J. Chem. Eng. Data **2002,** *47,* 1145−1153

Isochoric Measurements for CO_2 + R125 and CO_2 + R32 Binary Systems

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$P-V-T-x$ measurements, both in the two-phase and in the superheated vapor regions, were carried out for the CO_2 + R125 and CO_2 + R32 systems. The isochoric experiment covered a temperature range from 254 K to 363 K and a pressure range from 680 kPa to 4920 kPa. The number of moles charged into the isochoric cell was calculated by means of the virial equation of state using the second and third virial coefficients derived from our $P-V-T-x$ measurements taken with the Burnett method. After the number of moles was determined, the VLE parameters were derived from experimental data in the two-phase region, applying the flash method and the Carnahan−Starling−DeSantis equation of state (CSD EOS). The dew point parameters were found by interpolating the $P-T$ isochoric sequences, again applying the CSD EOS. Because of the lack of data, the $P-V-T-x$ data for the superheated region were compared with estimates of the REFPROP software 6.01.

Introduction

In our search for fluids that are potentially suitable for low-temperature refrigerant applications, we have turned our attention to systems composed of hydrofluorocarbons (HFCs) in mixtures with CO_2. In previous studies,[1,2] the $P-V-T-x$ properties of the CO_2 + R125 and CO_2 + R32 systems were measured by the Burnett method in a temperature range from 303 K to 363 K. The second and third virials for the system constituents and their respective cross virial coefficients were derived from the experimental results for both systems.

The present study applied the isochoric setup[3,4] and measurements were taken for both the two-phase and the superheated vapor regions, covering a wider temperature range (from 254 K to 363 K). The data in the two-phase region enable VLE parameters to be derived using a flash method with the Carnahan−Starling−De Santis[5] equation of state (CSD EOS); in addition, the dew point for each isochore was found from the intersection of $P-T$ sequences. These dew point values were also used to derive the VLE parameters. The methods adopted have been described previously.[6] The two derived parameters were compared with each other and a good consistency was found. The VLE data for the CO_2 + R32 system were compared with the literature,[7] but no data were available in the literature for the CO_2 + R125 system. The $P-V-T-x$ data in the superheated region were compared, for a wider temperature range than was previously measured by the Burnett method, with the REFPROP 6.01[8] estimate.

Experimental Section

Chemicals. Carbon dioxide was supplied by Sol SpA, while R32 and R125 were supplied by Ausimont SpA; their purity was checked by gas chromatography, using a thermal conductivity detector, and was found to be 99.99% on an area response basis for the CO_2 and 99.98% and 99.96% for the R32 and R125, respectively.

Experimental Apparatus. The experimental setup was as described previously,[3,4] so it is only briefly outlined here. An AISI 304 stainless steel spherical cell contains the refrigerant sample and is connected to a differential diaphragm pressure transducer coupled to an electronic null indicator. The spherical cell and pressure transducer are immersed in the main thermostatic bath containing a mixture of water and glycol and controlled by a PID device. An auxiliary bath, also controlled by a PID device, helps the system to keep the temperature constant. Temperatures were measured with a calibrated resistance thermometer and the total uncertainty in temperature was found to be lower than ±0.02 K. The uncertainty in the pressure measurements is due to the uncertainty of the transducer and null indicator system and of the pressure gauges. The digital pressure indicator (Ruska, mod. 7000) has an uncertainty of ±0.003% of the full scale. The total uncertainty in the pressure measurement is also influenced by temperature fluctuations due to bath instability; it was found to be less than ±1 kPa.

Experimental Procedure. A substantial modification was introduced in the charging and composition measuring procedures. The isochoric cell was originally charged[9] from special bottles and the mass of the charge was determined as the difference in the mass in the bottle before and after charging. Calculating the mass charged for each component gave us the composition of the mixtures. This procedure was accurate, but rather tedious. It was easy to implement, however, and provided a proper molecular weight and saturated pressure for the compounds likely to be involved in most HFCs. In some cases, however, a special bottle with a different capacity, size, and/or wall thickness, and

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10.1021/je015541y CCC: \$22.00

Table 1. Compositions of the Investigated Systems[a]

				no. expl. points			dew point	
	T range	P range	n				T	P
z_1	K	kPa	mol	2ph	Vap	tot	K	kPa
				$CO_2 + R125$				
0.3007	260−354	733−2184	0.22218	7	13	20	292.63	1614.9
0.5189	263−362	1125−2701	0.26358	7	14	21	287.84	1899.6
0.6301	258−363	1328−4600	0.48481	11	12	23	304.99	3327.9
0.6884	259−358	1497−4718	0.50659	10	12	22	297.19	3322.4
0.8240	253−348	1514−4059	0.42660	11	14	25	284.48	2904.9
				$CO_2 + R32$				
0.1010	264−358	682−1911	0.18509	6	14	20	287.97	1380.0
0.3895	266−357	1116−2678	0.26385	7	14	21	289.60	1950.6
0.6071	254−356	1219−4084	0.42087	9	13	22	294.07	2970.2
0.7343	256−348	1479−3622	0.37006	11	13	24	283.55	2639.0
0.8023	255−343	1659−4923	0.54119	8	11	19	288.67	3598.6

[a] 2ph and Vap denote data within the VLE boundary and superheated region, respectively.

Table 2. Experimental Data within the VLE Boundary for the $CO_2 + R125$ System

	T	P	V		T	P	V
z_1	K	kPa	$dm^3 \cdot mol^{-1}$	z_1	K	kPa	$dm^3 \cdot mol^{-1}$
0.3007				0.6884			
	260.11	732.8	1.145		258.90	1496.9	0.502
	262.78	786.1	1.145		262.92	1650.4	0.502
	267.34	878.6	1.145		267.56	1843.7	0.502
	273.46	1019.6	1.146		273.31	2097.6	0.502
	278.45	1163.8	1.146		278.46	2338.1	0.502
	283.35	1306.7	1.146		283.48	2583.7	0.503
	288.43	1469.5	1.146		287.46	2752.7	0.503
0.5189					291.38	2999.3	0.503
	263.11	1125.5	0.965		293.50	3115.5	0.503
	267.46	1239.4	0.965		298.59	3356.2	0.503
	270.89	1337.1	0.966	0.8240			
	273.42	1410.3	0.966		253.48	1514.4	0.596
	278.51	1576.9	0.966		256.32	1627.9	0.596
	283.45	1741.6	0.966		258.34	1710.3	0.596
	285.93	1829.1	0.966		261.17	1831.6	0.596
0.6301					263.21	1923.2	0.596
	257.61	1328.3	0.525		265.91	2039.6	0.596
	260.83	1438.5	0.525		268.25	2159.3	0.597
	263.27	1523.5	0.525		271.05	2274.7	0.597
	267.84	1694.8	0.525		273.47	2378.4	0.597
	273.32	1906.5	0.525		275.90	2485.4	0.597
	278.53	2116.9	0.525		278.31	2653.9	0.597
	283.46	2328.5	0.525				
	288.30	2546.6	0.525				
	293.38	2774.9	0.526				
	298.45	3007.8	0.526				
	303.58	3293.4	0.526				

consequently with a different tare, would have to be designed or a nongravimetric method developed. As an alternative better suited to systems with CO_2, we developed a procedure based on the virial equation of state for the system under study, using the virial EOS with coefficients found from our independent Burnett measurements. To be more precise, the mass charged was calculated by applying virial coefficients for individual components and cross virial coefficients (all found from the data reduction), providing the mixtures' composition was known from independent measurements. The composition was found by analyzing the sample withdrawn from the isochoric cell after collecting data for the P, T sequence. This was done with a thermal conductivity detector and gas chromatography. The gas chromatograph was calibrated using a set of samples of exactly known composition (different amounts by mass of the two fluids were charged in a small bottle and weighed with an analytical balance) and analyzing them until a statistically adequate data set was obtained. A third-degree polynomial expression, obtained by forcing it to the points corresponding to pure compounds, enabled the unknown composition to be established when its peak area ratio was measured. The uncertainty in composition measurements was estimated from the reproducibility of the gas chromatography and the uncertainty in sample preparation and amounted to 0.1% of the mole fraction. Considering the uncertainty in the composition measurements and the uncertainty in the virial coefficient values, we estimated that the overall uncertainty for the mass charged amounted to 0.001 mol on average and 0.005 mol in the worst case.

Results and Discussion

The temperature and pressure ranges are shown in Table 1, along with the mixture's composition and the number of moles charged. The experimental VLE data are given in Tables 2 and 3, while Tables 4 and 5 show the $P-V-T-x$ measurements for $CO_2 + R125$ and $CO_2 + R32$, respectively. The $T-P$ data are also presented graphically in Figures 1 and 2. Analyzing the slope of each $T-P$ sequence, each experimental point was described in rela-

Table 3. Experimental Data within the VLE Boundary for the CO_2 + R32 System

z_1	T/K	P/kPa	V/dm^3·mol^{-1}
0.1010			
	263.82	681.7	1.375
	268.82	794.1	1.375
	273.79	925.4	1.375
	278.47	1061.6	1.376
	283.37	1217.1	1.376
	288.37	1381.3	1.376
0.3895			
	265.69	1116.0	0.964
	274.48	1389.0	0.965
	270.29	1252.3	0.965
	277.31	1482.7	0.965
	280.33	1592.8	0.965
	283.42	1707.1	0.965
	288.34	1898.7	0.965
0.6071			
	254.35	1218.6	0.604
	258.33	1353.8	0.604
	263.32	1536.9	0.605
	268.39	1741.6	0.605
	273.35	1947.5	0.605
	278.49	2178.2	0.605
	283.40	2410.6	0.605
	288.46	2687.6	0.605
	293.34	2932.7	0.605
0.7343			
	255.83	1478.7	0.687
	258.40	1575.2	0.687
	261.03	1677.6	0.687
	263.39	1774.3	0.688
	265.96	1878.6	0.688
	268.45	1983.4	0.688
	270.88	2086.1	0.688
	273.30	2188.2	0.688
	275.89	2310.9	0.688
	278.38	2428.7	0.688
	283.28	2619.0	0.688
0.8023			
	255.45	1659.0	0.470
	258.50	1804.8	0.470
	263.51	2059.4	0.470
	268.38	2325.3	0.470
	273.43	2616.0	0.470
	278.43	2923.2	0.470
	283.40	3241.9	0.471
	289.36	3614.3	0.471

Table 4. Experimental Data in the Superheated Vapor Region for the CO_2 + R125 System

