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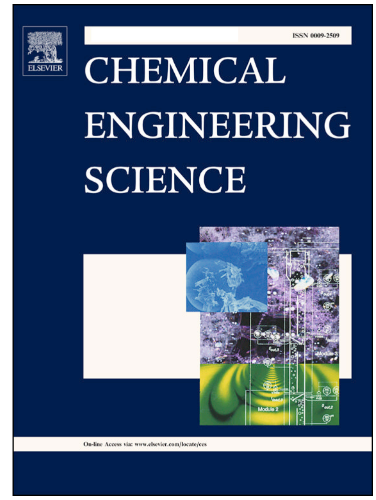

Thermodynamic modeling of VLE and VLLE for the ternary system of 2,3,3,3-tetrafluoroprop-1-ene(R1234yf) + propane (R290) + 1,1,1,2-tetrafluoroethane(R134a) at 253.15K-313.15K

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Abstract The excess Gibbs free energy-equation of state (G^{E}-EoS) models is presented based on the Peng-Robinson (PR) EoS combined with the Wong-Sandler (WS) mixing rule and the modified UNIFAC group contribution method (PR-WS-MUNIFAC). The average absolute deviation (AAD) of vapor phase mass fraction and the absolute average relative deviation (AARD) of pressure are 0.0047 and 0.53%, respectively, for R152a + R1234yf; 0.0064、0.0050 and 1.59%, respectively, for R32 + R125 + R134a. The VLE properties of the ternary mixture R1234yf + R290 + R134a as a drop-in replacement for R134a were predicted over the temperature range of (253.15 K-313.15 K) at 10 K intervals. The vapor-liquid-liquid equilibrium (VLLE) was qualitatively analyzed in theory, and the relevant phase equilibrium diagrams were constructed. The R290 + R134a system has clear characteristics of VLLE near the azeotropic point; the pressure of the upper critical end point (UCEP) is approximately 1.627 MPa. Liquid phase separation also exists in the ternary system of R1234yf + R290 + R134a.

Key words VLE; VLLE; G^{E}-EoS model; prediction; alternative refrigerants

1 Introduction

Global warming and greenhouse effects are two major problems faced by humans. A large part of the problem is due to emissions from refrigeration systems. Most refrigerants currently used in the air conditioning and refrigeration industry are hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs), which have either a high global warming potential (GWP) or an ozone depression potential (ODP). There is no pure refrigerant that performs well in both cooling and environmental protection. Therefore, it is urgent to discover environmental-friendly refrigerants. In a single stage vapor compression refrigeration cycle, the near-azeotropic mixtures are the most promising type of alternative refrigerants due to their great application in temperature matching of the variable temperatures of different heat sources, as well as the advantages of large volumetric refrigerating capacity, high back pressure and high coefficient of phase change heat transfer. Their performance is similar to that of pure working fluid near the azeotropic point, and therefore, they have become the most promising type of alternative refrigerant (Zhang et al., 2007).

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