IMPACT OF ALCOHOL TO OIL MOLAR RATIO ON THE YIELD OF BIODIESEL SYNTHESIZED FROM WASTE MUSTARD OIL

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ABSTRACT

Biodiesel is a persuading alternative fuel to petroleum based diesel fuel due to its non toxic, biodegradable and renewable nature. Transesterification is typical process used for the production of biodiesel from respective oil. The efficiency of biodiesel produced during transesterification depends upon several factors viz. nature of catalyst, alcohol to oil molar ratio, temperature, reaction time, feedstock genre etc. In the present study, yield of biodiesel obtained from transesterification of waste mustard oil has been investigated with varying molar ratio of alcohol (methanol) to oil, increased from 4:1 to 14:1. The optimum molar ratio of methanol to oil was determined as 6:1 for maximum yield of 79.4% biodiesel. However, the reaction time and catalyst ratio kept fixed during reaction.

Keywords: Biodiesel, molar ratio, Transesterification, Yield.

I. INTRODUCTION

The energy generated from the combustion of fossil fuels has indeed enabled many technological advancements and social–economic growth. However, it has simultaneously faced many environmental concerns, which can threaten the sustainability of our ecosystem. The high demand of diesel in the industrialized world and pollution problems caused by its widespread use make it necessary to develop renewable energy sources of limitless duration and ecofriendly nature. Therefore, another renewable fuel is required to replace diesel fuel and that could be biodiesel [1-3]. Biodiesels are mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal fats through transesterification. There are many feedstocks for the production of biodiesel with edible as well as non edible trait. The usage of non edible oils anticipates the food security. However, blending of straight oils in diesel fuel results into various discrepancies such that poor viscosity and poor density [4,5]. To keep the properties of biodiesel analogous to diesel fuel, transesterification is typical phenomenon followed up for oils in the presence of certain catalysts. Free fatty acid content of oil is key parameter for the selection of catalyst to be employed. In regards of selection of alcohol for production of biodiesel, ethanol is less toxic and derived from renewable feedstocks. However, methanol is less costly, has better reactivity and the fatty-acid methyl esters produced are more susceptible to evaporate than ethyl esters [6, 7]. In the present study, waste mustard oil has been used which is reported in many texts as non edible oil due to excessive amount of erucic acid [8]. It has also been seen that the low quality mustard oil, which is not suitable for cooking purposes can be used in the synthesis of biodiesel [9, 10]. In the current study, authors investigated the influence of oil to alcohol molar ratio for optimum biodiesel yield obtained by transesterification reaction of waste mustard oil.

II. MATERIALS AND METHODS

The waste mustard oil (WMO) was collected from a local cafeteria and all chemicals were purchased from Sigma Aldrich, were of analytical grade.

a. Free Fatty Acid (FFA) Content of oil

FFA of oil was determined via evaluation of acid number. Acid number of waste mustard oil was found to be 1.8 with titration against KOH and phenolphthalein as an indicator. The method followed for the synthesis of biodiesel is base transesterification, as FFA was observed to be less than unity.

b. Transesterification

Transesterification reaction is a chain reaction in which tri-glyceride (oil) reacts with alcohol (methanol) in the presence of catalyst (Potassium Hydroxide) followed by separation process as shown in the figure 1.

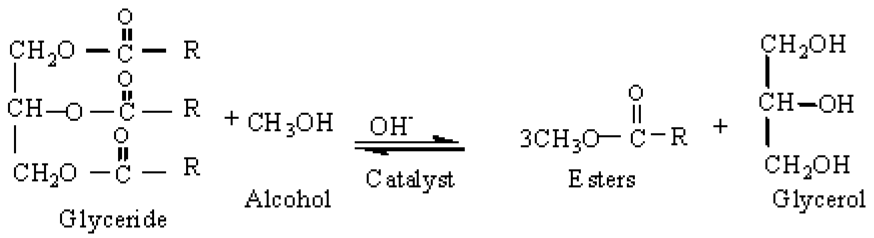

Figure 1: Transesterification Reaction

Methanol; in various ratios with respect to oil; was separately added to the potassium hydroxide pellets as catalyst (1.5 wt % of oil) and stirred until the complete dissolution of catalyst in methanol. The above stirred solutions were added to WMO in reactor and the reaction temperature was set at 65°C. The stirring of mixture was carried out for 1 hour at 400 rpm. After completion of the reaction, the material was transferred to separating funnel and kept overnight to settle down, which results in the formation of two phases. Upper phase was waste mustard methyl ester (biodiesel) and lower part was glycerol. Waste mustard biodiesel (WMB) was then washed with the warm water four to five times to remove the traces of glycerin, unreacted catalyst and soap formed during the transesterification [11]. This process was undertaken for each molar ratio of oil and methanol.

