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STUDY OF ASPHALTENE FLOCCULATION USING PARTICLE COUNTING METHOD

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ABSTRACT

Asphaltenes are a class of crude oil components. These components can flocculate upon a change in temperature, pressure or composition. On the other hand, asphaltene precipitation during production, transportation and storage of petroleum fluids is a common problem faced by the oil industry throughout the world. In this work a new accurate and simple method for onset study of asphaltene flocculation is introduced. This method has been successfully used for cloud point measurements of polymer solutions by the authors and in this work it is developed for study of asphaltene flocculation. The basis of this method is determining the number of particles in a mixture and study of its changes by temperature changing.

KEYWORDS

Asphaltene, Coagolation, precipitation, Particle Counting, Particle Measurement, Crude Oil

Introduction:

Asphaltenes are a class of crude oil components. These components can flocculate upon a change in temperature, pressure or composition. On the other hand, asphaltene precipitation during production, transportation and storage of petroleum fluids is a common problem faced by the oil industry throughout the world. Through complex phase transformations, dissolved and suspended solids (asphaltenes, resins, paraffin/wax, formation solids, etc) precipitate out of solution. Such phase segregations are sometimes followed by flocculation of the resulting precipitates. In many instances, these deposition phenomena render in complete clogging of flow lines and serious damages to storage vessels and processing equipment.

One major question of interest in the oil industry is ***when*** asphaltenes will flocculate under certain operating conditions. Actually, understanding the mechanism of the asphaltene deposition would result in more economical, environmentally sounder and speeder oil production, transportation and processing technologies. There are several methods for determining the onset of asphaltene flocculation [1-3] which may vary in their degrees of accuracy and difficulty. In this work we introduce a new accurate and simple method for onset study of asphaltene flocculation. This method has been successfully used for cloud point measurements of polymer solutions by the authors [4]. The basis of this method for cloud point measuring is determining the number of particles in a mixture. Namely, when a new phase appears in a solution, this phase arise as a large number of small particles. At this time, the solution becomes cloudy due to the scattering of the light beam passing through the solution. So, if the number of particles in a solution is measured at various temperatures, it is expected that at the temperature where a new phase appear, a sudden change in number of particles would be observed and this temperature indicates the cloud point for the solution. One of the results for cloud point measurement of a polymer solution ($PEG3350+H_2O+NaH_2PO_4$) is shown in figure **1**. According to this figure, on increasing the temperature of the solution from 54 to 55°C, the number of particles is constant, but at 55.1°C, a sharp increase is observed which is due to appearance of first particles for formation of a new phase. Therefore, 55.1°C is recorded as the cloud point of the mixture. We decided to apply this method for determining the onset of asphaltene flocculation in crude oils at various temperatures.

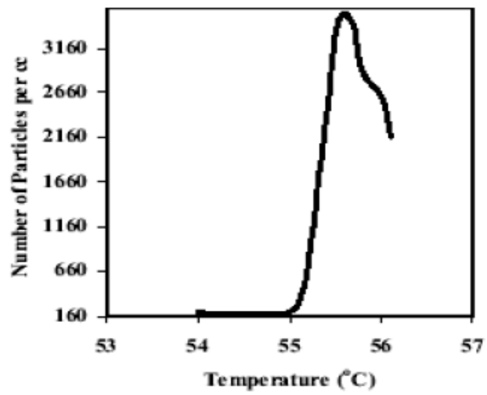

Figure 1 . Number of particles versus temperature for a mixture of PEG3350+H_2O+NaH_2PO_4
((PEG%)$_{\text{without salt}}$ =10.05, salt%=11.06)
Threshold=41

Apparatus and procedures:

Figure 2 shows the diagram for the experimental system. A laser particle counter (Spectrex Corporation, Model PC-2000, United States), was used for particle counting. The basis light source of the laser particle counter is a laser diode (wave length 670.8 nm). The beam from this laser is spatially filtered and focused by a lens assembly to form a small and well defined illuminated volume with in the liquid being inspected. A scanning mechanism provides a circular displacement of this illuminated volume at a constant rate of speed. As the illuminated volume moves across a particle suspended in the liquid, some light from the beam will be scattered. Much of this scattered light is in the near forward direction and is collected by the optical system of photodetector assembly. The flash of light striking the photodetector will cause an electrical pulse in the preamplifier connected to the photodetector. The amplitude and width of this pulse is a function of the size and number of the particles. The samples compartment consist of a flow cell where crude oil was pumped by a pump to it from storage vessel kept at constant temperature water bath system. The temperature of the crude oil was recorded at the entrance of the cell by a thermocouple. The precision and readability of the thermocouple was $\pm 0.1°C$ and $\pm 0.2°C$, respectively. The required time for determining the number of particles was 15 seconds. Therefore, the temperature of the water bath was changed and controlled by a thermostate with an appropriate rate to maintain the required temperature at the flow cell. At each temperature, the out put of the apparatus has been sent to a PC and finally the number of particles per cubic centimeter will be recorded by a printer.

