

Studies on Hybrid Transesterification and Pyrolysis

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ABSTRACT

The aim of this paper is to explore the enhanced methods of transesterification and pyrolysis of waste cooking oil and plastic scrap. Pyrolysis of plastic waste produces bio-oil. The waste cooking oil from hotel industries are subjected to transesterification. The combined bio-diesel and bio-oil from pyrolysis are subjected to cracking reaction which yields bio-diesel with excellent quality for using in automobile engines and to synthesis petrochemicals

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Introduction

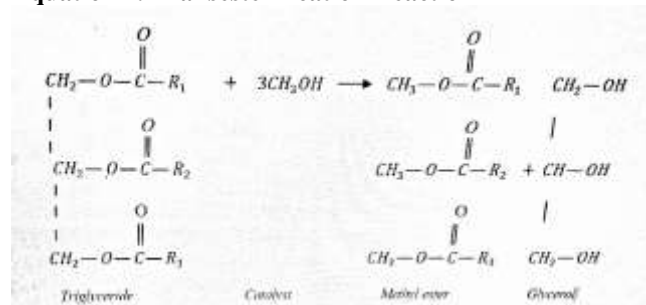
India consumes about 21 million tonnes of edible oil and generates 2 million tonnes of waste cooking oil annually. Hotels are putting waste cooking oil to good use by converting them to bio diesel through transesterification process using methanol and NaOH as catalyst. The bio diesel produced is used in powering local trains, lifts, hot water boiler operations and automobile engines. It is also possible to get bio diesel or bio gasoline converted into industrial organic solvent and thinners for painting. In fast food outlets, fried chicken and fried wafer production centres, a rough estimate of 15 litres per day waste cooking oil is generated per shop and the total installation produce several 1000 litres of waste cooking oil every day. If the waste cooking oil mixes in effluent stream, it gives corrosion initiation to metal piping and also makes effluent treatment costly. The transesterification process can be successful only if it is carried out efficiently and economically. The conversion efficiency depends on the free fatty acid (FFA) present. If more than 2.5% FFA is present, acid treatment to neutralise the soap formation reaction with sodium hydroxide has to be introduced. The amount of sulphuric acid to be added can be calculated. Further thermal cracking of bio diesel can be enhanced by mixing bio diesel with pyrolysis oil and refluxing in a packed bed. Using Dean and Stark apparatus the viscosity, density, flash point, fire point and cetane number of bio diesel obtained by various processes are stabilised to the standard values of commercial diesel. The present paper discusses the operating procedure and yield of bio diesel in transesterification using methanol and alkali catalyst, thermal cracking and neutralisation in a reflux column.

Process of Transesterification

Bio diesel can be produced by transesterification of triglycerides (TG) with alcohol (commonly methanol or ethanol) in the presence of a base or acid catalyst into fatty acid methyl ester (FAME). The TG are converted into step wise diglycerides (DG), monoglycerides (MG) and finally glycerol.

The triglycerides (TG) when treated with catalyst and methanol gives three parts methyl ester (Bio diesel) and one part of glycerol. In general, volume of biodiesel generated is equal to volume of vegetable oil taken initially.

Equation 1. Transesterification Reaction



Free Fatty Acid

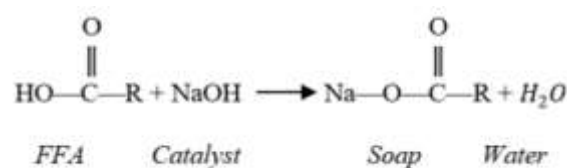
In using waste cooking oil, free fatty acid may pose a problem. FFA is one that has been already separated from the glycerol molecule. This is mainly due to the oil breaking down after many uses.

Major Problems of FFA

1. Soaps are formed-Making washing of final product difficult.
2. Water is formed which retards the reaction.
3. More catalyst needed.

FFA is not converted into product. Hence low yield

Equation 2. Formation of soap



The waste cooking oil (WCO) containing more than 2.5% FFA are treated with required quantity of sulphuric acid and reacted with methanol to convert into more useful products. Figure 1 shows a process a process flow diagram for transesterification using both types of WCO containing less than 2.5% FFA and more than 2.5% FFA.