z_1	T/K	P/kPa	V/dm^3·mol^{-1}
0.3007			
	293.50	1623.1	1.147
	298.55	1673.2	1.147
	303.53	1722.2	1.147
	308.53	1770.6	1.147
	313.71	1820.0	1.148
	318.61	1866.4	1.148
	323.50	1912.2	1.148
	328.09	1954.6	1.148
	333.47	2004.0	1.149
	338.39	2048.9	1.149
	343.37	2093.8	1.149
	348.49	2139.5	1.150
	353.53	2184.4	1.150
0.5189			
	290.95	1935.1	0.966
	293.53	1965.1	0.967
	299.00	2028.5	0.967
	303.61	2080.9	0.967
	308.59	2136.7	0.967
	313.45	2192.0	0.967
	318.58	2246.8	0.968
	323.44	2299.7	0.968
	328.52	2354.4	0.968
	333.45	2406.0	0.968
	343.44	2511.7	0.969
	348.40	2563.2	0.969
	353.37	2612.8	0.969
	362.00	2701.5	0.970
0.6301			
	306.53	3362.6	0.526
	311.43	3478.1	0.526
	318.42	3637.5	0.526
	323.41	3749.0	0.526
	328.70	3866.0	0.526
	333.35	3966.9	0.526
	338.56	4079.7	0.527
	343.39	4182.2	0.527
	348.53	4291.5	0.527
	353.47	4395.6	0.527
	358.35	4497.9	0.527
	363.27	4599.8	0.527
0.6884			
	303.55	3478.2	0.503
	308.61	3600.3	0.503
	313.68	3720.3	0.504
	318.63	3835.6	0.504
	323.62	3950.4	0.504
	328.39	4063.6	0.504
	333.50	4178.9	0.504
	338.49	4290.8	0.504
	343.37	4394.7	0.504
	348.46	4506.3	0.504
	353.31	4611.3	0.504
	358.24	4718.1	0.505
0.8240			
	283.36	2880.6	0.597
	288.21	2975.1	0.597
	293.23	3071.0	0.597
	298.09	3162.9	0.597
	303.53	3264.0	0.598
	308.48	3354.6	0.598
	313.41	3444.9	0.598
	318.39	3534.2	0.598
	323.46	3624.8	0.598
	328.42	3712.7	0.598
	333.32	3799.1	0.598
	338.37	3887.1	0.598
	343.42	3974.7	0.599
	348.32	4059.3	0.599

Table 5. Experimental Data in the Superheated Vapor Region for the CO_2 + R32 System

z_1	T/K	P/kPa	V/dm^3·mol^{-1}
0.1010			
	293.38	1425.6	1.376
	299.29	1472.7	1.377
	303.54	1503.9	1.377
	308.54	1546.0	1.377
	313.53	1584.5	1.378
	318.46	1621.8	1.378
	323.46	1659.3	1.378
	328.47	1696.5	1.379
	333.46	1733.1	1.379
	338.21	1767.1	1.379
	343.38	1804.5	1.380
	348.53	1841.3	1.380
	353.34	1875.6	1.380
	358.33	1910.7	1.381
0.3895			
	293.32	1992.0	0.966
	298.25	2048.5	0.966
	303.49	2107.8	0.966
	308.49	2163.2	0.966
	313.48	2218.0	0.966
	318.49	2272.5	0.967
	323.46	2325.0	0.967
	328.41	2377.8	0.967
	333.41	2430.5	0.967
	338.35	2482.2	0.968
	343.34	2534.0	0.968
	348.32	2585.2	0.968
	353.33	2636.5	0.968
	357.45	2678.2	0.968
0.6071			
	298.55	3055.6	0.606
	303.55	3151.0	0.606
	308.58	3245.6	0.606
	313.52	3336.7	0.606
	318.58	3431.3	0.606
	323.49	3520.3	0.606
	328.47	3609.7	0.606
	333.35	3696.7	0.606
	338.38	3785.2	0.607
	343.29	3871.1	0.607
	348.34	3958.9	0.607
	353.22	4042.8	0.607
	355.62	4084.0	0.607
0.7343			
	288.30	2714.0	0.688
	293.28	2793.8	0.688
	298.23	2872.5	0.689
	303.08	2947.9	0.689
	308.42	3030.2	0.689
	313.30	3104.6	0.689
	318.44	3182.3	0.689
	323.41	3256.7	0.689
	328.31	3329.6	0.690
	333.43	3405.2	0.690
	338.33	3477.2	0.690
	343.31	3549.5	0.690
	348.29	3621.7	0.690
0.8023			
	293.36	3719.2	0.471
	298.56	3852.8	0.471
	303.56	3977.9	0.471
	308.56	4101.0	0.471
	313.56	4222.3	0.471
	318.55	4342.4	0.471
	323.52	4460.5	0.471
	328.52	4578.1	0.472
	333.51	4694.3	0.472
	338.47	4809.1	0.472
	343.44	4923.3	0.472

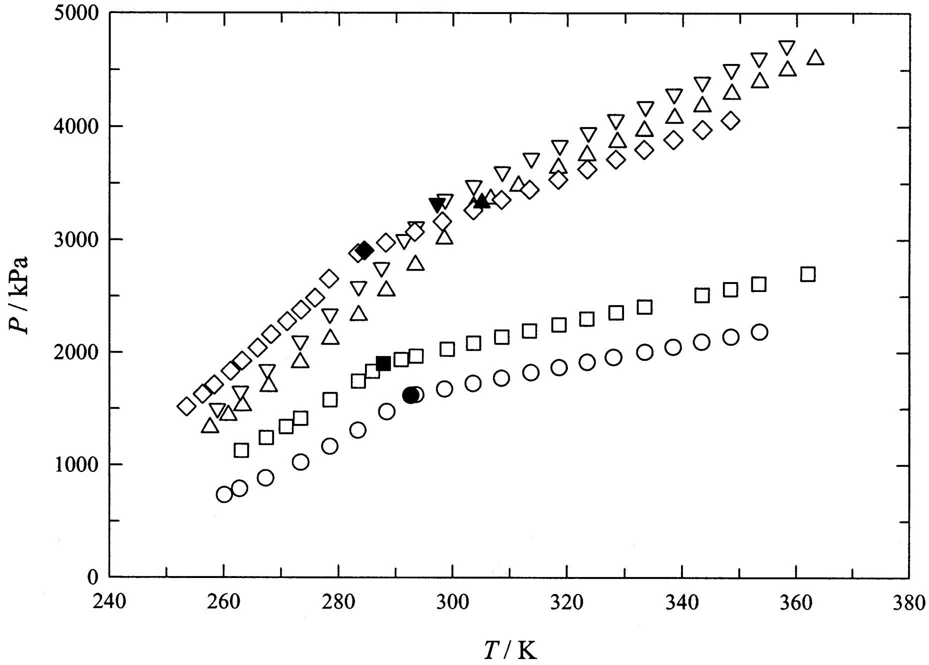

Figure 1. P,V,T,x experimental data for the CO_2 + R125 binary system (open symbols) and dew points found by interpolation (closed symbols): (○) $z_1 = 0.3007$; (□) $z_1 = 0.5189$; (△) $z_1 = 0.6301$; (▽) $z_1 = 0.6884$; (◇) $z_1 = 0.8240$.

