

# R227ea

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## An Experimental Study on the Vapor-Liquid Equilibria of Propane and R227ea Mixtures

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**Key Words :** R227ea, Propane, Vapor-liquid equilibrium( - ), Azeotrope( ), Equation of state( )

### Abstract

Vapor-liquid equilibrium data were obtained for system of propane + R227ea (Heptafluoropropane) over the temperature range from 253.15 K to 323.15 K at 10 K intervals. Experiments were performed in a circulation type apparatus by injecting vapor through liquid pool using a magnetic pump. This system forms azeotrope in the temperature range of this study. The experimental results were correlated with the Peng-Robinson (PR) equation of state and Redlich-Kwong-Soave (RKS) equation of state using the van der Waals one-fluid mixing rule and were compared with each other.

$k_{12}$  : 2  
 $P$  : [kPa] Protocol)  
 $T$  : [K] HFC  
 $x$  :  
 $y$  : (HC, Hydrocarbon)  
 azeo :  
 c : 가  
 cal :  
 exp : 가  
 1. HFC HC 가

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가 (azeotropic refrigerant mixture) propane + R227ea(Heptafluoropropane)  
 (mixing rule) van der Walls Peng-Robinson Redlich-Kwong-Soave

2.

2.1

Fig.1

가 (gas chromatograph, 가 GC)

SUS316

가 0.07m<sup>3</sup>

± 0.01K

(model

F250)

± 0.02K

± 2kPa 가

± 0.002

2.2

가

가

( 1 )

(± 0.005K)

가

(± 0.05kPa)가

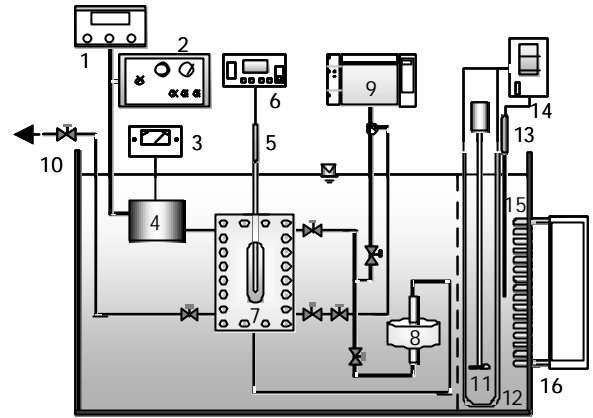


Fig. 1 Schematic diagram of experimental apparatus:  
 1. multifunction pressure indicator, 2. pneumatic pressure controller, 3. differential pressure null indicator, 4. differential pressure null transducer, 5. platinum resistance sensor, 6. digital temperature indicator, 7. equilibrium cell, 8. magnetic pump, 9. gas chromatograph, 10. charging port, 11. stirrer, 12. heater, 13. platinum resistance sensor, 14. PID controller, 15. evaporator, 16. refrigerator

3.

