ABSTRACT

High demand for biofuels by emerging economies as well as environmental issues has resulted in more indebt research in petroleum fuel production. The edible oil feedstocks are currently the main resources for biofuel production but lately, the switch to non-edible oil is considered. The non-edible oils are a leading option considering that they do not clash with food security policy. From extensive research, it was found that transesterification is not sufficient alone for biofuels production. Hydrocracking is the ideal solution as it can at once produce different biofuels (bio-jet and bio-gasoline) with high quality and higher yields of the desired product.

Castor oil as an alternative and re-usable source of liquid fuel was used in this research to study the production of bio-jet fuel. The project focused on differently prepared hydrocracking catalysts that may be used to produce bio-jet as the desired biofuel and the parameters that would give the optimal production yields of bio-jet. The co-impregnation and sequential impregnation methods were used for the synthesis of the Ni-Zn/CNO catalysts with varied Ni: Zn metal loading ratios of 1:2, 1:3, 1:1, 2:1, and 3:1 wt% calcined at 500°C. The catalysts were characterized using the TGA, BET, SEM, TEM, XRD, and FTIR, characterization techniques that revealed different properties. When the catalysts were analysed with SEM, it was revealed that they have agglomerates, while BET revealed that all the catalysts have pores in the mesoporous regions.

Castor oil was hydrocracked using the 2:1 and 1:3 catalysts ratios prepared by the co-impregnation and sequential impregnation methods respectively. The catalysts were used to study the effects that temperature, time, and catalyst loading have on the bio-jet selectivity. The results revealed that when the temperature was increased the bio-jet selectivity increased up to 250 °C then decreased. When the time was varied the increase in time increased the bio-jet selectivity throughout until 2.5 hours and when the catalyst loading effect was studied it was observed that the increase in catalyst loading drastically decreased the bio-jet fuel production. At high catalysts loadings, the catalysts favoured mostly biodiesel and long hydrocarbons production. From the hydrocracking runs, the 2:1 and 1:3 catalyst ratio produced maximum yields of 65.33 and 72.33% respectively. The catalyst preparation method, the metal used, and process temperature should be considered for the prediction and catalyst activity assessment.

The 1:3 catalyst was further used for the optimization of process parameters (Temperature, time, and catalyst loadings) that were carried out using the response surface methodology (RSM) of the design expert software. The experimental design was carried out by the RSM in order to evaluate the interactive effects. A higher regression coefficient of 82% was obtained which indicated a good evaluation of the experimental data by the obtained 2FI model. The RSM revealed a temperature of 280 ˚C, a reaction time of 3 hours and catalyst loading of 160 mg as the optimal reaction conditions. Bio-jet fuel was successfully produced with a maximum production yield of 55.62% obtained from the optimum conditions.