# INVESTIGATION OF DISPERSING AGENT IMPACT ON ASPHALTENE AGGREGATION IN MODELING SYSTEM

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Currently, there exists one significant problem during petroleum production and transportation - asphalt, resin, paraffin substances (ARPS) settling which increases the hydraulic friction and affects pumping equipment. Moreover, ARPS settling could cause oil gathering & processing system efficiency failure. These facts indicate the necessity to investigate the formation conditions of ARPS settlings and to define those methods which would prevent settling. Although there are numerous methods in preventing asphalt, resin, paraffin substances settling (chemical, physical, thermal etc.), the most effective method is the chemical method including application of agents in oil & gas production field.

The investigation objective is to study the effect of dispersing agents on asphaltene aggregation in modeling system by photon correlation spectroscopy.

Photon correlation spectroscopy (PCS) is a technique based on light scattering that can be used to determine the size of nano- and/or submicron dispersed particles. This method measures the diffusion coefficient of dispersed particles in a fluid. Spatial correlation function of scattered light irradiance fluctuations includes particle diffusion coefficient data. If the particle shapes are known and/or given, there size could be calculated by the relevant formula. For example, spherical particles could be calculated by Stokes-Einstein formula (1) [2]:

$$R = \frac{k_B \cdot T}{6 \cdot \pi \cdot \mu \cdot D} \qquad (1)$$

where, $k_B$ – Boltzmann constant, $T$ – absolute temperature, $\mu$ – environmental shearing viscosity, with suspended particle radius $R$, $D$ – diffusion coefficient.

Investigation target is asphaltene, extracted from highly viscous oil. Asphaltene aggregation was studied on the basis of asphaltenes-toluol-heptane model, where toluol solvent was used. Apshaltene concentration was 0.4 gr/l in toluol. Asphaltene aggregation initiation requires different n-heptane concentration feed. The maximum n-heptane concentration was 33% of bulk mixture volume. Alkenylsuccinimide agent C-5A was used as dispersing agent. Before aggregation all obtained solutions was exposed to dispersion in ultrasound bath for 15 seconds to intimately mix all components.

To measure asphaltene associate sizes and to trace the aggregation process itself, PhotoCor Complex system was used. Diffused laser with wave-length of λ =654 nm was applied in this unit. Light scattering was observed at a 40° angle. All experiments were conducted at 27 °C. To exclude the thermal lens effect neutral filters were matched for each experiment separately and were installed on laser radiation optical path [3]. Measurements were conducted only in the case when sedimentation is not prevalent to diffusion.

Results of asphaltene aggregation by adding different n-heptane volumes investigation are depicted in Figure 1. Experimentally obtained block curves by ordinary least squares (OLS) to power-law according to limited diffusion aggregation (LDA) [1].

