m-cresol can be used as a solvent for extractive distillation of cumene-phenol mixture with cumene as an overhead product.

**Acknowledgment**

We thank John Warner for revision of the manuscript.

**Glossary**

| | |
|---|---|
| $C$, $M$ | constants in Norrish and Twigg equation |
| $n$ | number of points |
| $n_D$ | refraction index |
| $P$ | pressure, kPa |
| $r^2$ | correlation coefficient |
| $S^\infty$ | selectivity at infinite dilution |
| $T$ | temperature, K |
| $T_B$ | boiling point, K |
| $x$ | liquid-phase mole fraction |
| $y$ | vapor-phase mole fraction |

*Greek Letters*

| | |
|---|---|
| $\gamma$ | activity coefficient |
| $\phi$ | fugacity coefficient |
| $\Lambda_{12}$, $\Lambda_{21}$ | constants in Wilson model |
| $\rho$ | density, g/cm$^3$ |
| $\sigma$ | average deviation ($\sum(y_{exptl} - y_{calcd})/n$) |

*Suscripts*

| | |
|---|---|
| 1 | more volatile component |
| 2 | less volatile component |
| calcd | calculated |
| exptl | experimental |

**Registry No.** Phenol, 108-95-2; m-cresol, 108-39-4; cumene, 98-82-8.

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# *PVTx* Properties of the Binary System R 115 + R 114 and Its Thermodynamic Behavior

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**This paper reports the *PVTx* properties of the R 115 + R 114 system in a wide range of temperatures from 296 to 443 K, of pressures from 0.4 to 9.8 MPa, and of densities from 149 to 1313 kg/m$^3$. Five hundred ninety-seven *PVTx* measurements for four compositions, i.e., 25, 50, 75, and 100 wt % R 115, have been measured along the 41 isochores. The uncertainties of the temperature, pressure, and density measurements are less than ±8 mK, ±2.2 kPa, and ±0.1%, respectively. On the basis of the experimental measurements of 100 wt % R 115, we confirmed the reliability of our experimental apparatus and measurements. From *PVTx* measurements for 75 wt % R 115, 50 wt % R 115, and 25 wt % R 115, we have established the thermodynamic behavior of this binary mixture. We have also compared the critical curve of the R 115 + R 114 system observed in the present experimental study with those of other binary fluorocarbon mixtures that have been reported by us.**

## Introduction

The *PVTx* properties of binary refrigerant mixtures must be known accurately for system design and for reliable assessment of cycle performance (*1*, *2*).

Although the binary refrigerant mixture of the R 115 ($CClF_2CF_3$; monochloropentafluoroethane) and R 114 ($CClF_2CClF_2$; 1,2-dichloro-1,1,2,2-tetrafluoroethane) system is one of the technically important mixtures, experimental measurements of the thermodynamic properties of this system are not available. Continuing our own project of *PVTx* measurements of refrigerant mixtures, the R 12 + R 22 system (*3*), R 22 + R 114 system (*4*), R 13B1 + R 114 system (*5*), and R 152a + R 114 system (*6*, *7*), this paper reports the *PVTx* properties of the R 115 + R 114 system over a wide range of temperatures from 296 to 443 K, of pressures from 0.4 to 9.8 MPa, and of densities from 149 to 1313 kg/m$^3$, respectively. Five hundred ninety-seven *PVTx* measurements for four compositions, i.e., 25, 50, 75, and 100 wt % R 115, have been measured along 41 isochores. On the basis of these experimental data, we have determined dew points, bubble points, and the critical point for each composition.

## Experimental Section

The method, apparatus, and procedure of the *PVTx* measurements used here have been described in detail in our previous publications (*9*, *10*). In principle, the *PVTx* measurements of this work were made by the constant-volume method coupled with isothermal expansion.

