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Production of Biodiesel using Used Ricebran Oil

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Abstract: ***The production of biodiesel from used ricebran oil at a fixed temperature and catalyst loading, various oil to methanol ratios (3:1, 4:1, 5:1 & 6:1) is carried out. The oil was transesterified using Potassium Hydroxide (KOH) and Sodium Hydroxide (NaOH) as catalysts in methanol to obtain ricebran oil methyl ester (Biodiesel). For the optimum reaction temperature, the biodiesel production was carried out at a constant loading of catalyst (1.05 grams) and temperature at 60^0C. From the experimental observations, comparative study on the processes using different catalysts the optimum yield obtained for KOH as catalyst which is 88.84% for 6:1 mole ratio at 60^0C, keeping agitator speed constant.***

Keywords: Transesterification, Biodiesel, Ricebran oil, Methanol, Catalyst

1. Introduction

Biodiesel is a cleaner burning fuel than diesel and a suitable replacement. It is made from non-toxic, biodegradable, renewable resources such as new and used cooking oils and animal fats. Fats and oils are chemically reacted with alcohols (methanol is used in the present work) to produce chemical compounds known as fatty acid methyl esters (biodiesel).

Glycerol, used in pharmaceuticals and cosmetics industry along with many other applications, is produced in this reaction as byproduct. The cost of the biodiesel however is the main hurdle in commercialization of the product. The cooking oil can be used as raw material, adoption of transesterification process and recovery of high quality glycerol from biodiesel byproduct are primary options to be considered to lower the cost of biodiesel.

There are four primary ways to make use of oil as biodiesel, direct use and blending, micro emulsions, thermal cracking and transesterification. Transesterification process is carried out by treating vegetable oils like sunflower oil, ricebran oil, groundnut oil and coconut oil etc. with methanol or ethanol using alkali catalyst (NaOH, KOH). If the production of biodiesel with KOH, the unsaturated fatty acids of the vegetable oil largely determines the extent of possible reaction. The higher the unsaturated fatty acid content, the higher will be the extent of transesterification reaction, the higher will be the glycerol formation but lower will be the biodiesel yield.

The main advantage of using biodiesel is it's renewably, better quality exhaust gas emissions it's biodegradability and given that there is no carbon present in it. It does not contribute to rise in level of carbon dioxide in the atmosphere and consequently to the greenhouse effect.

Fuel is a combustible substance containing carbon as a main constitutes which on burning gives larger amounts of heat (energy), which can be economically used for domestic and industrial purposes. Wood, charcoal, kerosene, petrol, diesel, producer gas, oil gas etc. are some of the fuels.

2. Experimentation

2.1 Objective

Batch production of Fatty Acid Methyl Ester (FAME) from used ricebran oils to use as a biodiesel fuel.

2.2 Methodology

The vital part of the process is the transesterification of triglyceride to methyl ester. The oils and fats belong to the family of lipids. Typically, fats come from animal source and
oils from plant sources. Fats and oils are formed primarily of triglyceride molecules. The triglyceride molecule is basically a tri ester of glycerol and three fatty acids (long alkali chain carboxylic acids). Mono and di glycerides can be obtained from triglyceride by substituting one or two fatty acids molecules with hydroxyl groups.

The process involves following steps
1) Testing the suitability of used ricebran oil by titration with NaOH or KOH.
2) Estimating of catalyst (lye: NaOH or KOH) required.
3) Transesterifying the triglycerides using base catalyst to get methyl ester.
4) Settling and separation of products.

2.3 Ingredients

1) **Oil:** The primary ingredient is oil or fat. This will be waste vegetable oil for the average producer at home, which may be collected for free in most restaurants.
2) **Alcohol:** The second ingredient is alcohol. Methanol, despite its toxicity and health hazards, is the preferred alcohol in the experiment.
3) **Catalyst:** The third and last ingredient is the catalyst. Both NaOH and KOH can be used. The advantage of KOH is that the residual glycerin is much less toxic than that produced with NaOH. KOH dissolves much more readily in methanol as well. However, an advantage of NaOH is that it is very simple and cheap to get as plunger, it is good to handle. Sometimes, it is found to be better to use NaOH of purity higher than of 96%.

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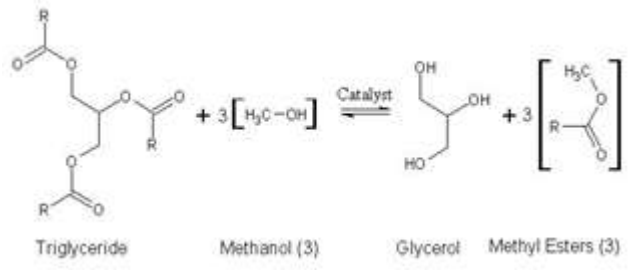
2.4. Methoxide Preparation

From standard literature, for 250ml of used ricebran oil and 50ml of methanol is to be mixed with 1.25gms of catalyst. Once prepared, it is stored in a glass jar or bottle that can be corked well. This mixture is called methoxide.

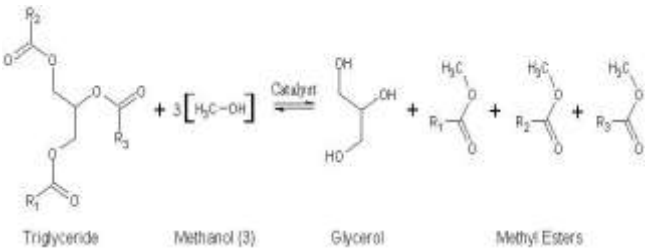
Depending on the catalyst with which the methanol is mixed, the methoxide is named after the catalyst.

1) If NaOH is the catalyst it is sodium methoxide solution.
2) If KOH is the catalyst it is the potassium methoxide solution.

An example of the transesterification reaction is:



Since natural oils are typically used in this process, the alkyl groups of the triglyceride are not necessarily the same. