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Asphaltene Precipitation, Aggregation and Deposition

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Asphaltene are heavy and aromatic crude oil components that precipitate and deposit on pipeline walls during production. Assessing risk of asphaltene deposition in a production facility is a crucial step when designing a new facility. Risk assessment at production condition, i.e., high pressure and temperature, are cost prohibitive, leading oil companies to use model systems to assess asphaltene deposition risks for given oil. The most common method to study asphaltene precipitation and deposition in the laboratory is by adding n-alkanes to crude oils at room temperature and room pressure. When n-alkane, such as heptane, is added to crude oil, asphaltenes precipitate and undergo an aggregation process. Using state-of-the art microscopy, centrifugation, and scattering techniques the aggregation kinetics of asphaltenes was investigated. It was observed that upon heptane addition oil, asphaltene experience an increase in their fractal dimension as they precipitate and undergo a reaction-limited aggregation process. A geometric form of the population balance was used to model the asphaltene aggregation data obtained by time-resolved centrifugation, indicating that for every 1 million collisions between asphaltenes suspended in the oil-heptane mixture, 1 collision will result in aggregation. In turn, the experimental results of time-resolved microscopy have shown that there is no such thing as a onset volume of asphaltene precipitation. If heptane is added to oil as concentration below the so-called onset volume, if one waits for long enough precipitation will be detected under optical microscopy. The long time for detecting asphaltene precipitation is due to the slow aggregation process due to a low collision efficiency. By postulating a relationship between the collision efficiency and the difference in solubility parameter of asphaltenes and oil-heptane mixture, a universal aggregation line for asphaltenes was obtained. The universality of the aggregation model was demonstrated by testing over 50 different crude oils and model oils and showing that they matched the aggregation line.

The asphaltene deposition was also studied using capillary and packed bed apparatus. Experimental results of asphaltene deposition rate show that for nanometer-sized asphaltenes at low Reynolds flow, the rate by which asphaltenes deposit is dictate by the diffusion time of asphaltenes nanoparticles from the bulk to the depositing surface. These findings provide solid ground for modeling asphaltene deposition in pipelines and predicting asphaltene deposition risk in a new facility based on lab-scale experiment and parameter estimations. The packed bed asphaltene deposition apparatus has also been used to evaluate performance of chemicals that are commercialized to alleviate asphaltene deposition in oil fields.

Biography:

H. Scott Fogler is the Ame and Catherine Vennema Professor of Chemical Engineering and the Arthur F. Thurnau Professor at the University of Michigan in Ann Arbor and was the 2009 National President of the American Institute of Chemical Engineers. He received his B.S. from the University of Illinois and his M.S. and Ph.D. from the University of Colorado. Scott recently received a doctor honoris causa degree from the Universitat Rovira i Virgili, Tarragona, Spain. He is the author of the Elements of Chemical Reaction Engineering and Essentials of Chemical Reaction Engineering which are the dominant books in this area worldwide. Scott has graduated 45 PhDs and they have published over 240 research articles and 12 books, in areas such as acidization of petroleum wells, gelation kinetics wax deposition in subsea pipelines and asphaltene flocculation and deposition kinetics. Scott is an associate editor of Energy & Fuels.