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IN SITU CATALYTIC UPGRADING OF OMANI HEAVY CRUDE OIL

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Abstract

The major challenge in the utilization of heavy crude oil reserves is the upstream production of the oil from the reservoir at sub-surface conditions and its downstream transportation to the refinery for subsequent refining processes (due to high viscosity, low API gravity, high sulphur, nitrogen, oxygen and metals content). In situ combustion and steam injection have become the most commercially applied thermal EOR methods in the last couple of decades. Their effects increase the overall heavy oil recovery, but do not notably improve the quality of the crude. There is also strong interest in heavy crude oils mainly due to increases in worldwide energy demand and the decrease in overall quality of crude oil. Therefore, it is necessary to upgrade heavy crude oils. Recently, there is much research interest in in-situ catalytic upgrading. In this work, and for the first time, experimental investigations on the application of catalyst for enhanced recovery and upgrading of Omani heavy crude oil was conducted in the presence and absence of a porous medium.

In the first phase of the study, the catalyst's performance was evaluated in a high temperature-high pressure laboratory batch reactor without a porous medium, mainly measuring the characteristics of the heavy oil while in contact with the catalysts. The reaction was conducted in the presence of hydrogen at elevated temperatures and pressures, and at static conditions with the help of a stirrer. Series of experiments were designed and then implemented to model a typical reservoir condition. A trimetallic catalyst system based on Ni, Co and Mo was used. The catalyst was introduced into the reaction media through different forms; zeolite-supported, dispersed submicron dissolved in DES and from water-in-oil emulsion.

Results from the batch-reactor study showed the catalyst is effective in upgrading the heavy crude oil in terms of Sulphur, coke and viscosity reduction, and API gravity increase. Solids, liquids and gaseous products formed from the upgrading experiments were recovered and characterized using FTIR and GC; for structural and compositional changes, XRD for phase and mineralogical identification, SEM-EDS for morphology and size of the solids including catalytic particles.

In the second stage of the work, the recovery performance of the catalyst was investigated in the presence of a porous medium. Firstly, the recovery performance of the DES (catalyst carrier) using core flood experiments. The core flood results showed the DES has the potentials for application in chemical EOR as 16%OOIP extra oil recovery was achieved.

In the second part of the recovery experiment, the catalysis effect of trimetallic dispersed submicron catalyst from water-in-oil emulsion was investigated. Experiments were conducted in a sand pack model during steam injection. Results from the recovery experiments showed that about 15%OOIP was achieved when the catalyst was utilized compared with a blank run without a catalyst. The quality of the produced oil was also enhanced in the presence of the catalyst as a substantial reduction in Sulphur and viscosity with an increase in API gravity was

achieved. Overall, the catalyst proved to be effective in upgrading and enhancing the recovery of the heavy crude oil.

The overall work showed a novel application of trimetallic catalyst formed from molybdenum, nickel and cobalt for upgrading and enhanced recovery of the heavy crude oil. It is the first time such combination of catalyst was used in heavy oil upgrading, both at surface conditions as in the batch reactor study and the reservoir simulation as it was done in the case of steam injection in the presence of porous media. The work with the DESs for both the upgrading using the batch reactor and the oil recovery experimentation using core flooding in the presence of formation water and Berea sandstone was also first of its kind.