

## Asphaltene and wax precipitation – Common principles of structuring

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Solid deposition during production, transport, and storage of crude oils leads to significant technical problems and economic losses for the oil and gas industry. The thermodynamic equilibrium between high-molecular-weight components of crude oil, such as asphaltenes, resins, and waxes, is an important parameter for the stability of crude oil. Once the equilibrium is disturbed due to variations in temperature, pressure, and oil composition during production, the solubility of high-molecular-weight waxes decreases.

Asphaltenes are a complex mixture of different molecules with similar chemical characteristics which are insoluble in aliphatic solvents (e.g. heptane) but soluble in aromatic ones (e.g. toluene). Asphaltenes are heavy and highly polar molecules found in crude oil, which contain polycondensation aromatic sheets and aliphatic chains along with various polar functional groups such as pyridine, pyrrole, hydroxyl, sulfoxide, carboxyl, and carbonyl. Asphaltene aggregation and deposition may lead to wettability change in the rock surfaces toward oil-wet, the formation of water in oil emulsion, formation damage, and plugging of the pipelines. Asphaltenes precipitate and aggregate in crude oils as a result of alterations in the pressure and temperature or composition, such as a normal alkane when mixed with crude oil. Generally, asphaltenes are described as the fraction of crude oil that is soluble in aromatic compounds (e.g., toluene or xylene) but insoluble in low-molecular-weight n-paraffins (e.g., n-pentane, n-hexane, or n-heptane). The role of asphaltenes during wax crystallization has not yet been well understood. The influence of asphaltenes has been explained contradictorily. Some researchers noted no significant interactions between wax and asphaltenes, but that asphaltenes may result in smaller interspersed wax crystals. However, being also known as the ‘cholesterol’ of crude oil, they precipitate, adhere to surfaces and, in the worst cases, cause costly pipe blockages and alter the wetting characteristics of mineral surfaces within the reservoir, hindering oil recovery efficiency. The role of asphaltenes during wax crystallization has not yet been well understood. The influence of asphaltenes has been explained contradictorily. Some researchers noted no significant interactions between wax and asphaltenes, but

that asphaltenes may result in smaller interspersed wax crystals. Similar effects are also observed with respect to waxes. Even at very low concentrations in ‘good’ solvents, both still have a strong tendency to form nanoaggregates or nano crystallites which transfer to micro- and macroaggregates whose structure and formation remain largely unknown despite much research. Aggregation proceeds from specific strong interaction sites located at the periphery of the asphaltene molecules. They drive the reversible association in two-dimensional sheets, a morphology which is consistent with reported scattering and viscosity data. Precipitation eventually occurs, determined by van der Waals attractions between aggregates, when the solubility parameter of the solvent is shifted. In our current research, we have focused on the several steps to tackle this problem which can heavily impact the economic value of a project, especially in harsh sub-sea environments, where deposition can halt production altogether. For example, intervention costs for asphaltene removal for a land-based well up to \$0.5 MM US translates to more than \$3 MM US for off-shore well production, and the economic loss as a result of lost/delayed production can amount to \$1.2 MM US per day. The ability to predict the occurrence and magnitude of asphaltene deposition in wellbores is critical to forecast the related flow assurance challenges for deep and ultra-deep water production. We therefore have the goal to find a solution (chemical, mechanical or otherwise) namely to: a) Understand the issues and help characterize the problem, b) Prevent or inhibit deposition (asphaltene alone or in combination with calcite) that interferes with production flow, and c) Manage or remediate deposits.