Study of the influences of fine particles on thermal property of heavy crude oil by using TG-DTA analysis

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1. Introduction

Geologically, most of heavy oil and extra heavy oil reservoirs are shallow and less consolidated with weak cementation, compared to medium and light oil reservoirs. [1] This can cause fine particles of loose solids materials, called formation fines, to migrate. On top of this, thermal recovery, a common recovery method for heavy oil, where heat is introduced to the reservoir formation, helps further provoke this migration by the dissolving the cementation. The dissolved fine particles the formation rock can thereafter mix up with the reservoir crude oil. This causes an alteration of physico-chemical properties of the stranded oil. [2]

This lead to the movitivation behind this reseach; to study the influences of these fine particles that have the possibility to have direct contact with crude oil via dissolution during thermal process on the crude oil.

2. Experimental

In this study, a dead Japanese heavy oil, HO, was used for the experiments. HO has a density of 0.955 g/cm^3 (measured at 15°C), a viscosity of 50 cP (measured at 30 °C) and an API of 16.6°. Silica oxide (SiO_2) and alumina oxide (Al_2O_3) were modeled as fine particles.

The weights of oil and NPs were weighed accordingly to achieve the desired weight percent. The oil was later mixed with nanoparticles using a homogenizer (AS ONE Homogenizer AHG-160A Series).

Thermo-gravimetric and Differential Thermal analysis (TG/DTA) were performed to observe effect of NPs on crude oil at elevated temperatures. At the same time, Derivative Thermogravimetry (DTG) can also be derived. TG/DTA7300 (Hitachi EXSTAR7000 Series) was used in this analysis. The temperature changes in the oven from room temperature to 300 °C under inert nitrogen atmosphere at constant heating rate of 15 °C/minute.

3. Result and Discussion

3.1. TG/DTA of OH and various HO-NPs mixtures

TG/DTA analyses were carried out for blank heavy and HO-NPs mixtures including SiO_2 and Al_2O_3 with concentration of 0.1 wt.%. From Fig.1, among all the samples, HO-SiO_2 mixture exhibited both the highest decomposition and differential temperature and the earliest decomposition rate. The plausible reason behind this alteration could be attributed to the bonding between SiO_2 and the heavy fractions of crude oil (asphaltene and/or resins), leaving the lighter fractions more exposed and susceptible to the heat. [3]

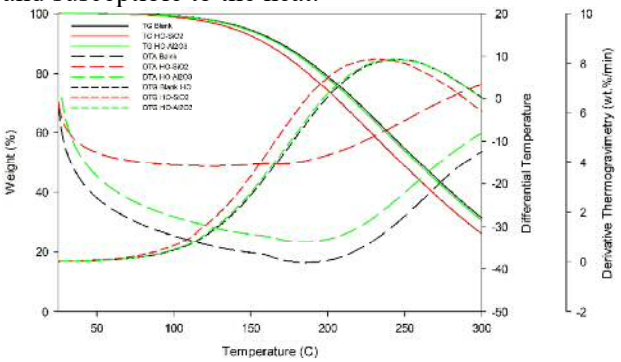

Fig. 1 TG/DTA curves of HO and various HO-NPs

3.2. TG/DTA of Blank HO and HO-SiO2 Mixtures

The concentrations of SiO_2 in oil mixture were varied for further insights. The concentrations were 0.1, 0.25, 0.5 and 1.0 wt.%. From Fig. 2, HO-SiO_2 mixture with the concentration from 0.1 up to 0.5 wt.% showed that the decomposition temperatures kept decreasing. However, the number bounced back as the concentration of SiO_2-NP hit 1.0 wt.%. From 0.5 to 1.0 wt.%, decomposition temperature advanced back. This change can be attributed to the fact that the amount of SiO_2-NP became excessive in crude oil and the fact that SiO_2 has higher tolerance to heat.

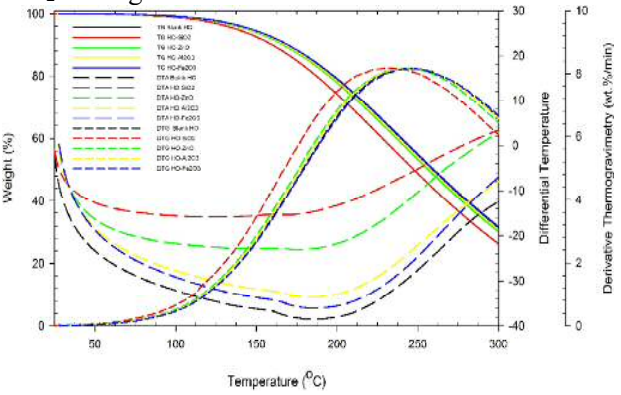

Fig. 2 TG/DTA curves of blank HO and various HO-SiO_2 mixtures with different concentration

1) Gruesbeck C, Collins RE. 1982. *Soc. Pet. Eng. J.* 22:847–56
2) Patel H, Shah S, Ahmed R, Ucan S. 2018. *J. Pet. Sci. Eng.* 167:819–28
3) Hashemi R, Nassar NN, Pereira Almao P. 2014. *Appl. Energy* 133: 374-387