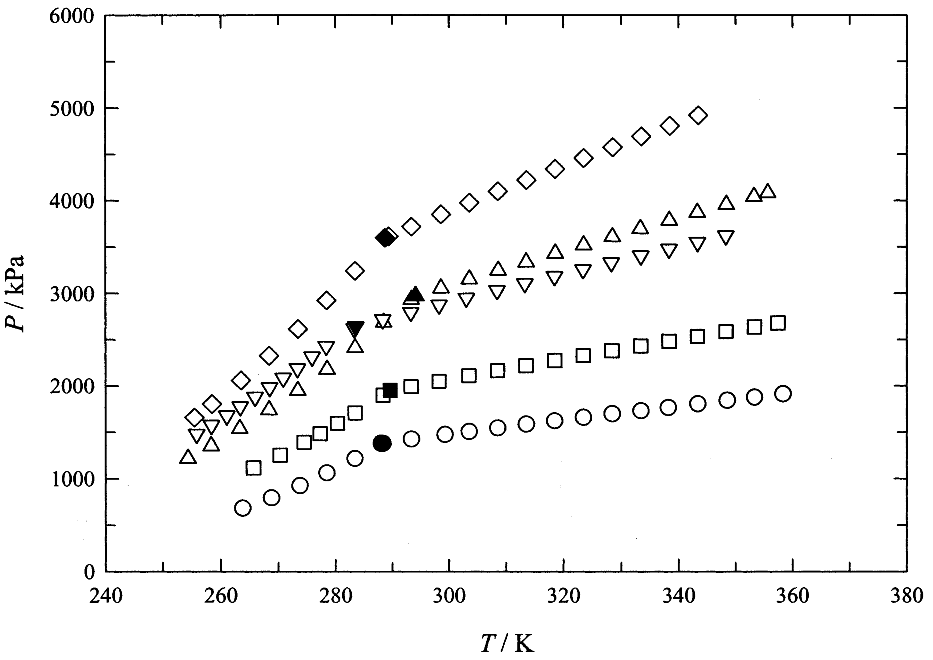

Figure 2. P,V,T,x experimental data for the CO_2 + R32 binary system (open symbols) and dew points found by interpolation (closed symbols): (○) $z_1 = 0.1010$; (□) $z_1 = 0.3895$; (△) $z_1 = 0.6071$; (▽) $z_1 = 0.7343$; (◇) $z_1 = 0.8023$.

Table 6. Binary Interaction Parameters and Bubble Point Composition (x_2) Found from the Dew Point Applying the CSD EOS

CO_2 + R125				CO_2 + R32			
series	$K_{12\mathrm{dew}}$	$K_{12\mathrm{flash}}$	x_2	series	$K_{12\mathrm{dew}}$	$K_{12\mathrm{flash}}$	x_2
1	−0.03616	−0.03280	0.1367	1	−0.02902[a]	−0.02070[a]	0.0426
2	−0.02648	−0.02315	0.2754	2	0.00084	0.00417	0.1856
3	−0.07403	−0.02770	0.4503	3	0.00894	0.01244	0.3791
4	−0.01830	−0.01847	0.4895	4	−0.00438	0.01556	0.5059
5	−0.04677	−0.02808	0.6346	5	0.01688	0.01829	0.6326
avg	−0.04035	−0.02600		avg	0.00557	0.00835	

[a] Not used in further regression.

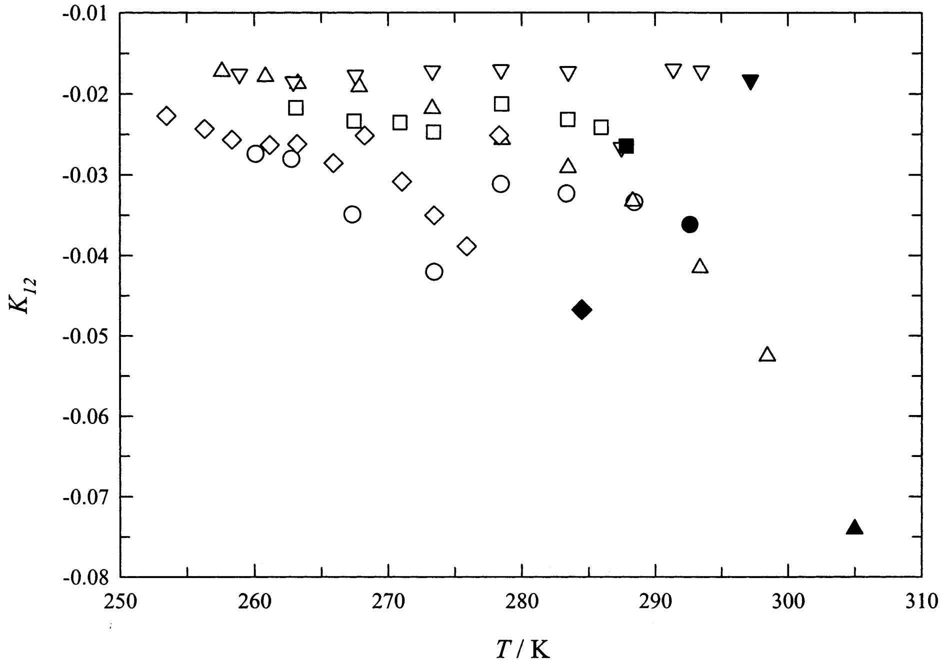

Figure 3. K_{12} values found by the flash method for the CO_2 + R125 system: Closed symbols. K_{12} values found by the dew point method: symbols denoted as in Figure 1.