The mass fraction of the mixture charged to the sample cell was determined by weighing the mass of each component on a chemical balance before mixing. The density of the sample was determined to be the ratio of the mass of the sample to the volume of the sample cell. The temperature of the sample was measured by a 25-Ω platinum resistance thermometer which was mounted near the cell in a thermostated fluid bath. The pressure of the sample was transmitted through the diaphragm of the differential pressure indicator (DPI) to an external pressure measuring system by balancing it with the pressure of nitrogen gas, the pressure transmitting gas. The fact that

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**Table I. Experimental Data**

| ρ, kg/m³ | T, K | P, MPa | ρ, kg/m³ | T, K | P, MPa | ρ, kg/m³ | T, K | P, MPa | ρ, kg/m³ | T, K | P, MPa |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 100 wt % R 115 | | | | | |
| 737.7[a] | 303.073 | 1.0263 | 735.5 | 363.094 | 4.0096 | 927.7[a] | 322.838 | 1.6475 | 924.7 | 383.149 | 8.3359 |
| 737.3[a] | 313.156 | 1.3149 | 735.1 | 373.129 | 4.9135 | 926.7[a] | 343.082 | 2.5507 | 924.2 | 393.161 | 9.8915 |
| 737.0[a] | 323.197 | 1.6315 | 734.7 | 383.131 | 5.8423 | 926.3 | 352.915 | 3.7745 | 926.7 | 345.229 | 2.6867 |
| 736.6[a] | 333.118 | 2.0682 | 734.3 | 393.168 | 6.7891 | 926.1 | 356.114 | 4.2408 | 926.6 | 346.150 | 2.8135 |
| 736.2[a] | 343.131 | 2.5507 | 733.9 | 403.171 | 7.7418 | 925.7 | 363.110 | 5.2727 | 926.8[a] | 341.124 | 2.4442 |
| 735.9 | 353.140 | 3.1441 | 733.5 | 413.166 | 8.7001 | 925.2 | 373.142 | 6.7938 | 926.8[a] | 342.121 | 2.4989 |
| | | | | | | 75 wt % (76.8 mol %) R 115 | | | | | |
| 266.5[a] | 303.145 | 0.8129 | 420.5[a] | 303.087 | 0.8239 | 634.7[a] | 363.103 | 2.9562 | 950.5 | 383.121 | 6.5941 |
| 266.3[a] | 323.126 | 1.2876 | 420.1[a] | 323.126 | 1.3186 | 634.1 | 383.110 | 4.2294 | 949.4 | 403.159 | 9.8152 |
| 266.0[a] | 343.151 | 1.9043 | 419.7[a] | 343.157 | 1.9927 | 633.4 | 403.132 | 5.6270 | 952.1[a] | 353.112 | 2.4944 |
| 265.8[a] | 363.136 | 2.6839 | 419.3[a] | 363.123 | 2.8669 | 632.7 | 423.173 | 7.0599 | 951.9[a] | 357.120 | 2.6916 |
| 265.5 | 383.059 | 3.1665 | 419.3[a] | 365.101 | 2.9618 | 632.4 | 433.177 | 7.7786 | 951.8 | 358.108 | 2.7727 |
| 265.2 | 403.125 | 3.6120 | 419.2 | 367.172 | 3.0630 | 632.0 | 443.193 | 8.4983 | 951.8 | 359.122 | 2.9201 |
| 265.1 | 413.209 | 3.8302 | 419.1 | 373.170 | 3.3459 | 634.6[a] | 366.227 | 3.1278 | 951.7 | 361.118 | 3.2130 |
| 265.0 | 423.200 | 4.0450 | 418.9 | 383.153 | 3.7695 | 634.6[a] | 367.172 | 3.1782 | 950.0 | 393.236 | 8.2118 |
| 264.8 | 433.178 | 4.2551 | 418.7 | 393.165 | 4.1832 | 634.5[a] | 368.145 | 3.2338 | 1035.0[a] | 303.433 | 0.8416 |
| 264.7 | 443.159 | 4.4510 | 418.3 | 413.146 | 4.9684 | 634.5 | 369.127 | 3.2910 | 1034.0[a] | 323.174 | 1.3459 |
| 265.9[a] | 353.198 | 2.3013 | 418.0 | 423.196 | 5.3639 | 634.4 | 371.092 | 3.4174 | 1033.0[a] | 343.116 | 2.0528 |
| 265.8[a] | 361.135 | 2.6066 | 417.8 | 433.240 | 5.7548 | 633.7 | 393.129 | 4.9189 | 1032.5 | 353.152 | 2.9671 |
