Catalytic Cracking of Jatropha-derived fast pyrolysis oil using FCC E-catalyst

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Abstract

This paper aims to convert the waste biomass, a byproduct of Jatropha based bio-diesel industry, into value added hydrocarbons using pyrolyzer followed by refinery fluid catalytic cracking unit. The catalytic cracking of biomass (Jatropha curcas cake)-derived fast pyrolysis oil with vacuum gas oil was studied using laboratory fluid catalytic cracking (advanced cracking evaluation) unit using refinery FCC equilibrium catalyst. The advanced cracking evaluation unit was operated at close to refinery FCC conditions. The fast pyrolysis oil was obtained from bubbling fluidized bed pyrolyzer, which is operated at atmospheric pressure. The fast pyrolysis oil (FPO) to vacuum gas oil (VGO) blends prepared in the ratio of 20:80, 30:70, 40:60, and 50:50. The increase of FPO: VGO ratio leads to increase the product yields of dry gas, gasoline and coke; whereas decreased the yields of liquefied petroleum gas. The gas chromatography analysis supports the information like lower yields of propane, propylene, butane, butylenes, and higher yields of ethylene, ethane.

Keywords: *Biomass, Fast pyrolysis, Bio-crude oil, Fluid catalytic cracking*

1. Introduction

Currently, almost all the liquid fuel used around the world comes from petroleum crude. A great advantage of using liquid hydrocarbons for the transport sector is their high-energy density and ease of use. The concerns regarding depleting petroleum supplies, secure energy supply and dwindling prices of crude oil and environmental issues have resulted in the need for development of renewable transportation fuels and chemicals to supplement or replace those derived from fossil resources. Biomass represents a potential alternative source of liquid fuels and chemicals. It is available abundantly and is a renewable source of carbon containing molecules. The basic structure of all woody biomass consists of three organic polymers: cellulose, hemicelluloses, and lignin. There has been a plethora of research on the thermo-chemical and bio-chemical biomass conversion methods and upgrading of products. Among various thermo-chemical conversion processes, pyrolysis is considered to be an emerging technology for liquid oil production.

The main problem with pyrolysis oils is its high amount of water and its instability because of the presence organic compounds with undesirable properties. Pyrolysis liquids contain compounds that self-react during handling at ambient temperatures to form larger molecules. Bio-oils contain many reactive species, which contribute to unusual attributes.

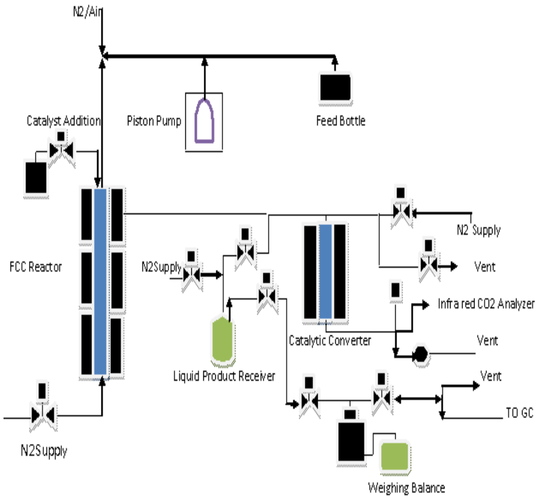
Chemically, bio-crude oil is a complex mixture of water, guaiacols, catecols, syringols, vanilins, furancarboxaldehydes, isoeugenol, pyrones, acetic acid, formic acid, and other carboxylic acids. It also contains other major groups of compounds, including hydroxyaldehydes, hydroxyketones, sugars, carboxylic acids, and phenolics. The bio-crude oil produced from fast pyrolysis needs up-gradation in order to use as transportation fuels or as petrochemical feedstock. In the present investigation, the fast pyrolysis of Jatropha curcas cake has been performed to produce the bio-crude followed by fluid catalytic cracking of bio-crude/vacuum gas oil (VGO) mixtures to produce usable products such as transportation fuels. Published literature [1-5] is available for the effect of fast pyrolysis oil model compounds and pure fast pyrolysis oil with VGO/LCO on product selectivity.

2. Materials and Methods

The electrically heated bubbling fluidized bed pyrolyzer with sand as fluidizing media has been used for the fast pyrolysis of biomass at temperature of 540°C. The fluidizing gas (nitrogen) was preheated up to 400°C by electric furnace, before reaching the pyrolysis reactor. The biomass fed (de-oiled Jatropha curcas cake) into the reactor by screw feeder system, which is operated at above atmospheric pressure. The char was separated by cyclone and vapor is condensed and separated as bio-crude oil in a series of condensers and the non-condensable gases are recycled to reactor via filter & recycle gas compressor system.

Advanced Cracking Evaluation (ACE-R) of M/s. Kayser Technology Texas (USA) unit was used for catalytic cracking of bio-crude oil i.e. fast pyrolysis oil. The schematic diagram of ACE-R unit is shown in Figure 1. A commercially available equilibrium FCC catalyst was used in this process. The gas products were analyzed using *in-situ* refinery gas analyzer (RGA) (GC HP 6890) equipped with three detectors, a flame ionization detector (FID) and two thermal conductivity detectors and liquid products were analyzed using simulative distillation analysis (SIMDIST). The coke deposited on the catalyst is burned with air in regeneration mode and the resulted total carbon dioxide was analyzed using IR spectroscopy.

Figure 1: Schematic diagram of advanced cracking evaluation FCC unit



3. Results & Discussion

The yield of liquid products obtained from the fast pyrolysis of biomass was in the range of 35-45 wt%. Different ratios of vacuum gas oil and FPO has been used for the fluidized catalytic cracking. The yield of gasoline was increased with the increase of FPO. Interestingly, the yield of LPG was decreased with the increase of FPO. The optimum ratio for the production of high gasoline was found to be 1:1 (VGO: FPO). With the addition of FPO, there was remarkable increase in the production of C_2 hydrocarbons, which can be used as a feedstock in the petrochemical complex.

The detailed investigation results along with the effect of different biomass feedstock will be discussed during the presentation.

Table 1: Product Analysis of FCC products

VGO:FPO	100:0	50:50	60:40	70:30	80:20
Products	Wt. %	Wt. %	Wt. %	Wt. %	Wt. %
Dry gas	2.41	3.56	3.44	2.99	2.87
LPG	23.58	16.03	17.72	17.89	18.74
IBP150°C	35.22	38.13	37.43	36.79	36.53
150-216°C	10.02	10.58	11.17	11.50	11.22
216-370°C	19.44	20.88	20.23	20.84	20.86
370°C +	6.34	6.91	6.84	6.87	6.74

4. Conclusions

The mixtures of biomass fast pyrolysis liquids and vacuum gas oil has been used for the production of transportation fuels along with the C_2 hydrocarbons useful for the petrochemical feedstock. There was remarkable increase in the quality and quantities of useful products obtained from the FPO and VGO mixtures.

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