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A batch reactor study of the effect of deasphalting on hydrotreating of heavy oil

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ABSTRACT

The effect of deasphalting of heavy oil with different degrees of asphaltene precipitation on catalytic hydrotreating is reported in this work. Deasphalted oils were obtained in a pressurized vessel using n-heptane and n-pentane as solvents. Various samples with different amounts of asphaltene were prepared by varying precipitation conditions. Hydrotreating of deasphalted oils was conducted with a commercial NiMo catalyst in a batch reactor at the following reaction conditions: hydrogen pressure of 100 kg/cm², temperature of 400 °C, stirring rate of 750 rpm and reaction time of 4 h. The heavy oil, the deasphalted oils and the hydrotreated products were characterized by sulfur, metals (Ni, V), asphaltene contents, and API gravity. Metals and carbon contents as well as textural properties and X-ray diffraction were also determined on fresh, spent and regenerated catalysts.

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1. Introduction

Studies of asphaltene precipitation and characterization have been traditionally carried out with the main objective of understanding the asphaltene deposition problem: flocculation, aggregation and precipitation mechanisms from crude oils, and the influence of metallic particles present [1]. However, the declining production of light crude oils together with the continuous growing up in the production of heavy and extra heavy crude oils, have caused an increase in the asphaltene content of the produced oils which are sent to petroleum refineries [2].

Ongoing advances in established technologies, together with recent commercial applications of residue fluid catalytic cracking (RFCC), hydroprocessing, solvent deasphalting and gasification of pitch and coke, have markedly enhanced options for processing and economically using residues [3]. In addition, processing of heavy oils to obtain more gasoline and other liquid fuels is nowadays a necessity; hence the knowledge of the constituents of these higher boiling point feedstocks is of great importance. It has been recognized that the problems associated to processing of heavy feedstocks can be equated to the chemical character and the amount of complex and higher boiling components in the feedstock. Refining heavy oils is not just a matter of applying know-how derived from refining conventional light crude oils but requires knowledge of the chemical structure and chemical

behavior of these more complex feedstocks [4]. Asphaltene, being the most intricate molecules present in petroleum, are also the most refractory and difficult to process portion of the crude oil. The main problems associated with hydroprocessing of heavy oils having high amount of asphaltene are: precipitation on the catalyst surface and blocking of the catalyst pore mouth, they act as coke precursors which ends up as catalyst deactivation, and limit the maximum level of conversion due to sediment formation [5].

Common fixed-bed catalytic hydroprocesses, which use atmospheric residue, vacuum residue, or heavy crude oils as feed, are multiple reactor units with graded catalyst systems to achieve desired levels of impurity removals and conversion. The catalytic system is frequently integrated by a hydrodemetallization (HDM) catalyst for metal removal, a balanced hydrodemetallization/hydrodesulfurization (HDM/HDS) catalyst and a hydrodesulfurization (HDS) catalyst, at the front, middle and last sections respectively [4,6,7]. The first catalyst is designed to have optimized textural properties, shape, active metal loading, etc. in order to achieve high metal retention capacity to protect the following catalysts against premature deactivation and allow the process for long-term operations [8]. Since most of the amount of metals present in heavy crudes, mainly V and Ni, are concentrated in asphaltene, removing this high-molecular weight material will consequently reduce the metal content in the feed to hydroprocessing. Therefore, deasphalting a heavy feed before its hydrotreating seems to be very convenient from operational and economical points of view.

Solvent deasphalting (SDA) is a molecular weight-based separation process member of the family of carbon rejection

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