| 265.8[a] | 364.130 | 2.7168 | 417.6 | 443.185 | 6.1388 | 633.1 | 413.117 | 6.3387 | 1031.9 | 363.171 | 4.8755 |
| 265.7 | 365.129 | 2.7457 | 419.4[a] | 361.141 | 2.7753 | 801.2[a] | 303.271 | 0.8344 | 1031.3 | 373.143 | 6.8341 |
| 265.7 | 366.124 | 2.7697 | 419.3[a] | 364.134 | 2.9096 | 800.5[a] | 323.157 | 1.3393 | 1031.0 | 378.154 | 7.8293 |
| 265.7 | 368.116 | 2.8176 | 419.3[a] | 366.142 | 3.0087 | 799.7[a] | 343.125 | 2.0406 | 1032.8[a] | 348.127 | 2.2675 |
| 265.6 | 374.091 | 2.9593 | 419.2 | 369.137 | 3.1555 | 798.9[a] | 363.149 | 2.9871 | 1032.7[a] | 349.155 | 2.3153 |
| 265.4 | 393.098 | 3.3919 | 418.5 | 403.159 | 4.5726 | 798.1 | 383.119 | 4.8195 | 1032.7 | 350.132 | 2.4015 |
| 334.5[a] | 323.166 | 1.3069 | 528.2[a] | 303.092 | 0.8267 | 797.2 | 403.141 | 6.9559 | 1032.6 | 351.135 | 2.5868 |
| 334.2[a] | 343.163 | 1.9593 | 527.7[a] | 323.126 | 1.3248 | 796.8 | 413.148 | 8.0482 | 1032.5 | 352.116 | 2.7709 |
| 333.8[a] | 364.338 | 2.8396 | 527.2[a] | 343.159 | 2.0091 | 796.4 | 423.212 | 9.1581 | 1032.2 | 358.148 | 3.9155 |
| 333.7 | 373.543 | 3.1976 | 526.7[a] | 363.195 | 2.9160 | 798.9[a] | 365.126 | 3.0932 | 1031.6 | 368.163 | 5.8494 |
| 333.3 | 393.132 | 3.8004 | 526.2 | 383.143 | 4.0079 | 798.8[a] | 366.152 | 3.1611 | 1030.7 | 383.133 | 8.8238 |
| 333.2 | 403.199 | 4.0989 | 525.9 | 393.183 | 4.5448 | 798.8 | 367.148 | 3.2339 | 1198.8[a] | 303.245 | 0.8380 |
| 333.0 | 413.184 | 4.3816 | 525.4 | 413.130 | 5.6316 | 798.7 | 368.143 | 3.3268 | 1198.2[a] | 312.773 | 1.0573 |
| 332.8 | 423.166 | 4.6678 | 525.1 | 423.136 | 6.1746 | 798.7 | 369.109 | 3.4183 | 1197.7[a] | 323.097 | 1.3458 |
| 332.7 | 433.166 | 4.9536 | 524.8 | 433.143 | 6.7151 | 798.6 | 371.130 | 3.6140 | 1197.0 | 333.133 | 3.5507 |
| 332.5 | 443.144 | 5.2330 | 524.5 | 443.185 | 7.2562 | 798.5 | 373.133 | 3.8106 | 1196.2 | 343.325 | 6.6929 |
| 333.9[a] | 357.126 | 2.5328 | 526.8[a] | 361.097 | 2.8152 | 797.7 | 393.126 | 5.8757 | 1197.5[a] | 325.118 | 1.4121 |
| 333.9[a] | 359.156 | 2.6166 | 526.7[a] | 364.129 | 2.9685 | 824.0[a] | 303.157 | 0.8337 | 1197.5[a] | 326.145 | 1.4420 |
| 333.9[a] | 361.142 | 2.7026 | 526.7[a] | 365.118 | 3.0186 | 823.2[a] | 323.134 | 1.3314 | 1197.4 | 327.141 | 1.7268 |
| 333.8[a] | 362.150 | 2.7522 | 526.6 | 367.121 | 3.1238 | 954.3[a] | 303.225 | 0.8349 | 1197.3 | 328.156 | 2.0358 |
| 333.8[a] | 363.132 | 2.7971 | 526.6 | 369.130 | 3.2311 | 953.5[a] | 322.935 | 1.3387 | 1197.2 | 330.115 | 2.6340 |
| 333.8[a] | 365.123 | 2.8824 | 526.4 | 373.168 | 3.4586 | 952.5[a] | 343.127 | 2.0412 | 1196.6 | 338.096 | 5.0722 |
| 333.8 | 367.132 | 2.9686 | 525.6 | 403.121 | 5.0877 | 951.6 | 363.139 | 3.5106 | 1195.8 | 348.145 | 8.1853 |
| 333.7 | 369.115 | 3.0531 | 636.5[a] | 303.126 | 0.8307 | 951.1 | 373.076 | 5.0142 | 1195.4 | 353.179 | 9.7544 |
| 333.5 | 383.136 | 3.4970 | 635.9[a] | 323.140 | 1.3373 | | | | | | |
| | | | | | | 50 wt % (52.5 mol %) R 115 | | | | | |
| 149.6[a] | 302.148 | 0.5749 | 235.2 | 376.129 | 2.5458 | 597.1 | 433.155 | 6.3052 | 945.9[a] | 353.144 | 1.9520 |
| 149.5[a] | 323.126 | 0.9202 | 235.2 | 377.143 | 2.5767 | 596.8 | 443.154 | 6.9406 | 945.4[a] | 363.166 | 2.3529 |