tion either to the superheated or to the two-phase region. The number of data belonging to each region is also included in Table 1. The data belonging to the two-phase region were fitted by the Antoine equation, while the data

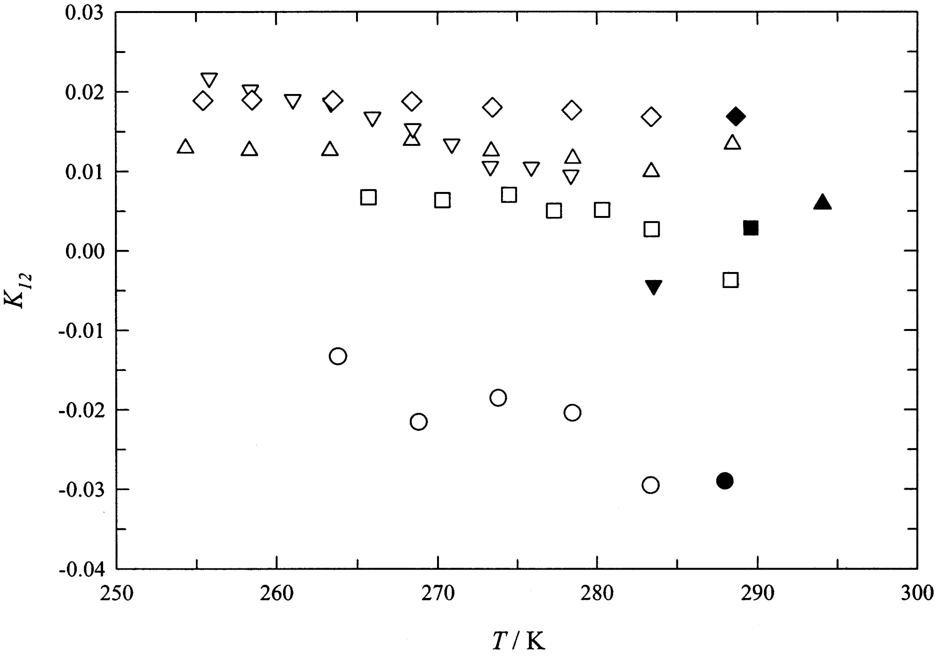

Figure 4. K_{12} values found by the flash method for the CO_2 + R32 system: Closed symbols. K_{12} values found by the dew point method: symbols denoted as in Figure 2.

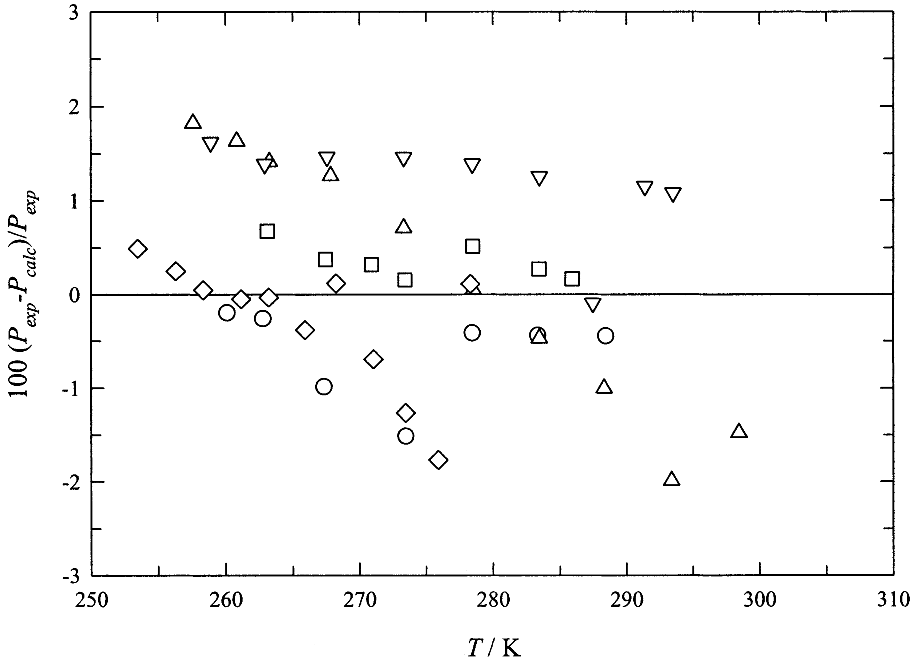

Figure 5. Deviations in pressure between experimental values and those calculated with the K_{12} coefficients for the CO_2 + R125 system; symbols denoted as in Figure 1.

in the superheated region were fitted by a polynomial of second degree, taking the temperature as the independent variable. Then, from the solution of the two equations representing the behavior of the system in the two-phase and superheated regions, the temperature and pressure corresponding to the dew point were found algebraically for each isochore. The solutions are given in Table 1.

VLE Derivation. Two methods were used to derive VLE data from the isochoric measurements, as reported previously.[6]

In the first method, the VLE parameters were derived using the "dew point" method with the CSD EOS. The necessary dew point parameters (Table 1) were used as independent variables, while the interaction binary parameter K_{12}, and the corresponding pressure and liquid-phase composition at the bubble point, considered as dependent variables, were adjusted until the phase equilibrium condition was reached. The resulting K_{12} values and bubble point parameters are shown in Table 6.

