The Role of Precipitation Environment on Asphaltene Physicochemical Properties

Grace K. M. Flozino[1], Ivanei F. Pinheiro[2], Lina M. Daza-Barranco[2], Talitha O. de Godoy[1], Paulo T. V. e Rosa[1]

[1]Univeridade Estadual de Campinas, Institute of Chemistry, Campinas, São Paulo, Brazil , [2]Univeridade Estadual de Campinas, Centro de Estudos de Energia e Petróleo, Campinas, São Paulo, Brazil

prosaiqm@unicamp.br

Asphaltene precipitation poses a significant challenge in deep-water offshore production [1], particularly within the complex thermodynamic environments of pre-salt reservoirs. Standard methods (e.g., ASTM D6560) typically characterize asphaltenes under atmospheric reflux, which may not accurately reflect the fractional selectivity of the precipitating medium. Variations in pressure and temperature during extraction can alter the purity and the physicochemical nature of the resulting solids, especially regarding the co-precipitation of waxes. This study investigates the impact of the precipitation environment by comparing asphaltenes obtained by two methods using n-pentane: a standard condition (AC51: 1 bar, 40 °C) and a pressurized condition (AC55: 5 bar, 60 °C). The resulting fractions were characterized using Gel Permeation Chromatography (GPC), Differential Scanning Calorimetry (DSC), and Fourier-transform Infrared Spectroscopy (FTIR). Colloidal stability was assessed through the Asphaltene Solubility Class Index (ASCI) using n-heptane/toluene mixtures (0 to 100%, in 5% increments), complemented by optical microscopy of the critical precipitation tubes. Distinct morphological differences were observed: AC51 exhibited a wet and easily agglomerated appearance, whereas AC55 appeared glassy and dry, resembling thin foils. DSC analysis revealed a significant peak around 90 °C for AC51 (both in crystallization and melting curves), likely associated with co-precipitated crystalline waxes [2]. In contrast, AC55 showed no such peaks, suggesting the pressurized extraction yielded a higher-purity asphaltene fraction. GPC analysis yielded similar molecular weights for both samples (2455 g/mol for AC51 and 2582 g/mol for AC55). While these values exceed those reported by the Mullins model (600–800 g/mol) [1], they remain within the ranges found in broader literature [3]. FTIR spectra revealed a distinct band at 3400 cm^{-1} in AC55, attributed to -OH groups, indicating higher polarity compared to AC51. Regarding stability, the ASCI for AC51 could not be determined as no visible precipitation occurred even at 100% n-heptane. This enhanced stability is likely due to the presence of co-precipitated waxes, as identified by DSC, which may act as stabilizers in solution. Conversely, AC55 exhibited an ASCI of 14 (70% n-heptane), confirming its instability. Optical microscopy confirmed that while AC51 contained dispersed aggregates not visible to the naked eye, AC55 showed significant agglomeration starting at 65% n-heptane, preceding the visible precipitation tube. The results demonstrate that the precipitation environment significantly changes asphaltene purity and stability. Moderate pressure and temperature effectively minimized wax contamination, resulting in a more polar and unstable asphaltene fraction, probably providing a more accurate representation of the solids' behavior in pressurized production systems.

Keywords:
Colloidal stability, Aggregation, Asphaltene.

References:

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