| 149.3[a] | 346.150 | 1.4296 | 235.2 | 379.137 | 2.6212 | 598.6[a] | 386.148 | 3.3879 | 944.9[a] | 373.166 | 2.8249 |
| 149.2 | 363.133 | 1.8746 | 235.2[a] | 374.156 | 2.4853 | 598.5 | 388.148 | 3.5065 | 943.9 | 393.122 | 5.6910 |
| 149.1 | 373.162 | 1.9875 | 234.7 | 423.162 | 3.4590 | 598.5 | 389.152 | 3.5670 | 943.3 | 403.142 | 7.2291 |
| 149.0 | 393.141 | 2.2025 | 553.9[a] | 303.331 | 0.6428 | 598.5 | 390.147 | 3.6270 | 942.8 | 413.163 | 8.7804 |
| 148.8 | 413.164 | 2.4103 | 553.3[a] | 323.113 | 1.0312 | 598.4 | 393.165 | 3.8109 | 944.9 | 374.160 | 2.9176 |
| 148.7 | 433.179 | 2.6136 | 552.8[a] | 343.047 | 1.5675 | 598.8[a] | 379.069 | 3.0202 | 944.8 | 375.138 | 3.0520 |
| 149.3[a] | 351.123 | 1.5635 | 552.3[a] | 363.128 | 2.2810 | 754.9[a] | 303.137 | 0.6443 | 944.8 | 376.156 | 3.1970 |
| 149.2[a] | 361.150 | 1.8412 | 551.7[a] | 383.135 | 3.1940 | 754.2[a] | 323.131 | 1.0430 | 944.7 | 377.112 | 3.3317 |
| 149.2 | 362.157 | 1.8629 | 551.7[a] | 385.135 | 3.2994 | 753.5[a] | 343.122 | 1.5924 | 944.4 | 383.138 | 4.2085 |
| 149.2 | 364.125 | 1.8837 | 551.7[a] | 386.144 | 3.3557 | 752.7[a] | 363.149 | 2.3240 | 943.6 | 398.146 | 6.4589 |
| 149.2 | 365.128 | 1.8950 | 551.6 | 387.170 | 3.4115 | 752.0 | 383.146 | 3.3028 | 1045.5[a] | 303.107 | 0.6472 |
| 149.1 | 367.127 | 1.9158 | 551.6 | 388.155 | 3.4645 | 751.6 | 393.178 | 4.0560 | 1044.5[a] | 323.147 | 1.0499 |
| 149.0 | 383.156 | 2.0911 | 551.6 | 389.141 | 3.5184 | 751.2 | 403.122 | 4.9681 | 1043.5[a] | 343.154 | 1.6074 |
| 148.9 | 403.168 | 2.3038 | 551.5 | 393.154 | 3.7455 | 750.4 | 423.149 | 6.8159 | 1042.5[a] | 363.144 | 2.3614 |
| 148.7 | 423.145 | 2.5097 | 550.9 | 413.135 | 4.8621 | 749.9 | 433.151 | 7.7595 | 1041.9 | 373.062 | 4.2173 |
| 236.0[a] | 300.916 | 0.6270 | 550.6 | 423.116 | 5.4306 | 749.5 | 443.180 | 8.7128 | 1041.6 | 378.121 | 5.1728 |
| 235.8[a] | 323.143 | 0.9732 | 550.3 | 433.147 | 5.9984 | 751.9 | 385.153 | 3.3653 | 1041.3 | 383.136 | 6.1605 |
| 235.6[a] | 343.128 | 1.4496 | 550.0 | 443.130 | 6.5640 | 751.9 | 386.181 | 3.4399 | 1041.0 | 388.135 | 7.1508 |
| 235.5[a] | 353.179 | 1.7444 | 551.2 | 403.124 | 4.3066 | 751.8 | 387.150 | 3.5236 | 1040.7 | 393.139 | 8.1495 |
| 235.2[a] | 373.130 | 2.3763 | 601.0[a] | 304.819 | 0.6711 | 752.1[a] | 381.147 | 3.1111 | 1042.5[a] | 362.126 | 2.3119 |
| 235.1 | 383.074 | 2.6979 | 600.4[a] | 323.091 | 1.0372 | 752.0 | 383.263 | 3.2381 | 1042.4 | 364.188 | 2.5077 |
| 235.0 | 393.165 | 2.8960 | 599.9[a] | 343.030 | 1.5781 | 751.9 | 384.147 | 3.2936 | 1042.4 | 365.145 | 2.6859 |
| 234.9 | 403.174 | 3.0860 | 599.3[a] | 363.138 | 2.2996 | 750.8 | 413.157 | 5.8260 | 1042.2 | 368.132 | 3.2526 |
| 234.8 | 413.211 | 3.2735 | 598.7[a] | 383.110 | 3.2245 | 948.0[a] | 306.491 | 0.7037 | 1040.3 | 398.132 | 9.1531 |
| 234.5 | 433.166 | 3.6372 | 598.1 | 403.127 | 4.4157 | 947.2[a] | 324.163 | 1.1021 | 1312.6[a] | 312.184 | 0.8458 |
| 234.4 | 443.180 | 3.8157 | 597.8 | 413.132 | 5.0381 | 946.8[a] | 333.164 | 1.3038 | 1311.7 | 323.113 | 4.2589 |
| 235.2[a] | 375.206 | 2.5214 | 597.4 | 423.164 | 5.6727 | 946.3[a] | 343.141 | 1.6056 | 1312.4[a] | 315.181 | 0.9340 |