In the second method, the VLE parameters were derived for each data point in the two-phase region by means of the "flash method" with the CSD EOS. To apply the flash method to the isochoric data, the volumetric properties of both phases are also needed and were calculated from the CSD EOS. During the fitting procedure, T, P, z_i, and n (number of moles charged) were kept constant for each experimental point. Because the isochoric cell volume was known from the gravimetric calibration, the binary interac-

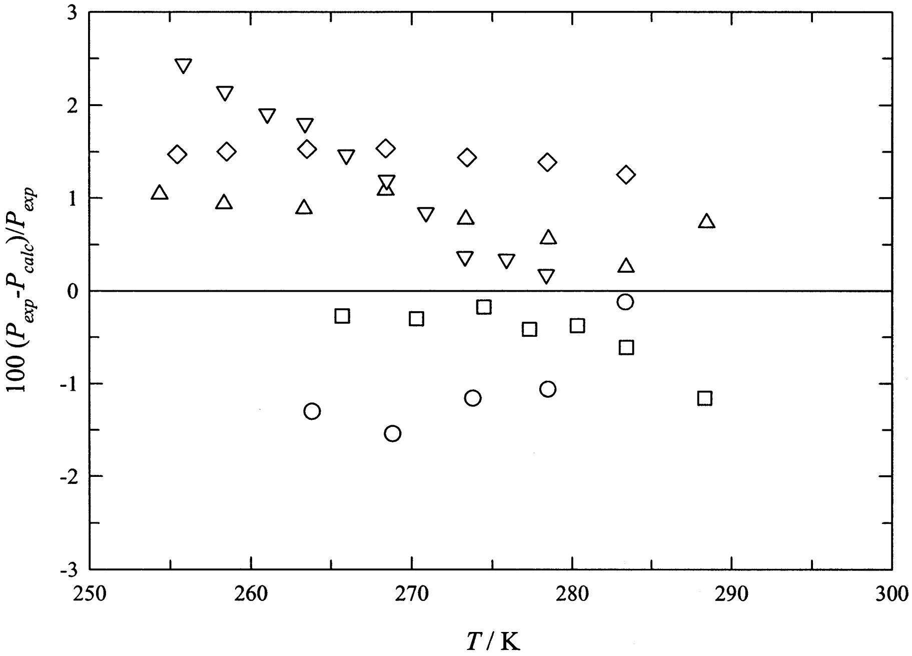

Figure 6. Deviations in pressure between experimental values and those calculated with the K_{12} coefficients for the CO_2 + R32 system; symbols denoted as in Figure 2.

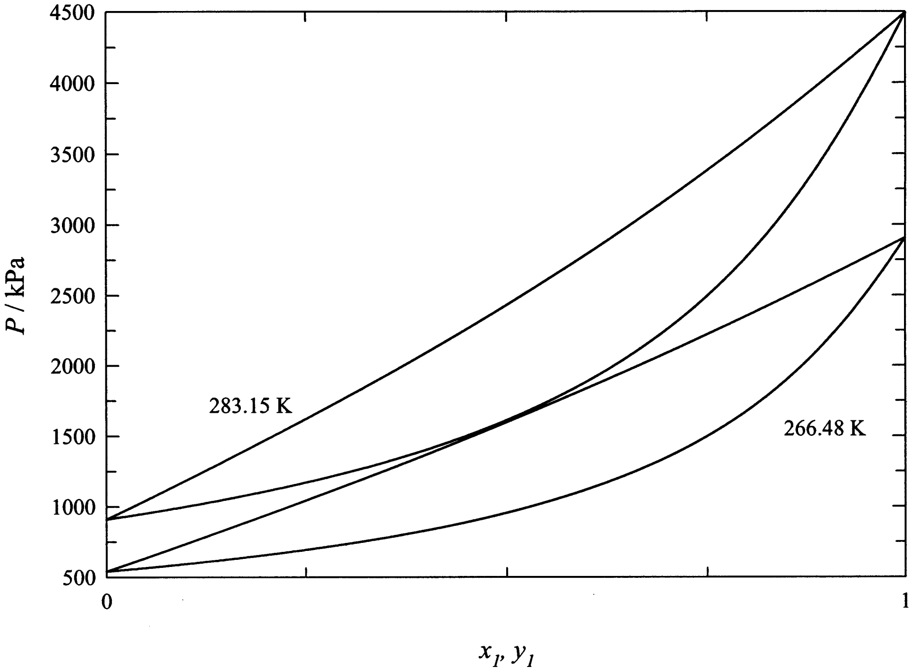

Figure 7. VLE data for the CO_2 + R125 system at two temperatures: solid lines, present results, correlated.

tion parameter, K_{12}, and the composition at bubble and dew point were found, considering them as dependent variables. The K_{12} values found for each data point in the two-phase region are shown in Figures 3 and 4. The K_{12} values found from the dew point are included for comparison in the same figures, revealing good consistency. The values calculated with the dew point method K_{12} clearly follow the trend of the values calculated for each point with the flash method. A small temperature dependence is evident for the K_{12} of both systems. In another attempt to assess the quality of the derived VLE parameters, the system pressure was reproduced using the averaged K_{12} values, disregarding the small temperature dependence of the K_{12} values. The absolute average deviation in the system pressure was 0.79% and 1.02% for the CO_2 + R125 and CO_2 + R32 mixtures, respectively. The deviations in pressure are plotted in Figures 5 and 6.

The actual values of K_{12} were also used to calculate the VLE at 266.48 and 283.15 K for the CO_2 + R32 system. The chosen temperature corresponds exactly to the experimental data in the literature,[7] which were also correlated using the CSD EOS. The comparison showed that ref 7 pressures are about 2% higher than the present results, a figure within or close to the uncertainty for the data from both sources.

Comparing K_{12} from the dew point and flash methods revealed good consistency. It is also worth noting that, in some cases, the CSD EOS was used outside of the temperature range for which its parameters were established, that is, above the critical temperature of CO_2.

