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Phase composition and saturated liquid properties in binary and ternary systems containing carbon dioxide, *n*-decane, and *n*-tetradecane

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ABSTRACT

Experimental phase equilibrium data have been measured for the binary and ternary systems containing (carbon dioxide, *n*-decane, and *n*-tetradecane) at 323.2 K over the pressure range (1 to 6) MPa using a designed PVT apparatus. The measurements presented in this paper were undertaken to determine liquid phase composition and liquid saturated properties (density and viscosity) when a liquid hydrocarbon (*n*-decane, *n*-tetradecane, and their mixtures) was saturated with carbon dioxide. The generated data for compositions and densities were correlated with the Soave–Redlich–Kwong (SRK) and Peng–Robinson (PR) equations of state (EOS). The adjustment of binary interaction parameters and volume translation technique has been employed to correlate the experimental compositions and densities. The adjusted binary parameters from the data of binary pairs (carbon dioxide + *n*-decane) and (carbon dioxide + *n*-tetradecane) were used to correlate the generated ternary data. The calculated ternary compositions were found to be in good agreement with the experimental data using the binary parameters from the data of binary pairs for both EOSs. The results for the density of saturated liquid phase indicated that the volume translation should be applied to all components in the binary and ternary systems to describe accurately the saturated liquid densities for mixtures.

1. Introduction

Emission of greenhouse gases is one of the most environmental concerns in 21 century. Carbon dioxide is one of the popular greenhouse gases which is produced in large quantities by industry and its concentration has increased from around 280 parts per million (ppm) by volume in the 18th century to over 360 ppm by 1997 [1–3]. Therefore, the development of technique to reduce carbon dioxide level has been received high attention. Carbon dioxide sequestration, injection of carbon dioxide into depleted oil and gas reservoir or using carbon dioxide as injection solvent for enhance recovery methods are among the common technique which can be considered to reduce the amount of carbon dioxide in the atmosphere.

Gas injection is considered as an efficient method for oil recovery from the reservoir in oil industry; however, the injection of hydrocarbon gases is not practical due to limited availability and/or high cost. Carbon dioxide is readily available, cheap, non-toxic and non-flammable, making it a favoured solvent for use in recovery process. Thus, carbon dioxide can be considered as an alternative for hydrocarbon gases. The advantage of carbon dioxide compared to methane and nitrogen is its higher solubility and corresponding miscibility condition with oil at lower pressures. Accurate evaluation of any gas injection recovery technique requires the understanding of physical properties as well as the phase behavior properties of injected gas/oil system. However, the mixture of carbon dioxide and hydrocarbon exhibits complex phase-behavior.

Thermodynamic and transport property data for carbon dioxide/hydrocarbon mixtures are essential for obtaining binary interaction parameters for EOS modeling. The knowledge of carbon dioxide/hydrocarbon interactions is increasingly important for technical people in the industry to design, operate and develop carbon dioxide-based processes. This information will help to improve project performance and economics and lesser the environmental impact. However, there is a distinct lack of basic data and mechanistic knowledge relevant to the carbon dioxide/hydrocarbon systems.

Based on the above discussion, carbon dioxide is an important non-hydrocarbon component in chemical engineering and petroleum industry. Accurate predictions of equilibrium properties and physical properties of carbon dioxide/hydrocarbon mixture play a crucial role in chemical and petroleum engineering for process design and optimization. In addition, the experimental measurements made on chosen carbon dioxide/hydrocarbon mixtures can be used to evaluate EOS capability and finding the proper interaction parameters. The generated data can be used as basis

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