**Table I** (Continued)

| ρ, kg/m³ | T, K | P, MPa | ρ, kg/m³ | T, K | P, MPa | ρ, kg/m³ | T, K | P, MPa | ρ, kg/m³ | T, K | P, MPa |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1312.2 | 317.161 | 1.7642 | 1312.1 | 319.129 | 2.5885 | 1311.0 | 331.109 | 7.6027 | 1310.6 | 335.134 | 9.2927 |
| 1312.3 | 316.147 | 1.3401 | 1311.3 | 327.130 | 5.9296 | 1310.8 | 333.125 | 8.4457 | | | |
| 25 wt % (26.9 mol %) R 115 | | | | | | | | | | | |
| 155.1[a] | 304.161 | 0.4315 | 250.1 | 408.162 | 2.9802 | 702.8[a] | 323.152 | 0.7527 | 952.4 | 433.178 | 9.5086 |
| 155.0[a] | 323.140 | 0.6803 | 315.7[a] | 308.954 | 0.5122 | 702.1[a] | 343.134 | 1.1682 | 954.9[a] | 387.079 | 2.6817 |
| 154.8[a] | 343.106 | 1.0377 | 315.5[a] | 323.094 | 0.7214 | 701.4[a] | 363.183 | 1.7356 | 954.8[a] | 388.134 | 2.7331 |
| 154.7[a] | 363.129 | 1.5204 | 315.2[a] | 343.172 | 1.1124 | 700.7[a] | 383.173 | 2.4778 | 954.8 | 389.155 | 2.8298 |
| 154.5 | 383.137 | 1.9911 | 314.9[a] | 363.151 | 1.6373 | 699.9 | 405.785 | 3.5692 | 954.7 | 390.168 | 2.9729 |
| 154.5 | 393.140 | 2.1053 | 314.6[a] | 383.120 | 2.3201 | 698.5 | 443.173 | 6.4496 | 954.7 | 391.154 | 3.1141 |
| 154.4 | 403.165 | 2.2157 | 314.3 | 403.165 | 3.1135 | 700.4[a] | 393.186 | 2.9288 | 1109.7[a] | 303.099 | 0.4599 |
| 154.3 | 413.130 | 2.3235 | 314.1 | 412.913 | 3.3879 | 700.2[a] | 399.145 | 3.2328 | 1108.7[a] | 323.161 | 0.7566 |
| 154.6[a] | 371.138 | 1.7555 | 313.9 | 423.197 | 3.6676 | 700.1[a] | 401.153 | 3.3442 | 1107.7[a] | 343.131 | 1.1792 |
| 154.6[a] | 373.147 | 1.8146 | 313.8 | 433.156 | 3.9325 | 700.0 | 403.153 | 3.4683 | 1107.1[a] | 353.144 | 1.4472 |
| 154.6[a] | 374.121 | 1.8460 | 313.6 | 443.082 | 4.1903 | 700.0 | 404.144 | 3.5360 | 1106.6[a] | 363.140 | 1.7607 |
| 154.6[a] | 375.123 | 1.8771 | 314.4[a] | 393.146 | 2.7369 | 699.9 | 406.378 | 3.6960 | 1106.0 | 373.152 | 2.8368 |
| 154.6[a] | 376.147 | 1.9048 | 314.4[a] | 396.156 | 2.8672 | 699.8 | 408.155 | 3.8277 | 1106.4[a] | 367.133 | 1.8923 |
| 154.6 | 377.161 | 1.9196 | 314.3[a] | 397.149 | 2.9069 | 699.3 | 423.163 | 4.9628 | 1106.3[a] | 368.143 | 1.9277 |
| 154.6 | 379.000 | 1.9407 | 314.3[a] | 398.136 | 2.9467 | 883.5[a] | 303.590 | 0.4654 | 1106.3[a] | 369.137 | 1.9665 |
| 154.2 | 423.182 | 2.4315 | 314.3 | 399.153 | 2.9945 | 882.7[a] | 323.179 | 0.7560 | 1106.2 | 370.143 | 2.1548 |
