Modelling and Measurements of Viscosity and Volumetric Behaviour of Mixtures of Heavy Hydrocarbon + CO_2 at High Pressures.

Mohamed E. Kandil [C, S]
Centre for Petroleum and Minerals, King Fahd University for Petroleum and Minerals, Dhahran, Saudi Arabia
mkandil@kfupm.edu.sa

Nayef Al-Saifi
Department of Chemical Engineering, King Fahd University for Petroleum and Minerals, Dhahran, Saudi Arabia

Saifur Rahman
Centre for Petroleum and Minerals, King Fahd University for Petroleum and Minerals, Dhahran, Saudi Arabia

Abdullah Sultan
Department of Petroleum Engineering, King Fahd University for Petroleum and Minerals, Dhahran, Saudi Arabia

The investment in the petroleum industry in projects involving CO_2 is increasing while the impact of CO_2 on global economy is rising steeply. CO_2 is becoming widely used for heavier oil production but the mechanism by which the hydrocarbon rich phase is displaced is not fully understood especially in the miscible and near miscible regimes. Accurate data on viscosity and phase behaviour of mixtures containing hydrocarbons and CO_2 are necessary not only for upstream recovery and production but also for midstream oil and gas pipelines and transport networks and also for downstream separation and chemical process plants including coal bed methane and Natural gas plants where CO_2 co-exists in high proportions. CO_2 is highly soluble in most hydrocarbons at low and moderate pressures where viscosity, and density of the mixture decrease and volume swelling is observed. At high pressure range, density crossover can occur due to the dramatic increase in the density of CO_2 with pressure. For example, at 100 °C, when pressure increases from 2000 to 8000 psi, density of n-decane only increases from 680 to 720 kg/m^3 while the density of CO_2 significantly increases from 290 to 850 kg/ m^3, crossing over the hydrocarbon density. In such a complex volumetric behaviour a second liquid CO_2-rich phase can also exist. Viscosity of the hydrocarbon is also reduced when mixed with CO_2 and also depends, to a great extent, on pressure. In this work we report measurements on viscosity and volumetric properties for binary mixtures of CO_2 + heavy n-alkanes including isothermal compressibility, mass density, bubble points at temperatures from (313 to 410) K and pressures up to 76 MPa (11000 psi). Our data are compared with the predictions of both theoretically-based equation of state SAFT and PR cubic eos commonly used in software simulators. Excess volume calculations for this mixture are also presented. The accuracy of experimental data and challenges with the experimental technique are also discussed.