE PROPANE—*n*-BUTANE SYSTEM AT HIGH PRESSURES

PETR BERÁNEK and IVAN WICHTERLE

Institute of Chemical Process Fundamentals, Czechoslovak Academy of Sciences, 165 02 Prague 6 (Czechoslovakia)

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ABSTRACT

Beránek, P. and Wichterle, I., 1981. Vapour—liquid equilibria in the propane—*n*-butane system at high pressures. *Fluid Phase Equilibria*, 6: 283–287.

The vapour—liquid equilibria in the propane—*n*-butane system were measured isothermally at 303.14, 323.10, 343.17, and 363.38 K. An interaction parameter in the mixing rule used in the Redlich—Kwong—Soave correlation method was evaluated.

INTRODUCTION

As a continuing project of investigation in high pressure vapor—liquid equilibria, the propane—*n*-butane system was measured to complete the binary data determined previously, namely the ethane—propane system measured by Mikšovský and Wichterle (1975) and the ethane—*n*-butane system measured by Lhoták and Wichterle (1981).

EXPERIMENTAL EQUIPMENT AND PROCEDURE

Experimental technique and procedure used for vapour—liquid equilibrium data measurement are described in detail in the previous paper by Lhoták and Wichterle (1981). The equipment has a transparent static equilibrium cell with a volume of 50 ml. Temperature was measured by means of mercury thermometers (with a full scale range of 10 K; 0.02 K/division) calibrated against a Leeds and Northrup standard Pt-resistance thermometer and a precise Mueller bridge. The absolute error in temperature measurement is believed to be ± 0.01 K. Pressure was measured by a dead weight gauge (Ruska Instrument Corp.); the absolute error certified by the manufacturer is 0.001 MPa. The capillary sampling technique developed earlier was used to take samples for analyses. The estimated relative error in concentration determination is about 1.5%.

MATERIALS

Propane, research purity, was manufactured by the Matheson Gas Comp., USA with a minimum 99.99% certified purity and containing isobutane as the main admixture.

n-Butane, research grade (Puriss.), was supplied by Fluka, Switzerland with a 99.96% certified purity and containing isobutane and neopentane as main admixtures. Both substances were not purified further.

TABLE 1

Vapour-liquid equilibrium in the propane-*n*-butane system

x	y	$P(\text{MPa})$	Δx	Δy	$\Delta P(\%)$
$T = 303.14 \text{ K}$					
0.096	0.261	0.3540	0.0048	-0.0099	-1.56
0.164	0.388	0.4005	0.0044	-0.0073	-1.58
0.257	0.530	0.4681	0.0064	-0.0083	-1.69
0.437	0.707	0.5910	0.0003	-0.0002	0.00
0.867	0.942	0.9474	-0.0159	0.0065	0.14
0.910	0.958	0.9935	-0.0167	0.0066	-0.56
$T = 323.10 \text{ K}$					
0.066	0.155	0.5669	-0.0002	0.0005	-0.83
0.225	0.411	0.7279	-0.0072	0.0106	-1.77
0.399	0.635	0.9304	-0.0004	0.0008	-1.72
0.541	0.742	1.0884	-0.0095	0.0076	-1.26
0.700	0.853	1.2912	-0.0059	0.0037	-0.40
0.857	0.931	1.4930	-0.0094	0.0043	0.65
0.905	0.954	1.5687	-0.0081	0.0036	0.53
$T = 343.17 \text{ K}$					
0.065	0.144	0.9063	0.0019	-0.0038	0.43
0.133	0.267	1.0035	0.0025	-0.0042	0.24
0.216	0.400	1.1275	0.0055	-0.0076	0.34
0.411	0.601	1.4131	-0.0046	0.0042	0.62
0.535	0.710	1.6388	-0.0053	0.0045	-0.26
0.691	0.833	1.9389	0.0026	-0.0020	0.24
0.854	0.918	2.2361	-0.0069	0.0028	1.23
0.903	0.944	2.3573	-0.0067	0.0031	0.70
$T = 363.38 \text{ K}$					
0.063	0.122	1.3812	0.0014	-0.0028	0.78
0.128	0.232	1.5090	0.0025	-0.0041	0.46
0.207	0.351	1.6735	0.0051	-0.0067	0.16
0.399	0.559	2.0577	0.0003	-0.0011	0.82
0.527	0.669	2.3683	-0.0022	0.0019	0.01
0.691	0.797	2.8005	-0.0001	0.0001	-0.02
0.847	0.891	3.2184	a	a	a
0.900	0.933	3.4136	a	a	a

Note: Deviations are evaluated from the Redlich-Kwong-Soave method with interaction parameter $k_{12} = -0.0146$; compositions indicated are mole fractions of propane; a — not calculated.

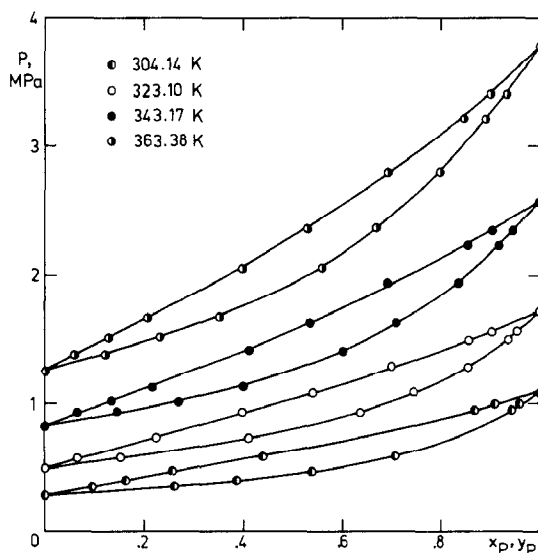


Fig. 1. P - x, y diagram of the propane- n -butane system.

RESULTS AND EVALUATION

The vapour-liquid equilibrium data of the propane- n -butane system were measured isothermally at 303.14, 323.10, 343.17, and 363.38 K. The 29 experimental points are summarized in Table 1 where x and y stand for liquid and vapour phase compositions in mole fractions, respectively, and pressure, P , is given in MPa. The P - x, y diagram is shown in Fig. 1.

The data were reduced by means of a direct method using the Redlich-Kwong equation of state as modified by Soave (1972). The only adjustable parameter (k_{12}) is that in the mixing rule for calculation of the cross-parameter $a_{12} = (1 - k_{12})\sqrt{(a_1 a_2)}$. All experimental points were included in the parameter evaluation which was carried out by the method proposed by Wichterle (1979) enabling the simultaneous evaluation of deviations in both phase compositions and in pressure. The two experimental points indicated were automatically excluded during the data reduction due to convergence problems. The optimization was carried out using the sum of squares of deviations in pressure as an objective function; the resulting interaction parameter is $k_{12} = -0.0146$. Mean deviations between calculated and experimental values are 0.0051 and 0.0044 for liquid and vapour phase compositions (in mole fractions), respectively, and 0.70% in pressure. The deviations for individual experimental points are presented in Table 1.

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- Lhoták, V. and Wichterle, I., 1981. Vapour—liquid equilibria in the ethane—*n*-butane system at high pressures. *Fluid Phase Equilibria*, 6: 229—235.
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