| 154.2 | 433.178 | 2.5360 | 314.3 | 401.142 | 3.0568 | 881.9[a] | 343.098 | 1.1740 | 1106.1 | 371.121 | 2.3773 |
| 154.1 | 443.175 | 2.6401 | 560.0[a] | 302.694 | 0.4488 | 881.0[a] | 363.193 | 1.7478 | 1105.7 | 378.185 | 3.9840 |
| 200.2[a] | 302.016 | 0.4104 | 559.5[a] | 323.105 | 0.7465 | 880.6[a] | 373.165 | 2.0982 | 1105.0 | 388.153 | 6.2767 |
| 200.0[a] | 323.641 | 0.6970 | 559.0[a] | 343.125 | 1.1572 | 880.1[a] | 383.100 | 2.5033 | 1104.7 | 393.160 | 7.4499 |
| 199.8[a] | 343.112 | 1.0565 | 558.5[a] | 363.093 | 1.7099 | 879.7[a] | 393.139 | 2.9677 | 1104.0 | 403.162 | 9.8030 |
| 199.6[a] | 363.105 | 1.5487 | 557.9[a] | 383.150 | 2.4428 | 879.2 | 403.159 | 4.0179 | 1204.0[a] | 307.141 | 0.5090 |
| 199.4[a] | 383.123 | 2.1982 | 557.6[a] | 393.155 | 2.8855 | 878.7 | 413.108 | 5.2121 | 1203.1[a] | 323.038 | 0.7562 |
| 199.2 | 403.163 | 2.5778 | 557.3[a] | 403.180 | 3.3889 | 877.7 | 433.108 | 7.7356 | 1202.0[a] | 343.154 | 1.1842 |
| 199.1 | 413.160 | 2.7308 | 557.0 | 413.177 | 3.9420 | 877.2 | 443.179 | 9.0304 | 1201.4 | 353.172 | 1.7244 |
| 199.0 | 423.119 | 2.8800 | 556.7 | 423.196 | 4.4868 | 879.6 | 395.137 | 3.0884 | 1200.6 | 363.132 | 4.7094 |
| 198.9 | 433.114 | 3.0294 | 556.5 | 433.107 | 5.0344 | 879.6 | 396.143 | 3.2004 | 1200.2 | 368.084 | 6.2146 |
| 198.8 | 433.180 | 3.1735 | 556.2 | 443.169 | 5.5901 | 879.6[a] | 394.140 | 3.0089 | 1199.8 | 373.101 | 7.7406 |
| 199.4 | 386.149 | 2.3063 | 557.3[a] | 404.154 | 3.4460 | 879.5 | 398.138 | 3.4294 | 1199.4 | 378.154 | 9.2865 |
| 199.3 | 387.145 | 2.3231 | 557.3 | 405.191 | 3.5034 | 878.2 | 423.171 | 6.4718 | 1201.7[a] | 348.116 | 1.3133 |
| 199.3 | 388.105 | 2.3410 | 557.2 | 406.141 | 3.5569 | 956.9[a] | 343.104 | 1.1747 | 1201.6[a] | 350.154 | 1.3682 |
| 199.3 | 389.139 | 2.3579 | 557.2 | 407.217 | 3.6151 | 955.1[a] | 383.089 | 2.5108 | 1201.5[a] | 351.124 | 1.3936 |
| 199.3 | 391.119 | 2.3877 | 557.2 | 409.117 | 3.7197 | 954.6 | 393.154 | 3.4006 | 1201.4 | 352.129 | 1.4423 |
| 199.3 | 392.269 | 2.4223 | 557.4[a] | 399.141 | 3.1836 | 954.0 | 403.146 | 4.8668 | 1201.3 | 354.119 | 2.0035 |
| 250.9[a] | 347.296 | 1.1802 | 557.4[a] | 401.151 | 3.2862 | 953.5 | 413.169 | 6.3925 | 1200.9 | 358.629 | 3.3590 |
| 250.4[a] | 383.135 | 2.2604 | 703.4[a] | 302.992 | 0.4538 | 952.9 | 423.163 | 7.9412 | | | |

[a] Values measured at a state of vapor–liquid coexistence. The values of density and mass fraction in this state are only nominal.

the differential pressure between the sample and nitrogen gas depends only on temperature requires some systematic calibration of the DPI at different temperatures. The required correction due to mechanical behavior of the DPI is at most 0.1% of the sample pressure. It should be noted that the thermodynamic equilibrium between the sample and thermostated bath fluid is always maintained carefully not only by stirring the fluid continuously so as to keep the temperature fluctuation within ±5 mK but also by observing the temperature and pressure always at the same time every $^1/_4$ h.

The uncertainty in calibrating the platinum resistance thermometer is less than ±3 mK, and the bath fluid temperature was always controlled within the fluctuation of ±5 mK. Thus the uncertainty of the temperature measurements was less than ±8 mK. Since the total hydrostatic pressure correction is much smaller than 0.5 kPa, we ignore it. The uncertainty of the pressure measurements due to the differential pressure indicator is less than ±0.2 kPa and that of the air-piston pressure gauge used in the pressure range below 4 MPa is less than ±0.4 kPa, while that of the oil-piston pressure gauge used in the pressure range above 4 MPa is less than ±2 kPa. Therefore, the overall uncertainty in the pressure measurements was less than ±0.6 kPa for pressures below 4 MPa and less than ±2.2 kPa for those above 4 MPa, respectively. The uncertainty in the density measurements accumulates after repeated expansions. The uncertainty in mass measurement is less than 0.04%, whereas that of inner volume calibration is less than 0.03%. Since the number of expansions does not exceed three in the present work, the overall uncertainty in the density measurements is estimated to not exceed ±0.1%. The uncertainty of the mass fraction measurements is estimated to be less than ±0.1%. The prescribed quantity of 99.97 wt % pure R 114, being an isomeric blend of 95% $CClF_2CClF_2$ and 5% $CCl_2FCF_3$, and that of 99.999 wt % pure R 115 were prepared in separate vessels, which were evacuated prior to being filled.

## Results

The experiments were carried out for four compositions, i.e., 25, 50, 75, and 100 wt % R 115. In this study we measured the vapor pressures and *PVT* properties of pure R 115 along two isochores in order to test their agreement with our own data reported previously (*8*). The present vapor-pressure data and *PVT* data of pure R 115 are in good agreement with those in our previous publication (*8*) within ±0.2% and ±0.8% pressure deviation, respectively. Table I summarizes all the unsmoothed experimental data including vapor–liquid data in the two-phase region (in Table I those data are identified by footnote *a*). Ten series of *PVTx* measurements for the mixture of 25 wt % (26.9 mol %) R 115 + 75 wt % (73.1 mol %) R 114 cover the density range from 154 to 1204 kg/m³. Table I shows the 143 *PVTx* data for this composition along 10 isochores including 69 data in the vapor–liquid two-phase region. For the mixture of 50 wt % (52.5 mol %) R 115 + 50 wt % (47.5 mol %) R 114, the observations correspond to densities from 149 to 1313 kg/m³. Table I lists 124 *PVTx* measured data for this composition along eight isochores, including 68 points in the vapor–liquid two-phase region. For the mixture of 75 wt % (76.8 mol %) R 115 + 25 wt % (23.2 mol %) R 114, the mea-

