Catalytic Hydro-cracking of Bio-oil to Bio-fuel

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Abstract

Over the last hundred years, the fossil fuels consumption is increasing dramatically and this lead to a significant increase in greenhouse gas emissions, the depletion of natural reserves of fossil fuels and increase the fuel production cost. Consequently, renewable and sustainable fuel sources such as bio-oil are receiving increased attention. In bio-based oil such as micro-algae oil, triglycerides and fatty acids are sustainable resources with high energy densities that can be converted into liquid hydrocarbon fuels, efficiently. One of the efficient ways for bio-oil conversion to applicable fuels is hydro-cracking. Hydro-cracking with acidic catalysts is a single step and energy efficient process for bio-oil upgrading towards bio-fuels. Zeolitic structures such as ZSM-5 and beta-zeolite are prevalent acidic catalysts in hydro-treating processes due to their strong acidity, their crystalline porous structure and their high hydrothermal stability. The aim of this research is checking the feasibility of hydro-cracking synthesis towards the light (LC) and middle (MC) range of hydrocarbons over the zeolite based catalysts. Two different types of zeolite catalysts, ZSM-5 and beta-zeolite, were chosen and they were impregnated with Ni $(NO_3)_2.6H_2O$ and calcined at 500 °C. The prepared catalysts were tested with oleic acid which is the main component of plant-derived oil. The catalysts were injected in a lab-scale trickle bed reactor in certain operating conditions. The oleic acid conversion over beta-zeolite was greater than ZSM-5 due to higher pore size distribution and acidity of beta-zeolite compared with ZSM-5. Also the reaction rate constant and Arrhenius equations for beta-zeolite and ZSM-5 were identified. The second step of this research is investigating the hydro-cracking performance with performing a mathematical modelling. The model predictions showed reasonable correlation with experimental data and conversion rates. The total conversion for the hydro-cracking reactor model was 82.54 % for 4 major classes of hydrocarbons (light [LC], middle [MC], heavy [HC] and oligomerised [OC]). In addition, the concentration distribution and temperature profile along the reactor were investigated. At the end, a comprehensive sensitivity analysis was performed to analyse the hydro-cracking reactor performance.

Declaration

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