Physical and Chemical Characterization of Upgraded Bio-oils via Hydrodeoxygenation

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Introduction

Fast pyrolysis is a potentially important route for biomass conversion to fuels. Researchers have shown that the problematic raw bio-oil properties of high acidity, high water content, lower heating value and variable viscosity are resolved by application of hydrodeoxygenation (HDO). Raw bio-oil from pine wood was upgraded by HDO single-stage catalysis. The hydrocarbons produced in the HDO bio-oil range from naphtha to diesel weight, at relatively wide range. We distilled the HDO bio-oil to determine the potential for producing relatively clean hydrocarbon fractions with relatively little overlap in molecular weight. The HDO bio-oil was distilled by using spinning band distillation column into fractional boiling point ranges. The upgraded bio-oil and distilled fractions were characterized by GC/MS, FT-IR, NMR, GPC and elemental analysis. Physical properties, such as higher heating value, viscosity, density, water content, and acid value, were also determined.

Materials and Methods

The effect of various catalysts (Ru and Pd) on bio-oil in a batch reactor was studied at various conditions of temperature, weight of catalyst, time of reaction and initial pressure. All the experiments were performed in a batch reactor under hydrogen partial pressure. Reactants comprises of bio-oil and methanol. Products formed in the form of gases, liquids and char/coke were collected, analyzed and preserved for further studies. Upgraded bio-oil samples will be analyzed by various analytical techniques like GC/MS, GPC, FT-IR and NMR. In order to fully characterize the upgraded bio-oil, different tests must be done to the samples i.e. Karl-Fischer water titration, pH, viscosity, density and acid value measurements. Used catalyst characterization will also be done by using BET, SEM and TEM techniques.

Results and Discussion

Table 1. Raw bio-oil Vs HDO bio-oil properties

Properties	Raw bio-oil	Upgraded bio-oil
Water (wt %)	15-40	5
Acid value	92	36
HHV (MJ/kg)	17	37
Viscosity at 40^0C (cSt)	53	18
pH	2.5-4	6-7
Ash (wt %)	0.04	0.04

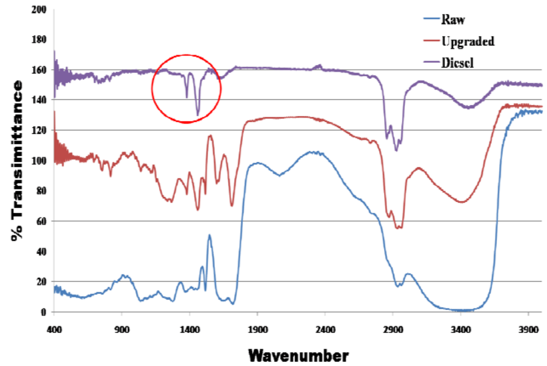

Figure 1. FTIR spectra of raw bio-oil, HDO bio-oil and Diesel Fuel.

- Upgraded HDO bio-oil is having higher concentration of C8 to C16 hydrocarbons
- High heating values are doubled for the upgraded HDO bio-oil comparing with raw bio-oil.
- Upgraded HDO bio-oil is easily miscible with the diesel fuel without using any surfactants.

5% Diesel blend is having similar physical and chemical properties comparing with Diesel fuel.

Future work

- Catalyst characterization. Assessing the strength of the catalyst and using spent catalyst for the prolonged HDO of bio-oil
- Continuous HDO process set up
- Developing the suitable diesel blend to obtain maximum octane number possible

Significance

Thermochemical routes to produce liquid transportation fuels from lignocellulosic biomass are required to supplement the shortage of sugar-based biochemical fuels limited by constraints on productivity of agricultural lands and limits on the sugar volumes that can be diverted from food feed stocks. While plans are to increase biochemical lignocellulosic yields in the future, there remain serious hurdles to this pathway. Thermochemical routes with lignocellulosic biomass feed stocks promise very a viable alternative route to reduce the national dependence on imported petroleum.

References

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