3.1 Propane + R227ea

Table 1

Fig 2 253

K-323 K

RKS

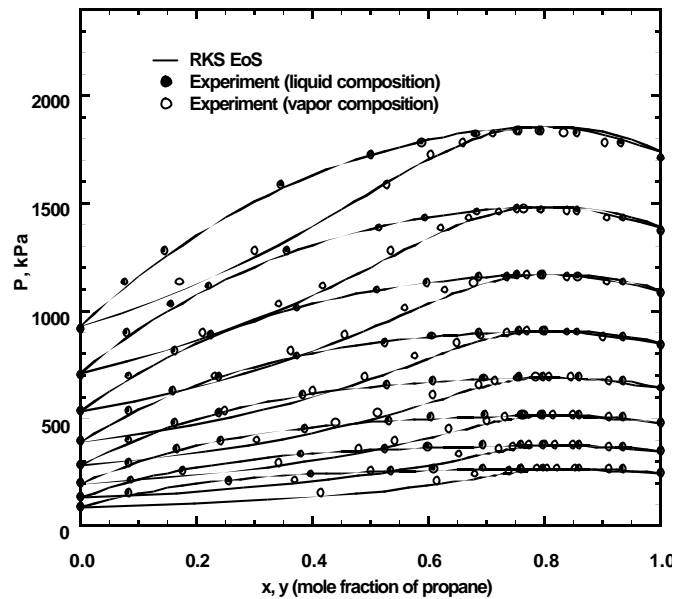
Table 2

van der Walls

PR RKS

**Table 1** Vapor-liquid equilibrium data of propane(1) + R227ea(2)

| $P_{exp}$ (MPa) | $x_{1,exp}$ | $y_{1,exp}$ | $P_{exp}$ (MPa) | $x_{1,exp}$ | $y_{1,exp}$ |
|-----------------|-------------|-------------|-----------------|-------------|-------------|
| T=253.15 K      |             |             |                 |             |             |
| 0.088           | 0.000       | 0.000       | 0.267           | 0.695       | 0.787       |
| 0.149           | 0.084       | 0.415       | 0.269           | 0.760       | 0.806       |
| 0.206           | 0.257       | 0.616       | 0.268           | 0.798       | 0.822       |
| 0.238           | 0.397       | 0.681       | 0.267           | 0.860       | 0.853       |
| 0.255           | 0.536       | 0.738       | 0.260           | 0.936       | 0.911       |
| 0.263           | 0.610       | 0.760       | 0.246           | 1.000       | 1.000       |
| T=263.15 K      |             |             |                 |             |             |
| 0.134           | 0.000       | 0.000       | 0.375           | 0.694       | 0.774       |
| 0.211           | 0.088       | 0.371       | 0.378           | 0.760       | 0.800       |
| 0.257           | 0.176       | 0.502       | 0.377           | 0.799       | 0.817       |
| 0.332           | 0.380       | 0.652       | 0.376           | 0.859       | 0.850       |
| 0.357           | 0.525       | 0.722       | 0.366           | 0.936       | 0.911       |
| 0.368           | 0.600       | 0.747       | 0.347           | 1.000       | 1.000       |
| T=273.15 K      |             |             |                 |             |             |
| 0.198           | 0.000       | 0.000       | 0.512           | 0.698       | 0.765       |
| 0.293           | 0.083       | 0.342       | 0.516           | 0.762       | 0.793       |
| 0.353           | 0.166       | 0.479       | 0.516           | 0.798       | 0.814       |
| 0.392           | 0.243       | 0.543       | 0.514           | 0.860       | 0.848       |
| 0.451           | 0.386       | 0.634       | 0.502           | 0.936       | 0.912       |
| 0.487           | 0.532       | 0.703       | 0.476           | 1.000       | 1.000       |
| 0.502           | 0.604       | 0.731       |                 |             |             |
| T=283.15 K      |             |             |                 |             |             |
| 0.282           | 0.000       | 0.000       | 0.684           | 0.696       | 0.753       |
| 0.398           | 0.083       | 0.304       | 0.690           | 0.758       | 0.786       |
| 0.474           | 0.165       | 0.441       | 0.690           | 0.797       | 0.808       |
| 0.524           | 0.241       | 0.514       | 0.687           | 0.860       | 0.847       |
| 0.603           | 0.384       | 0.607       | 0.671           | 0.936       | 0.911       |
| 0.650           | 0.529       | 0.687       | 0.639           | 1.000       | 1.000       |
| 0.670           | 0.608       | 0.715       |                 |             |             |
| T=293.15 K      |             |             |                 |             |             |
| 0.392           | 0.000       | 0.000       | 0.898           | 0.687       | 0.735       |
| 0.532           | 0.083       | 0.249       | 0.905           | 0.756       | 0.771       |
| 0.626           | 0.161       | 0.400       | 0.904           | 0.796       | 0.802       |
| 0.688           | 0.241       | 0.492       | 0.900           | 0.856       | 0.838       |
| 0.789           | 0.374       | 0.578       | 0.879           | 0.935       | 0.902       |
| 0.852           | 0.525       | 0.651       | 0.838           | 1.000       | 1.000       |
| 0.879           | 0.607       | 0.692       |                 |             |             |
| T=303.15 K      |             |             |                 |             |             |
| 0.531           | 0.000       | 0.000       | 1.155           | 0.687       | 0.735       |
| 0.695           | 0.084       | 0.233       | 1.164           | 0.755       | 0.771       |
| 0.808           | 0.163       | 0.365       | 1.163           | 0.796       | 0.798       |
| 0.884           | 0.227       | 0.457       | 1.157           | 0.858       | 0.840       |
| 1.012           | 0.372       | 0.559       | 1.130           | 0.936       | 0.908       |
| 1.094           | 0.511       | 0.630       | 1.078           | 1.000       | 1.000       |
| 1.129           | 0.597       | 0.679       |                 |             |             |
| T=313.15 K      |             |             |                 |             |             |
| 0.698           | 0.000       | 0.000       | 1.459           | 0.684       | 0.724       |
| 0.893           | 0.080       | 0.210       | 1.468           | 0.754       | 0.765       |
| 1.028           | 0.158       | 0.342       | 1.468           | 0.795       | 0.793       |
| 1.112           | 0.221       | 0.419       | 1.460           | 0.858       | 0.838       |
| 1.275           | 0.358       | 0.535       | 1.428           | 0.935       | 0.909       |
| 1.383           | 0.515       | 0.621       | 1.367           | 1.000       | 1.000       |
| 1.427           | 0.594       | 0.672       |                 |             |             |
| T=323.15 K      |             |             |                 |             |             |
| 0.911           | 0.000       | 0.000       | 1.819           | 0.682       | 0.711       |
| 1.130           | 0.076       | 0.172       | 1.834           | 0.753       | 0.756       |
| 1.278           | 0.147       | 0.301       | 1.833           | 0.795       | 0.792       |
| 1.581           | 0.347       | 0.530       | 1.822           | 0.857       | 0.834       |
| 1.722           | 0.503       | 0.606       | 1.780           | 0.933       | 0.905       |
| 1.780           | 0.589       | 0.659       | 1.709           | 1.000       | 1.000       |