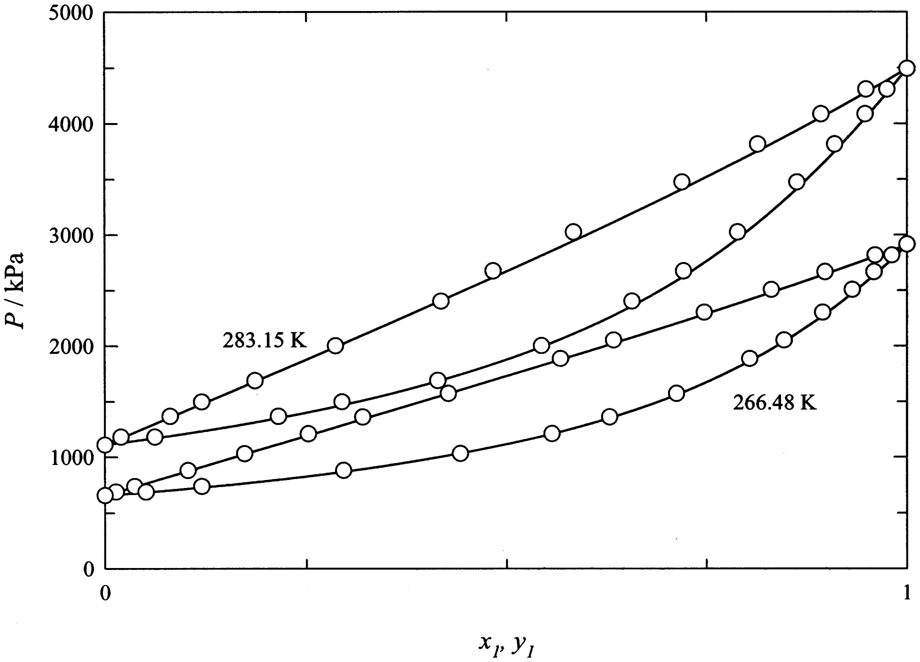

Figure 8. VLE data for the CO_2 + R32 system at two temperatures: solid lines, present results, correlated. (○) Experimental data from Adams and Stein.[7]

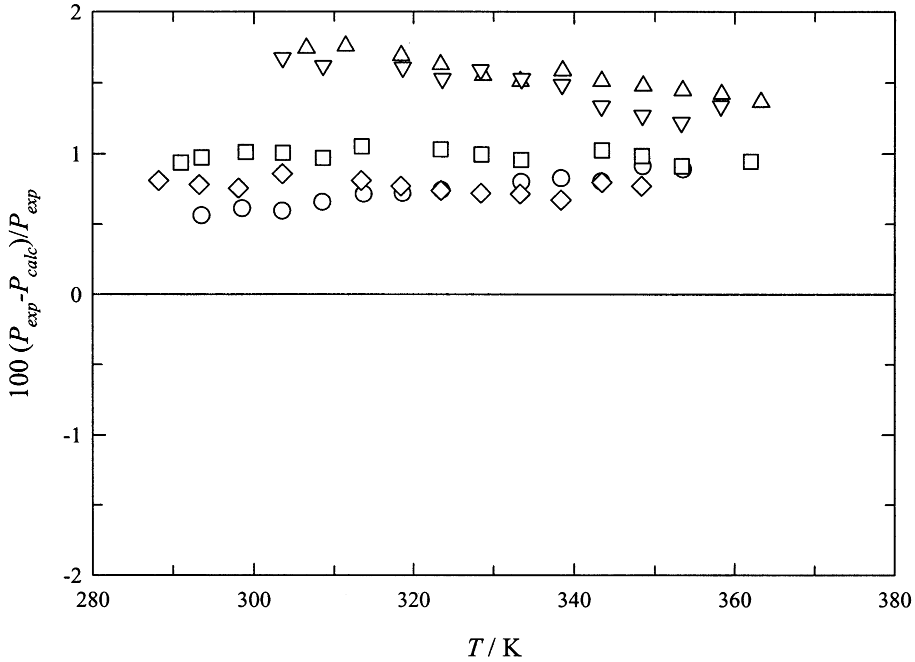

Figure 9. Deviations in pressure for the CO_2 + R125 system between experimental values and those calculated with the prediction of REFPROP 6.01; symbols denoted as in Figure 1.

With K_{12} values from our measurements in the two-phase region, the VLE data calculated at two temperatures are shown in Figures 7 and 8 to illustrate the behavior of the CO_2 + R125 and CO_2 + R32 systems. Figure 8 also shows data from the literature[7] compared with our experimental data interpolated to the literature isotherms.

The VLE behavior of both systems can be considered to be ideal, in terms of Raoult's law, as shown in Figures 7 and 8. This could presumably be interpreted as a compensation of two opposing effects of repulsive forces of −CF groups in HFCs with CO_2 and attractive forces between the hydrogen in HFCs and CO_2. Qualitatively, it is consistent with the results of a study[10] on hydrogen bonding in HFC + dimethyl ether systems.

P−V−T−x. Because of the total absence of published data for the superheated vapor region for the binary systems considered, our experimental $P-V-T-x$ data were compared with the REFPROP 6.01 estimate. The comparison is reported in Figures 9 and 10. The consistency averaged 1.1% and 0.73% of the pressures for CO_2 + R125 and CO_2 + R32, respectively. Though the values calculated by the REFPROP 6.01 are not based on direct experiment for the systems and temperature range considered, said consistency was considered satisfactory.