The glycerol produced is decanted using siphoning system from the settling tank.

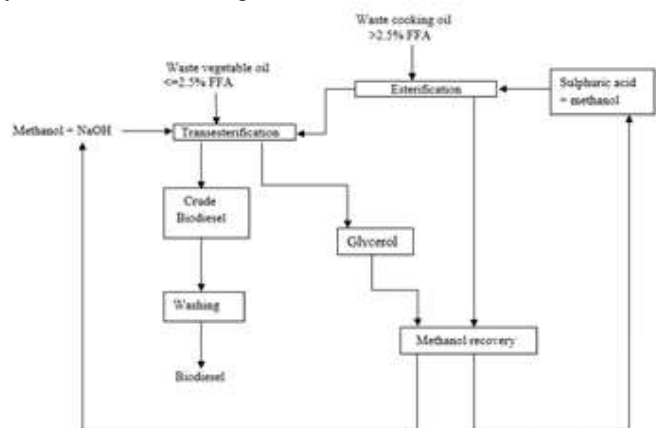


Figure 1. Process flow sheet for Biodiesel production

Pyrolysis of Ldpe Waste

The reactor for pyrolysis can be tubular with electrical heating furnace surrounding it. The LDPE charged into the reactor and heated to around 400°C. The vapours are condensed and the condensing liquid collected over a water column. The bio-oil is collected and dried at 110°C to remove moisture.

Fractional Distillation and Thermal Cracking

Studies indicate bio-diesel produced by transesterification of WCO exhibit variation in characteristic properties depending on the raw material WCO composition. Also the bio-oil from pyrolysis plant contain different C/H ratio depending on the plastic waste and WCO feed stock used. The possibility of obtaining by pyrolysis of vegetable oils to gasoline range is demonstrated. The bio-oil produced contains gasoline range of octane number 90-96. To make uniform products and different petrochemicals, a fractionation and thermal cracking operation is carried out in a setup similar to Dean and Stack. The effects of reaction condition on products distribution needs to be studied extensively so that the reaction may be optimised to produce range of petrochemical, thinners and solvent besides auto fuels.

Materials and Methods

Waste cooking oil from college canteen is obtained. The free fatty acid content varies with different samples as the waste cooking oil is derived from various process of cooking viz; fish frying, chicken, mutton, waste fats, wafers frying and poori making etc; sodium hydroxide, potassium hydroxide, ethanol, methanol are analytical grades.

Apparatus Used

Three different setups are fabricated for transesterification, pyrolysis of plastic waste and thermal cracking of mixed Bio diesel-Bio oil. Bio oil from pyrolysis of plastic waste is produced and collected over water column. The bio diesel from transesterification process are taken in various proportions along with pyrolysis oil and subjected to thermal cracking. The water present is removed and unconverted triglycerides (TG) are reacted further to FAME.



Figure 2. Pyrolysis setup



Figure 3. Transesterification



Figure 4. Thermal cracking of oils.

RESULTS AND DISCUSSIONS

The final product obtained was a clear volatile liquid with the following characteristic properties.

Table 1. Properties of final Biodiesel

Appearance	Visual	Clear
Specific Weight	Using specific gravity bottle	0.85kg/ litre
Flash point	Recorded from experiment	600C
Flash point	Lab setup	200C
Odour	Aromatic hydrocarbons	-----
Solubility	Insoluble	-----
Cetane number	-----	40
Octane	-----	92

The cold flow property such as pour and cloud point of the pyrolysis oil are improved after thermal cracking with bio diesel mix. The octane number obtained after fractionation of the pyrolysis oil and transesterification bio diesel mix shows close proximity with gasoline.

Conclusion

The difference in final products of pyrolysis oil and transesterification bio diesel depends on reactor type, reaction temperature, residence time and initial feed stock. To make uniformity in properties and characteristics of the final product, the thermal cracking of mixture in a cracking unit similar to Dean and Stark apparatus is used.

The product obtained is a clear, volatile liquid with properties similar to diesel.

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