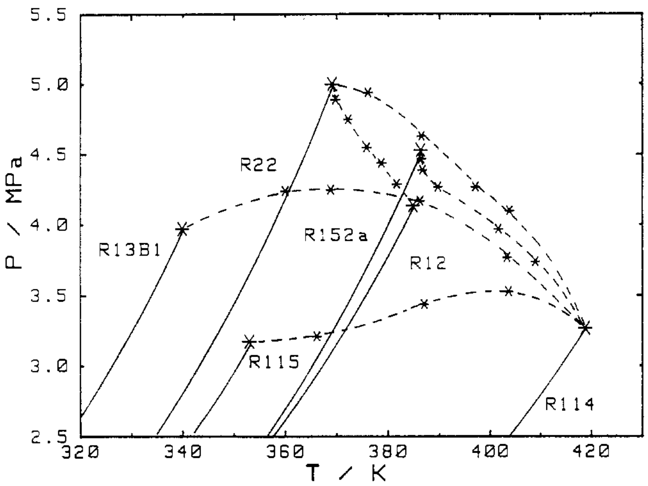


**Figure 1.** Critical curves of binary refrigerant mixtures.

surements cover densities from 265 to 1199 kg/m$^3$. The 144 *PVTx* data along 10 isochores, including 79 data in the vapor-liquid two-phase region are tabulated in Table I.

## Discussion

The detailed examination and discussion of the dew- and bubble-point curves of this R 115 + R 114 system have been described in another paper (*11*). In this report we discuss the comparison of this system with other refrigerant mixtures that have also been reported by the present authors (*3-7*).

For the purpose of comparing some typical thermodynamic behaviors for the R 115 + R 114 system with those of the four refrigerant mixtures that we have measured previously, i.e., R 12 + R 22 (*3*), R 22 + R 114 (*4*), R 13B1 + R 114 (*5*), and R 152a + R 114 (*6*, *7*), we have prepared Figure 1. Although the critical curves usually bend near the critical points of polar substances, as discussed in ref *7*, we do not find such behavior for the present R 115 + R 114 system. We found that the behavior of the present mixture is similar to that of the system R 13B1 + R 114. Both critical curves have a tendency to be convex to the high-pressure side. The mixture of R 13B1 + R 114 is unique in the sense that its components have a large difference in the critical temperature (about 80 K) and a small difference in critical pressure (about 0.70 MPa). For the present mixture, the difference in the critical temperature of the components is also large (about 60 K), and in the critical pressure the difference is similarly small (about 0.14 MPa). Thus, the behavior of thermodynamic properties for binary refrigerant mixtures may depend rather heavily on the differences in the critical parameters of their respective components. This should be subjected to more detailed discussion with further accumulation of additional data.

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**Registry No.** R 115, 76-15-3; R 114, 76-14-2.

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# Correlation of the Phase Equilibrium Data for the Heptane–Toluene–Sulfolane and Heptane–Xylene–Sulfolane Systems

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**Liquid–liquid equilibrium data were measured for the heptane–toluene–sulfolane system at 25 °C and for the heptane–xylene–sulfolane system at 17, 25, and 50 °C. The NRTL and UNIQUAC equations were used to correlate the experimental data and to predict the phase compositions of the ternary systems. The agreement between the predicted and the experimental results was equally good with both equations.**

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## Introduction

Because of the important industrial applications of sulfolane, several investigators have studied the liquid–liquid phase equilibria for ternary systems containing sulfolane and aromatic hydrocarbons (*1-4*). Due to the lack of experimental data for some ternary systems, however, thermodynamic models are frequently used for predicting phase equilibrium compositions. Some of the more widely used models are the Wilson equation for excess Gibbs energy (*5*), the nonrandomness two-liquid equation (NRTL) proposed by Renon and Prausnitz (*6*), and the UNIQUAC equation of Abrams and Prausnitz (*7*). The interaction parameters present in these equations are evaluated

 