Promoting In-Situ Hydrothermal-upgrading of Heavy Oil by Catalytic Dehydrogenation of Decalin in the Presence of Nickel-Based Catalyst - Al-Muntaser Ameen Ahmed Mohammed - Kazan Federal University

Al-Muntaser Ameen Ahmed Mohammed

Abstract

One of the main and cost-effective solutions for the successful use of heavy oil reservoirs around the world is hydrothermal upgrading. This research is a study of the in-situ upgrading of Ashalcha oil field (Republic of Tatarstan) using steam, decalin, and catalyst (Nickel (II) stearate) at temperatures of 300 °C for 24 hours, using a stainless-steel 300-ml batch Parr reactor. In addition, decalin as a hydrogen-donor solvent was used to improve the efficiency of the catalytic and non-catalytic hydrothermal upgrading process. Moreover, the donating capacity (dehydrogenation) of decalin was evaluated under catalytic and non-catalytic hydrothermal upgrading to gether with steam, Nickel (II) stearate and heavy crude oil in the same batch reactor. The viscosity, chemical composition, SARA fractions, composition of the evolved gases, and carbon number distribution were studied. After 24 hours of contact at 300°C, it might reduce oil viscosity by 11%. But with the catalyst, the effect of steam increases, as the viscosity decreases by 50% at 300°C. While the combination of decalin and catalyst reduced the viscosity of the mixture the most, by 69±1% with decalin at 300°C, compared with pre-upgrading mixture. In addition, the remined propeties such as SARA analysis a carbon number distribution in the saturates were significantly improved. The results of thermal conversion of decalin showed that decalin was dehydrogenation to tetralin, and the residual were converted into lower boiling products with dry gas. The produced hydrogen from decalin was used for hydrogenation the upgraded oils improving their main characteristics.

Producing sustainable liquid fuels from renewable sources is one of the most exciting challenges of engineering nowadays. Liquid fuels are indeed utilized in very large amounts and, since they are mostly produced from fossil oil, they represent a remarkable contribution to global warming. Although many steps forward have been made for the transition to more sustainable solutions for transportations, for example by means of a more extensive usage of electricity, liquid fuels still represent an important share of the world's energy demand. Indeed, applications such as long distance road transportations, aviation and marine traffic will rely on liquid fuels into the foreseeable, even long-term future. Such liquid fuels must be sustainable in all senses of the term, and biomass or organic waste streams are probably the most promising sources for the production of these. Through the last decade, hydrothermal liquefaction (HTL) has been gaining a prominent position in the production of sustainable liquid fuels. HTL consists in reacting biomass in hot pressurized water, at pressures high enough to keep water in its liquid or even supercritical state. The valuable product from this process is a dark viscous liquid, commonly referred to as biocrude, which is immiscible with water and which has a significantly higher heating value and lower oxygen content than bio-oils from other liquefaction technologies (e.g. pyrolysis). However, despite its remarkable characteristics, biocrude does not fulfill the requirements for drop-in transportation fuels due to the still high heteroatoms content, low hydrogen-to-carbon ratio and relatively high share of high-boiling fractions. Hence, upgrading processes are required, among which the most widely adopted one is hydrotreating, i.e. the reaction of biocrude with H2 at high temperature and pressure in the presence of a catalyst. In the literature, the number of studies concerning biocrude hydrotreating is quite limited. The large majority has been carried out on the upgrading of biocrudes from algal feedstock, for which the challenge is represented by the removal of nitrogen. The Pacific Northwest National Laboratory (USA) research group hydrotreated different algal biocrudes in a continuous bench-scale reactor, obtaining an almost complete removal of nitrogen, with a residual 1% of oxygen. Other studies in the literature were conducted with different catalysts and operating conditions, such as: ZSM-5 zeolites, sulfided NiMo and CoMo on Al2O3 support, Pt/Al2O3 and HZSM-5 and several other supported metallic catalysts. Two-stage upgrading has been investigated as well. A few hydrotreating studies are also available for wood bio crude. Early work addressed the upgrading of wood biocrudes from the pioneering HTL experiments at the Albany PDU. More recently, a parametric study on wood biocrude upgrading was carried out by Jensen et al., showing that temperature is the most significant parameter affecting the extent of deoxygenation.

Bottom Note: *This work is partly presented at 12th World Congress on Petroleum Chemistry at November 22-23, 2021 | Webinar*

Al-Muntaser Ameen Ahmed Mohammed

Kazan Federal University, Russia, E-mail: almuntaser.ameen@gmail.com