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Sunflower Based Biodiesel with Maximum Yield Production Using Response Surface Methodology – A Review

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Abstract — **The exponential growth of world population would ultimately lead to increase the energy demand in the world. Petroleum is a non-renewable energy source, which means that the resources of this kind of fossil fuel are finite and would be run out upon continuous use. Biodiesel is a liquid biofuel obtained by chemical processes from vegetable oils or animal fats and an alcohol that can be used in diesel engines. Bio diesel derived from sunflower vegetable oil has considerable advantages of environmental production. It is produced from sunflower crude oil using strong base catalyst NaOH, reaction temperature (70°C), and methanol. These three parameters in various levels to be optimized using RSM Method to find out the Maximum yield in particular combination. This review addresses the maximum yield production of SFME and performance analysis.**

***Keywords*— Sunflower Oil, Sunflower Methyl Ester, Biodiesel, Response Surface Methodology.**

I. Introduction

Biodiesel is defined as mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats which conform to ASTM D6751 specifications for use in diesel engines. Biodiesel refers to the pure fuel before blending with diesel fuel.

The large increase in number of automobiles in recent years has resulted in great demand for petroleum products. With crude oil reserves estimated to last only for few decades, there has been an active search for alternate fuels. The depletion of crude oil would cause a major impact on the transportation sector. Of the various alternate fuels under consideration, biodiesel, derived from vegetable oils, is the most promising alternative fuel to conventional diesel fuel [1].

A lot of research work has been carried out using vegetable oil both in its neat form and modified form. Studies have shown that the usage of vegetable oils in neat form is possible but not preferable [2]. The high viscosity of vegetable oils and the low volatility affects the atomization and spray pattern of fuel, leading to incomplete combustion and severe carbon deposits, injector choking and piston ring sticking.

Methods such as blending with diesel, emulsification, pyrolysis and transesterification are used to reduce the viscosity of vegetable oils. Among these, the transesterification is the most commonly used commercial process to produce clean and environmentally friendly fuel[3].In general, catalyst used for improving biodiesel production is divided into two group, that are homogeneous and heterogeneous (solid) catalysts. Base homogeneous catalysts are widely used and applied in transesterification of vegetable oils, for example NaOH and KOH are the most active under mild reaction condition [4].

However, homogeneous catalysts are difficult and lead to downstream waste treatment, increasing the cost of large scale biodiesel production. In addition, base homogeneous catalysts have limitation leading to soap formation and high consumption of the catalysts. Solid catalysts are promising candidates to be applied in biodiesel production from vegetable oils. On the contrary with homogeneous catalysts and heterogeneous catalysts can be recycled and reused, ease to separate from the mixture, cheap, and environmentally benign. Solid base catalysts are more active than solid acid catalysts requiring relatively shorter reaction time and lowering temperature of reaction [5-6]. The reaction parameters are temperature, catalyst concentration and speed on the biodiesel yield and to optimize the reaction conditions using RSM.

II. OBJECTIVE

Preparation of biodiesel from transesterification process

- Optimize the process parameters using RSM technique
- To check the engine performance using the prepared bio sample with and without Nano additives

- To analyse the tribological behaviour of all prepared samples

III. BACKGROUND

In order to convert oil to biodiesel it is mixed with methanol, or occasionally ethanol and a catalyst (potassium hydroxide, sodium hydroxide) added to speed up the reaction. This transesterification reaction produces biodiesel and glycerol. Biodiesel is less dense than glycerol and the two products are separated by gravity or using centrifuges. The biodiesel can be used to replace regular diesel or mixed with regular diesel in varying concentrations, while glycerol can be used in soap and cosmetics applications. The KOH catalyst increases the rate of reaction but does not increase the yield. Most of the KOH separates out into the lower glycerol layer and any remaining in the biodiesel is removed by washing with water.

