Conversion of resins and asphaltenes under thermo-catalytic influence of magnetite at 200°C

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Abstract. This paper discusses the influence of magnetite on conversion of Ashal’cha heavy oil under the temperature of 200°C. The role of catalyst in in-situ upgrading of heavy oil is directed on the content reduction of high-molecular components such as resins and asphaltenes, as well as their molecular masses. The significant increase (10%) in the content of aromatic fraction and decrease in high-molecular hydrocarbons (8%) is observed. The results of measurements indicate the positive influence of catalyst on the rheology. Magnetite participates in destruction of associated complexes in resins and thereby decreases the viscosity of crude oil. The destruction products increase the content of light hydrocarbons, particularly saturates and aromatics. Investigation of temperature-dependent rheology characteristics revealed significant viscosity reduction in the products of catalytic aquathermolysis.

1. Introduction

In the last decade, there is a big interest in unconventional hydrocarbon resources, the industrial development of which needs modern technologies. Shale gas, shale oil, heavy oil and natural bitumen belong to unconventional hydrocarbon resources. It is expected that in the near future such resources will supply a stable oil production [1,2]. The main issue in production of such hydrocarbons are high content of resins, asphaltenes, heteroatom compounds and absence of light fractions. This is the main reason of its low mobility in reservoir conditions. Currently, there are many researches devoted to the modification of production technologies, particularly steam based recovery methods [3-5]. Many scientists work on the synthesis of catalysts for in-situ upgrading of crude oil and investigate their efficiency in terms of incremental oil recovery. The best effect from catalysts is achieved in case of introducing as nanoparticles or oil-soluble catalyst precursors, active form of which is obtained after steam injection. The active form of catalysts is commonly oxides and sulfides of corresponding metal [6-10]. In comparison with conventional catalysts, nanoparticles do not allow diffusive restrictions and their active form are stable [11-13].
2. Methodology

The object of this study was heavy oil from Ashlcha oil field, Republic of Tatarstan. The aim of the given study was to analyze the efficiency of ultra-dispersed catalyst – mixture of iron (II, III) oxides in terms of viscosity reduction and changes in the composition of heavy oil, as well as investigation of phase changes in magnetite under hydrothermal-catalytic processes at 200°C.

To reach the goal, following tasks were required to be solved:

1) catalyst synthesize – mixed iron (II, III) oxides - Fe₃O₄(Fe₂O₃·FeO);
2) to carry out physical laboratory simulation of catalytic hydrothermal treatment;
3) measure the temperature dependent viscosity values of catalytic and non-catalytic aquathermolysis products
4) to determine the group composition of obtained non-catalytic and catalytic aquathermolysis products.

The laboratory stimulation of aquathermolysis process was carried out in high-pressure reactor with stirrer (300 mL volume), manufactured by Parr Instruments, USA. The model system was a mixture of oil and water with the ratio 70:30. The emulsion was treated at 200°C in the presence of catalyst. The catalyst is a powdery compound of mixed iron oxides (magnetite, Fe₂O₃·FeO). We used naphthenic-aromatic benzene fraction of oil as a hydrogen donor. The working pressure was 2 MPa. The treatment time was 24 hours. At the end of the process, the hydrocarbon was separated from water by settling for 16 hours, then centrifuged in Eppendorf 5804R at 3000 rpm for 1 hour. Further, the group composition was determined according to ASTM D 4124-09. The temperature dependent characteristics of oil were measured in rotation viscometer FUNGILAB Alpha L, equipped with an adapter - a thermostatic jacket. The required temperature was supplied by cooling thermostat HUBER MPC K6.

3. Results and Discussion

The catalyst was synthesized according to the literature [14]. In order to evaluate the efficiency of the catalyst in the process of steam and thermal treatment, a kinetic experiment was carried out and the products of thermo-catalytic exposure were analyzed depending on the duration and temperature.

Figure 1. The relation between the viscosity of non-catalytic and catalytic aquathermolysis products after 24 hours from the temperature
The viscosity of crude oil after hydrothermal-catalytic treatment for 24 hours at 200°C was reduced in contrast with non-catalytic treatment.

Currently, the study of chemical group composition of crude oil, which is a complex structural unit and includes many different chemical compounds, is mainly carried out using reliable methods such as SARA analysis. The results of group composition analysis of non-catalytic and catalytic aquathermolysis products for 24 hours are represented in Figure 2.

![Figure 2. Group composition of non-catalytic and catalytic aquathermolysis products after 24 hours treatment.](image)

The significant increase (10%) in the content of aromatic fraction and decrease in high-molecular hydrocarbons (8%) is observed. The results of measurements indicate the positive influence of catalyst on the rheology. Magnetite participates in destruction of associated complexes in resins and thereby decreases the viscosity of crude oil.

4. Conclusion

The physical stimulation of steam treatment of heavy oil in the presence and absence of catalyst at 200°C was carried out. The catalyst was composed of mixed iron (II, III) - Fe₂O₃ (Fe₂O₃•FeO) oxides within ultradispersed size range. The influence of catalyst in in-situ upgrading of heavy oil is in improving the group chemical composition of oil, particularly reduction of resins and asphaltenes. Moreover, it is directed on reduction of viscosity of obtained products of catalytic aquathermolysis.

Acknowledgments

The work is performed according to the Russian Government Program of Competitive Growth of Kazan Federal University.

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