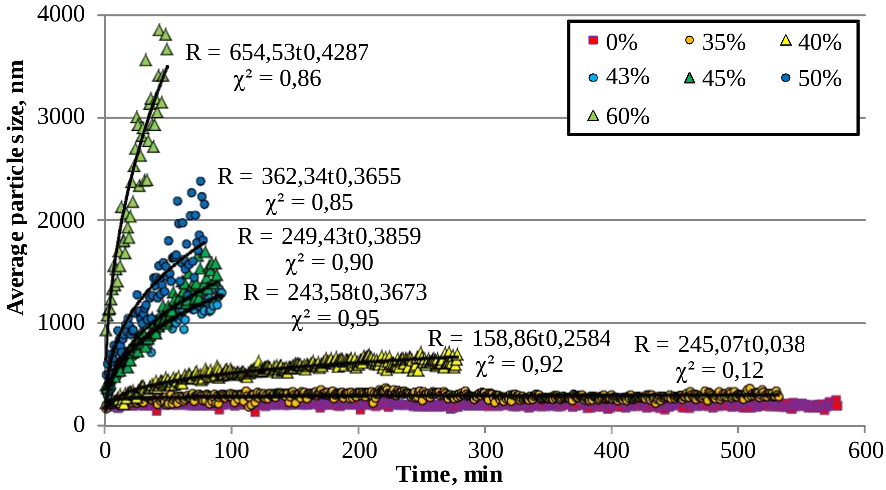


***Fig. 1. Asphaltene aggregation by adding different n-heptane volumes (% of bulk mixture volume)***

According to Figure 1, asphaltene particles in toluol, excluding n-heptane addition, are colloido-dispersion (average particle radius R – about 250 nm). In most cases asphaltene aggregation in modeling system could be described by power-law (accurate approximation $\chi^2$=0.12), which, in its turn, indicates asphaltene LDA. The only exception could be if n-heptane concentration is 35%, then LDA is not applicable in aggregation ($\chi^2$=0.12). Such a behavior could be explained by the fact that n-heptane concentration value is nearly to maximum (33% of bulk mixture volume) would result in slow asphaltene aggregation, because of the inadequate amount of n-heptane in modeling system. Rapid asphaltene aggregation is also hindered by large-sized asphaltene particles in initial toluol solution, which prevents coagulation during particle collisions.

Asphaltene resistance to sedimentation is estimated to initial sedimentation time when asphaltene particles settle (table 1).

*Table 1*

***Asphaltene resistance to sedimentation in modeling system***

| n-heptane concentration, % of bulk mixture volume | Initial sedimentation time, min |
|---|---|
| 0 | – |
| 35 | 532 |
| 40 | 280 |
| 43 | 93 |
| 45 | 89 |
| 50 | 79 |
| 60 | 51 |

As seen in Table 1, increasing n-heptane addition furthers aggregation rate, resulting in early asphaltene particle settling.

Figure 2 shows the results of asphaltene aggregation in initial solution and after the addition of different dispersing agent concentrations. To examine the influence of agent concentration in asphaltene aggregation, the amount of n-heptane was 43% of bulk mixture volume in all experiments.

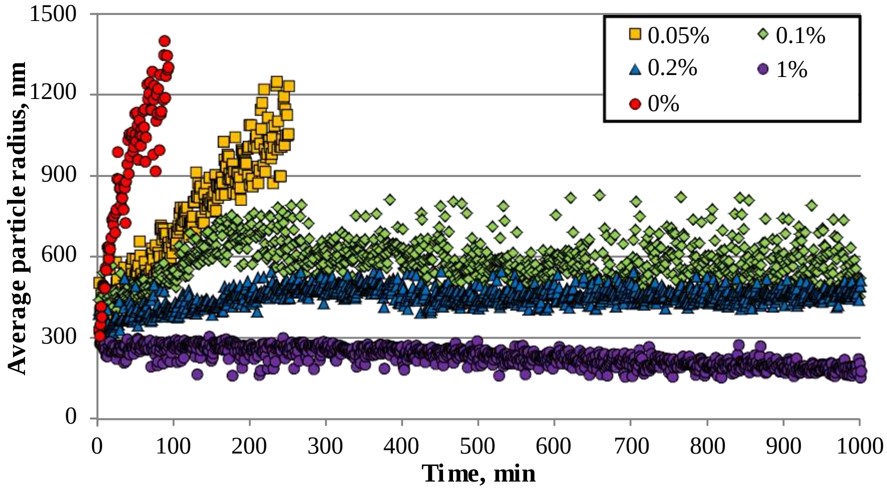


***Fig. 2. Asphaltene aggregation in initial solution and after the addition of different dispersing agent concentrations (% of bulk mixture volume)***

As seen in Figure 2, agent addition results in aggregation rate decrease, while adding >1% C-5A agent stabilizes asphaltene particle sizes throughout the whole experiment. Asphaltene resistance to aggregation when adding agents is estimated by the average particle radius during the experiment (Table 2).

*Table 2*

***Asphaltene resistance to aggregation in modeling system when adding C-5A agent***

| Agent concentration, % of bulk mixture volume | Initial sedimentation time, min | Average particle radius, nm |
|---|---|---|
| 0 | 93 | aggregation |
| 0.05 | 234 | aggregation |
| 0.1 | – | 560 |
| 0.2 | – | 475 |
| 1 | – | 230 |

Experimental results showed that increasing C-5A agent concentration up to 0.1% of bulk mixture volume decreases asphaltene aggregation rate. However, in this case asphaltene settling it not eliminated from modeling solution. Further agent concentration increase to 1% leads to asphaltene resistance to sedimentation, and decreases average asphaltene particle radius in the modeling system during the experiment. This fact proves the existing of dispersion properties of C-5A agent.

## References

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