

Application of Regular Solution approach to asphaltene precipitation from a live oil

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To date, regular solution theory has been adapted to model asphaltene precipitation from diluted heavy oils and bitumens (1). Live oil precipitation data have also been fitted using solubility parameters determined from measured refractive indices (2). In the former, a composition changes caused the phase instability while in the latter, a change in the density of the fluid is responsible. The objective of the work is to determine if a common characterization methodology based on regular solution theory can be developed to model both mechanisms.

The bubble point, onset pressure for asphaltene precipitation, and the asphaltene yield near the bubble point were measured for a recombined Gulf of Mexico oil with 2.2 wt% asphaltene content. The asphaltene yield from the dead oil diluted with n-heptane was also measured at ambient conditions.

The live, flashed, and dead oils were characterized based on GC analysis and SARA analysis. A merged analysis was created to make use of the available SARA properties for a C16+ equivalent fraction. Densities and solubility parameters were required for the fractions below C16.

Effective densities were used rather than pure component densities. Effective density is the density of the component when it is part of a liquid mixture. The advantage of using effective liquid densities is that, by definition, there is no volume change with mixing, consistent with the regular solution approach. The effective densities of C5+ fractions were assumed to be identical to the pure component densities. The effective densities of the lower carbon number hydrocarbons were determined from extrapolations of density versus molecular weight (MW) of the n-alkane series.

Solubility parameters of the pure components at 25°C were taken from the literature. The effect of temperature and pressure were accounted for as follows:

$$\delta = \delta_{25^\circ\text{C}} \left(\frac{v_{25^\circ\text{C}}}{v} \right)^{1/2} - 0.0232(T - 298.15) \quad (1)$$

where δ is the solubility parameter, v is the molar volume, T is temperature, and 25°C indicates the property is at 25°C.

The proposed characterization was then applied with a previously developed regular solution model (1). The only unknown was the average MW of the asphaltene nano-aggregates in the oil, which is a function of temperature. The MW was therefore used as a fitting parameter.

The effective density approach predicted the densities from 80 to 120°C and pressures from 10 to 100 MPa to within the estimated error of the data. Figure 1 shows the measured and modeled onsets of precipitation for the live oils. The nano-aggregate average MW used to fit the data ranged from 2900 to 2620 g/mol from 80 to 120°C, respectively.

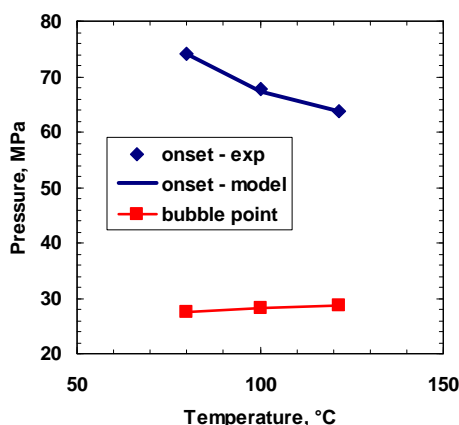


Fig. 1. Experimental and modeled onset of asphaltene precipitation for a live Gulf of Mexico crude oil.

The MW used to fit the dead oil data was 2930 g/mol. The results indicate that a common characterization can be used to model both solvent and pressure induced precipitation. However, the pressure induced precipitation is very sensitive to the average aggregate MW. Therefore, the predictive capability of this approach is limited.

References

- [1] Akbarzadeh, K., Alboudwarej, H., Svrcek, W.Y., Yarranton, H.W., (2005) Fluid Phase Equil, 232, 159.
- [2] Buckley, J.S., Hirasaki, G.J., Liu, Y., Von Drasek, S., Wang, J.-X., Gill, B.S., (1998) Petr. Sci. Technol. 16, 251.