Experimental and Modelling Study of the Phase Equilibria of CO_2 + Crude Oil

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Crude oil is a complex mixture, making compositional analysis challenging. Furthermore, being largely opaque, visual observation of phase behavior is difficult. Consequently, experimental data on the phase behavior of compositionally-characterized real crude oil systems under CO_2 addition are scarce. In this work, we report on experimental phase behavior measurements of a crude oil under CO_2 addition. The experiments were performed in a synthetic apparatus designed to measure the phase behavior of CO_2 and hydrocarbon systems at high temperature and pressures. The apparatus consisted of a thermostatted variable-volume view cell into which oil and CO_2 could be injected quantitatively.

The crude oil, free of solution gas (dead oil) was found to have an API specific gravity of 31, its composition was studied by gas chromatography (GC), and the mean molar mass was obtained by freezing-point depression. Density measurements are reported for the dead oil at temperatures from (298 to 423) K and pressures up to 69 MPa. The phase behavior of both the dead oil and a live oil, prepared by the addition of light-hydrocarbon solution gas, has been studied under CO_2 addition at temperatures from (298 to 423) K and pressures up to about 40 MPa. Measurements of bubble pressures and vapor-liquid-liquid equilibria are reported as a function of CO_2 mass fraction.

In order to model the crude oil with an equation of state, the GC data were interpreted to obtain a set of 20 pseudo-components, each characterized by molar mass, acentric factor, and critical temperature and pressure. The Peng-Robinson equation of state (PR-EoS), with temperature-independent binary interaction parameters, was used to compute the bubble curves under the experimental conditions. The PR-EoS model predicts results that are in fair agreement with experiment but deviations are observed to increase with the addition of either solution gas or CO_2.

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