**Fig. 2** VLE diagram of propane + R227ea**Table 2** Critical properties and acentric factors of pure components (REFPROP 7.0)

|                             | R290   | R227ea |
|-----------------------------|--------|--------|
| Critical temperature, T ( ) | 96.70  | 101.74 |
| Critical pressure, P (kPa)  | 4248   | 2929   |
| Acentric factor,            | 0.1524 | 0.3632 |

**Table 3** Calculated azeotropic composition and pressure for two EoS model

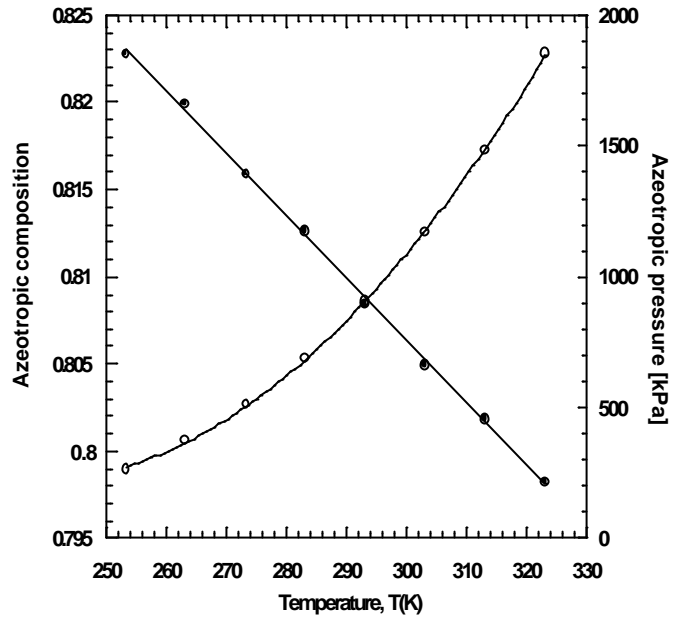
| T (K)  | PR EoS     |         | RKS EoS    |         |
|--------|------------|---------|------------|---------|
|        | $X_{azeo}$ | P (kPa) | $X_{azeo}$ | P (kPa) |
| 253.15 | 0.822      | 263.7   | 0.823      | 263.5   |
| 263.15 | 0.817      | 371.9   | 0.820      | 372.3   |
| 273.15 | 0.812      | 511.3   | 0.816      | 512.5   |
| 283.15 | 0.807      | 686.1   | 0.813      | 688.1   |
| 293.15 | 0.801      | 902.8   | 0.808      | 905.5   |
| 303.15 | 0.797      | 1165.4  | 0.805      | 1168.7  |
| 313.15 | 0.793      | 1479.7  | 0.802      | 1483.1  |
| 323.15 | 0.788      | 1853.0  | 0.798      | 1855.1  |

**Table 4** Interaction parameter and Absolute Average Deviation (AAD) of P and y

| T (K)         | k <sub>12</sub> | AAD of P <sup>a</sup> (%) | AAD of y <sup>b</sup> (%) |
|---------------|-----------------|---------------------------|---------------------------|
| PR EoS model  |                 |                           |                           |
| 253.15        | 0.1340          | 1.98                      | 2.40                      |
| 263.15        | 0.1344          | 1.38                      | 2.76                      |
| 273.15        | 0.1353          | 1.18                      | 2.22                      |
| 283.15        | 0.1356          | 0.92                      | 2.26                      |
| 293.15        | 0.1363          | 0.74                      | 3.28                      |
| 303.15        | 0.1363          | 0.53                      | 2.57                      |
| 313.15        | 0.1358          | 0.77                      | 1.60                      |
| 323.15        | 0.1354          | 1.08                      | 1.89                      |
| RKS EoS model |                 |                           |                           |
| 253.15        | 0.1394          | 2.06                      | 2.51                      |
| 263.15        | 0.1389          | 1.28                      | 2.72                      |
| 273.15        | 0.1391          | 0.97                      | 2.05                      |
| 283.15        | 0.1388          | 0.73                      | 1.99                      |
| 293.15        | 0.1391          | 0.69                      | 2.99                      |
| 303.15        | 0.1389          | 0.59                      | 2.26                      |
| 313.15        | 0.1384          | 1.03                      | 1.38                      |
| 323.15        | 0.1381          | 1.23                      | 1.76                      |

$$^a \text{AAD of P} = (100/N) \sum (|P_{exp} - P_{cal}| / P_{exp})$$

$$^b \text{AAD of y} = (100/N) \sum (|y_{exp} - y_{cal}| / y_{exp})$$



**Fig. 3** Azeotropic composition and pressure of propane + R227ea in RKS EoS

4.

propane + R227ea

x-y propane + R227ea PR P-T-RKS

가 RKS PR

BK21

가

(Absolute Average Deviation,

AAD) Table 4 . PR

1.07% ,  
2.37% . RKS  
1.07%  
2.21% .

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