Determination of partial solubility parameters and improvement of Flory-Huggins based models for studying asphaltene stability in crude oils

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Rapid and accurate prediction of asphaltene stability in crude oil systems is a key element in flow assurance. Although multiple models have been proposed for modeling asphaltene stability, the complexity of the problem and the lack of data constitute challenges in determining a universal model to be implemented for different crude oil systems under a wide range of operating conditions. Many of these models are based on the Flory-Huggins theory that uses the Hildebrand solubility parameters as a measurement of the miscibility of asphaltenes in oil. Flory-Huggins based models are simple to implement, however sometimes these models fail to reproduce experimental or field observations because the compressibility effects are not explicitly considered.

To overcome this problem, authors have used equations of state or combination of Flory-Huggins based models and equations of state in order to account for compresibility effects. An example of the latter is the ASIST method developed by Wang and Buckley [1].

In this work a new approach based on partial solubility parameters of mixtures containing asphaltenes is proposed.

The experimental determinations based on refractive index measurements are presented and discussed. The validation of a new mixing rule [2], averaging cohesive energy density and not solubility parameter, is also presented.

This approach is effective not only to study the precipitation tendency of asphaltenes in dead oils but also to analyze the effect of gases such as methane, nitrogen and CO_2. Values of Hildebrand solubility parameters of gases reported in the literature are revised.

The objective of this work is not only to offer an improvement of the Flory-Huggins based models to study asphaltene stability but also to provide a new experimental protocol for characterizing the different constituents of oil, ranging from heavy components to gases.

References

[1] Wang, J.X., Buckley, J.S. (2001) Energy Fuels. 15, 1004-1012.
[2] Vargas F.M. et al. (2009) Energy Fuels. 23, 1147-1154.