The experimental $PVTx$ data from the isochoric experiment and the calculated ones applying the virial EOS with coefficients found from the Burnett experiment were also compared. For the CO_2 + R32 system over the whole

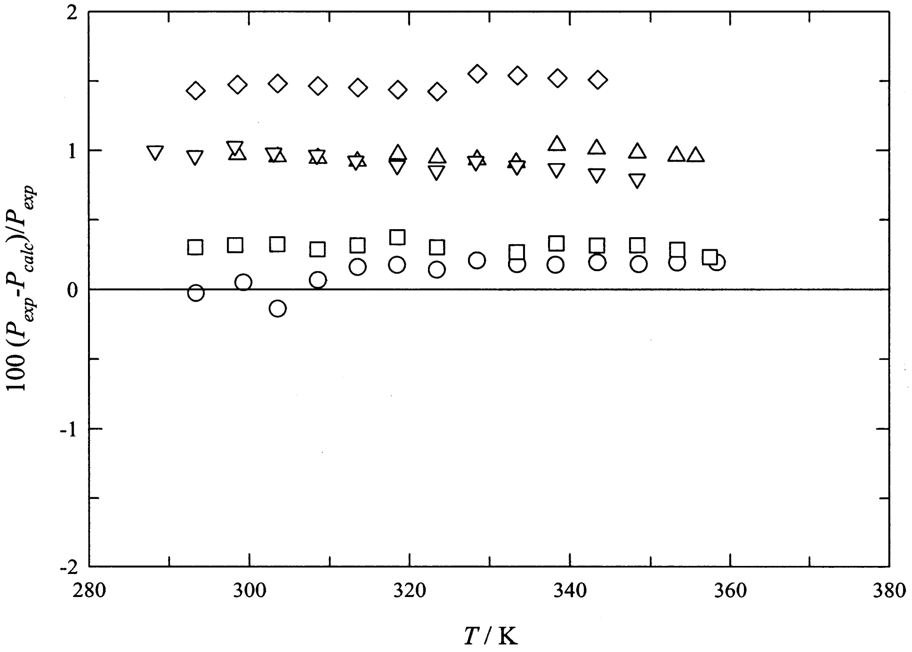

Figure 10. Deviations in pressure for the CO_2 + R32 system between experimental values and those calculated with the prediction of REFPROP 6.01; symbols denoted as in Figure 2.

temperature range and for CO_2 + R125 for temperature T > 315 K deviations are well within ±1%. For the CO_2 + R125 system we observed systematic deviations for temperatures T < 315 K increasing up to −3% at the lowest temperature. Presumably, the increase of deviation with lowering temperature are resulting (i) from the extrapolation of the virial coefficients to lower temperatures using purely empirical expression for their temperature dependence and (ii) from the relatively short temperature range covered by the Burnett experiment. Finally, a comparison of the *PVTx* data with prediction by the CSD was performed using K_{12} values found from the two-phase region data reduction. For the CO_2 + R125 and CO_2 + R32 systems, AAD values equal to 0.27% and 1.08% were found, respectively.

Conclusions

Both measured systems showed a very small deviation from Raoult's law. The comparison of our findings with the literature for the CO_2 + R32 system showed good consistency. Independent experiments using both the Burnett and the isochoric setups enabled us to check the internal consistency of all results. The values found from our experimental density data in the superheated region were also compared with data calculated using the REFPROP 6.01 program and consistency to within 1% was recorded. This also validates the cross virial coefficients derived using the Burnett method. Moreover, the VLE data were consistent to within 1% when analyzed as a function of temperature or liquid-phase composition. Generally speaking, the global validity of the methods and results can be claimed to within 1% of the density and/or pressure values.

Literature Cited

(1) Di Nicola, G.; Giuliani, G.; Polonara, F.; Stryjek, R. *PVTx* Measurements for the R125+CO_2 System by the Burnett Method. *Fluid Phase Equilib.* **2002**, *199*, 163−176.
(2) Di Nicola, G.; Polonara, F.; Stryjek, R. Burnett Measurements for the R32 + CO_2 System. *J. Chem. Eng. Data* **2002**, *47*, in press.
(3) Giuliani, G.; Kumar, S.; Zazzini, P.; Polonara, F. Vapor Pressure and Gas-Phase PVT Data and Correlation for 1,1,1,-Trifluoroethane (R143a). *J. Chem. Eng. Data* **1995**, *40*, 903−908.
(4) Giuliani, G.; Kumar, S.; Polonara, F. A Constant Volume Apparatus for Vapour Pressure and Gas Phase *P-v-T* Measurements: Validation with Data for R22 and R134a. *Fluid Phase Equilib.* **1995**, *109*, 265−279.
(5) De Santis, R.; Gironi, F.; Marrelli, L. Vapor-Liquid Equilibrium from a Hard-Sphere Equation of State. *Ind. Eng. Chem. Fundam.* **1976**, *15*, 183−189.
(6) Di Nicola, G.; Giuliani, G.; Passerini, G.; Polonara, F.; Stryjek, R. Vapor−Liquid Equilibria (VLE) Properties of R-32 + R-134a System Derived from Isochoric Measurements. *Fluid Phase Equilib.* **1998**, *153*, 143−165.
(7) Adams, R. A.; Stein, F. P.; Vapor-Liquid Equilibria for Carbon Dioxide-Difluoromethane System. *J. Chem. Eng. Data* **1971**, *16*, 146−149.
(8) McLinden, M. O.; Klein, S. A.; Lemmon, E. W.; Peskin, A. P. *NIST Thermodynamic and Transport Properties of Refrigerants and Refrigerant Mixtures (REFPROP) version 6.01*, Boulder, CO, 1998.
(9) Di Nicola, G.; Giuliani, G.; Polonara, F.; Stryjek, R. Saturated Pressure and $P-V-T$ Measurements for 1,1,1,3,3,3-Hexafluoropropane (R-236fa). *J. Chem. Eng. Data*, **1999**, *44*, 696−700.
(10) Bobbo, S.; Fedele, L.; Camporese, R.; Stryjek, R. Hydrogen-bonding of HFCs with dimethyl ether: evaluation by isothermal VLE measurements. *Fluid Phase Equilib.* **2002**, *199*, 155−162.

Received for review December 11, 2001. Accepted May 27, 2002. This work was supported by the Italian *Ministero dell'Università e della Ricerca Scientifica e Tecnologica*.

JE015541Y