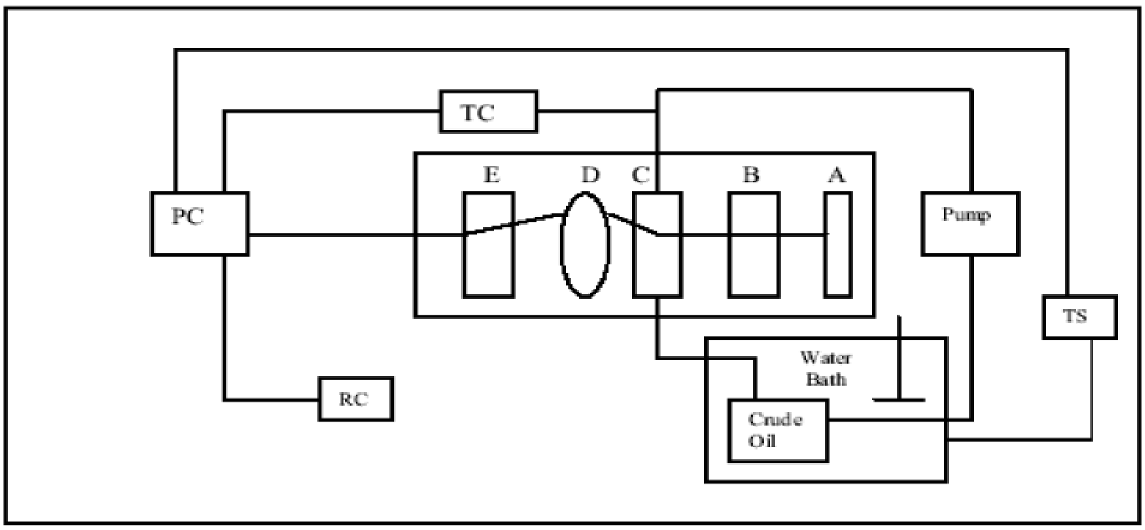

Figure 2. Shematic diagram of the apparatus used in this work for determining of onset of crude oil. PC: personal computer TC: thermocouple TS: thermostate RC: recorder A: laser diode B: scanner C: flow cell D: detector lens E: photo detector

Results

Figures 3 and 5 show the changes of number of asphalten particles for two different crude oil samples which are considered in this work. Figure 3 shows a sudden increase in number of particles at 33°C. This temperature shows the beginning of asphalten flocculation. Figure 4 shows the behavior of asphaltene flocculation at a wide range of temperature. According to this figure, the number of particles is nearly constant at temperatures higher than 45°C, but at 35°C the number of particles begins to a sudden increasing and finally, it remains constant at below 13°C.

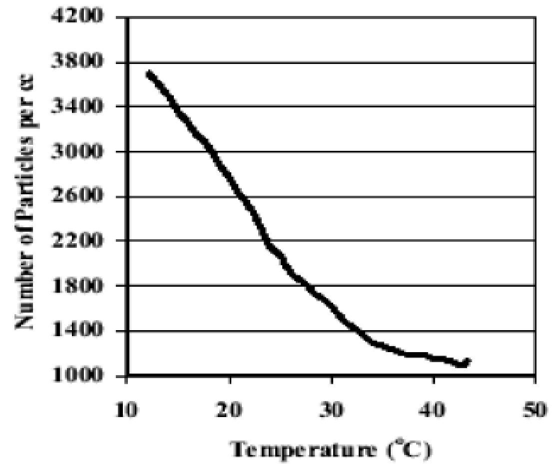

Figure 3. Number of particles versus temperature temperature for crude oil (sample 1)

Threshold=3

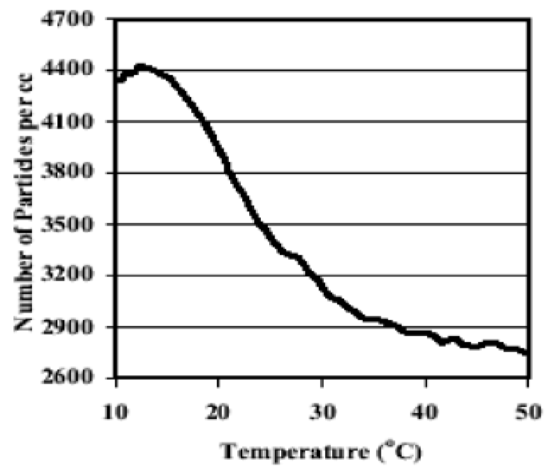

Figure 4. Number of particles versus temperature for crude oil (sample 2)

Threshold=3

Figure 5, shows the variation of the number of particles of a crude oil sample versus temperature. According to this figure a sharp change on number of particles observe at 25°C.

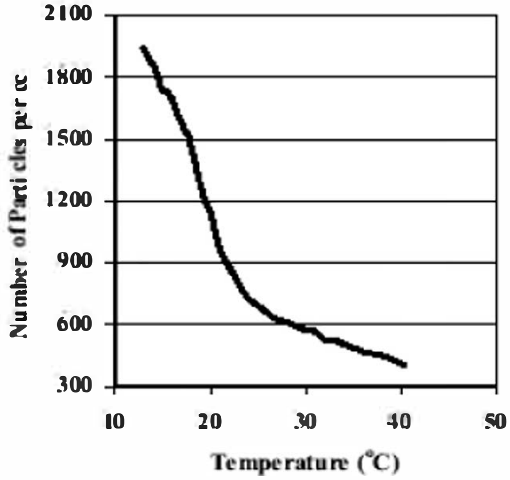

Figure 5. Number of particles versus temperature for crude oil (sample 3)

Threshold=3

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