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Measurement of property relationships of nano-structure micelles and coacervates of asphaltene in a pure solvent

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Abstract

We have made some progress in studies towards formation and measurement of the behavior of asphaltene micelles nano-structures that might be formed to serve as elements of nano-materials and also on synthetic strategies for creating such structures. An investigation of the micellization and coacervation measurements of asphaltenes in polar solvents at various concentrations and temperatures are made. The critical micellization concentration (CMC) and the micelle coacervation point (MCP) of nano-structure asphaltene micelles are measured using viscometry. At concentration above the CMC, asphaltene in the solution will self-associate, saturation phase will be formed and then at a higher concentration asphaltene nano-structure micelles in the solution will coacervate represented by a second sharp point of inflection corresponding to the asphaltene MCP and finally, at a higher concentration the aggregation of asphaltenes coacervates will occur.

As a result of these measurements, for the first time it has become possible to produce phase diagrams for the whole range of asphaltene micellization and micelle coacervation.

Keywords: Coacervates of asphaltene; Nanostructure micelles; Property relationship; Solvent; Measurement

1. Introduction

Asphaltene, resin, wax, etc. are heavy organic compounds which may exist in petroleum, heavy oil, tar sand, etc. in different quantities. Such compounds could precipitate out of petroleum fluids due to various forces causing fouling in the oil reservoir, in the well, in the pipeline and in the oil production and processing facilities. During refining of petroleum heavy organic compounds, including asphaltene, other heterocyclic compounds, heavy hydrocarbons and non-volatile products will remain in the bottom of the refinery's fractionation column as a very complex mixture known as "resid" (Yen & Chilingarian, 1994). Our group is investigating unusual behavior of asphaltene molecules in petroleum fluids and in model systems that use pure solvents and well-characterized asphaltene molecules. Our interest in these molecules was originally stimulated by a desire to characterize their various phase transitions. These molecules are found to be the basic reason for fouling in the flow of petroleum fluids. The focus of the work on these unusual molecules is to characterize their structure, dynamics and thermodynamics, and to establish the relationship between these properties and petroleum fluid behavior. Asphaltene particles are believed to exist in petroleum partly dissolved and partly in steric-colloidal and/or micellar forms depending on the polarity of their oil medium and presence of other compounds in oil. In the last few years, the precipitation, flocculation and deposition of these molecules have been characterized and analyzed (Kawanaka, Leontaritis, Park, & Mansoori, 1989, Chapter 24; Mansoori, 1999).

A steric colloid is formed when a large non-soluble particle (asphaltene) is stabilized in the solution by adsorption of grafted polymers (resin) on its surface. The layer(s) of resin on large asphaltene particles will then repel each other if they are in a "good" solvent and this overcomes the van der Waals attraction so that the asphaltene particles will not aggregate. A micelle consist of a reversible assembly of molecules such as surfactants (asphaltene) that assemble together in a solution. Micellization is a phenomenon originally observed due

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