c. Biodiesel Yield

The biodiesel yield can be calculated by using the expression given below:

$$\text{Biodiesel yield (in \%)} = \frac{\text{Weight of Biodiesel}}{\text{Weight of Oil used}} \text{ X } 100$$

The process yield for biodiesel form waste mustard oil was calculated with varying molar ratio of alcohol (methanol) to oil viz. 4:1; 6:1; 8:1; 10:1:; 12:1; 14:1and reaction time was kept same for all the content ratios i.e. 1 hour. The ratio of catalyst (KOH) was also kept same (1.5 wt. % of oil).

III. RESULTS AND DISCUSSIONS

The optimum molar ratio of methanol to oil was determined as 6:1 for maximum yield of 79.4% of biodiesel fuel from WMO. However, yield was low for ratios below 6:1 proportion and attains maximum value at 6:1 and decreased when percent of alcohol increased afterwards as shown in figure 2 and figure 3.

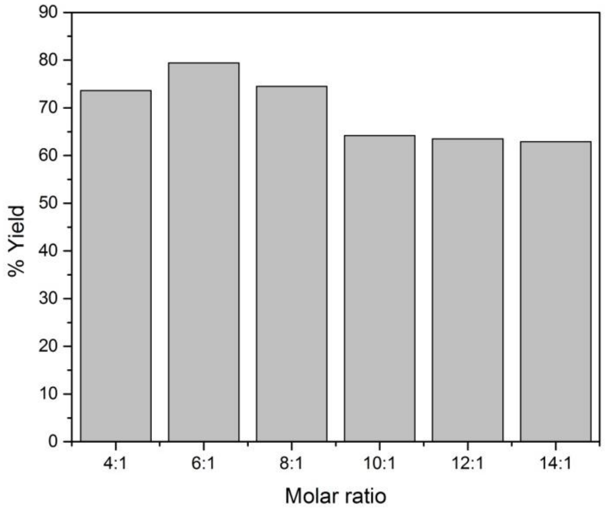

Figure 2: Variation of %yield with molar ratio of oil and methanol

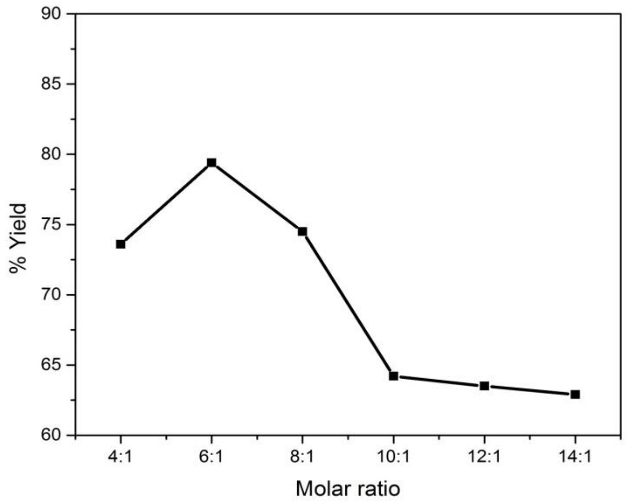

Figure 3: Variation of %yield with molar ratio of oil and methanol

The ratio for the transesterification requires three moles of alcohol and one mole of triglyceride to yield three moles of biodiesel and one mole of glycerol. The large excess of alcohol is required to drive the reaction to the forward direction. However, the high molar ratio of alcohol to vegetable oil enhances the solubility of glycerin in oil and it declines the yield [12].

IV. CONCLUSION

The molar ratio of alcohol to oil is an important variable for the biodiesel yield. The yield of biodiesel obtained from transesterification of waste mustard oil has been investigated with varying molar ratio of alcohol (methanol) to oil, increased from 4:1 to 14:1. The optimum molar ratio of methanol to oil was determined as 6:1 for maximum yield of 79.4% biodiesel and decreased when percent of alcohol increased afterwards.

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