The combined vegetable oil and animal fat production in the United States total about 35.3 billion pounds per year. This production could provide 4.6 billion gallons of biodiesel.. If all of the vegetable oil and animal fat produced in the U.S. were available to produce biodiesel, it would only displace about 14% of the current demand for on-highway diesel fuel. Although biodiesel cannot entirely replace petroleum-based diesel fuel, there are at least four reasons that justify its development.

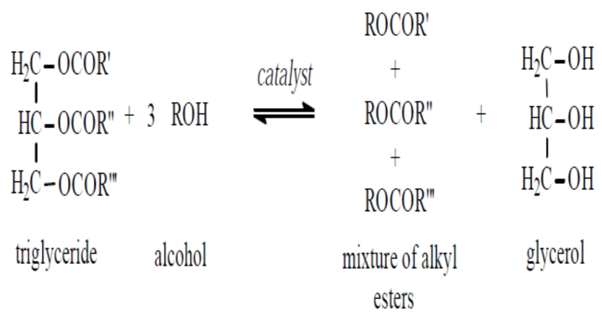
IV. TRANSESTERIFICATION

Transesterification is the general term used to describe the important class of organic reactions where an ester is transformed into another through interchange of the alkoxymoiety. When the original ester is reacted with an alcohol, the transesterification process is called alcoholisms. The Transesterification is an equilibrium reaction and the transformation occurs essentially by mixing the reactants. However the presence of a catalyst (typically a strong acid or base) accelerate considerably the adjustment of the equilibrium. In order to achieve a high yield of the ester, the alcohol has to be used in excess.

$$RCOOR' + R''OH \xrightleftharpoons{catalyst} RCOOR'' + R'OH$$

V. TRANSESTERIFICATION OF VEGETABLE OILS

In the transesterification of vegetable oils, a triglyceride reacts with an alcohol in the presence of a strong acid or base, producing a mixture of fatty acids alkyl esters and glycerol. The overall process is a sequence of three consecutive and reversible reactions, in which di and monoglycerides are formed as intermediates.



The stoichiometric reaction requires 1 mol of a triglyceride and 3 mol of the alcohol. However, an excess of the alcohol is used to increase the yields of the alkyl esters and to allow its phase separation from the glycerol formed.

Transesterification of sunflower oil to obtain biodiesel consists in replacing the glycerol of triglycerides with a short chain alcohol in the presence of a catalyst. The process was carried out in an alkaline medium, dissolving the catalyst in methanol, under low temperature conditions and atmospheric pressure, thus the process established was based on previous works Taguchi's Design of Experiments (Taguchi, 1989) was carried out on 20 tests in order to determine the operation conditions that maximized yield and fulfilled the specifications enforced by the European pre-legislation on biodiesel quality related to mono, di, and triglycerides, methanol, free glycerol and fatty acid contents.

VI. DESIGN OF EXPERIMENT AND ANALYTICAL METHODS

A. Design of Experiment:

Response surface methodology (RSM) was applied to design the matrix of experiments to investigate the effect of three main independent variables on methyl ester content (y, w/w%) of sunflower oil as the response. The factors chosen were the reaction time (x1, 60–180 min), the excess stoichiometric amount of methanol to oil (x2, 25–125 w/w%), and the catalyst concentration (x3, 0.1–0.9 w/w%). The type of catalyst and alcohol, the agitation rate and reaction temperature were kept fixing during the experiments. Therefore, twenty Transesterification trials were designed based upon central composite design(CCD). The designed matrix incorporated 3 independent variables with 5 levels for every factor. The system repeatability was determined through repeating the center point (6 times) .Where, the sequence of experiments was randomized for the sake of reducing the effects of any uncontrolled factor on response .

VII. CONCLUSIONS

The above review for the sunflower biodiesel preparation leads to the following conclusions,

- Transesterification of vegetable oil studied
- Strong base catalyst selected for good yield
- Range of factors with using RSM and levels selected
- Methodology has been created.

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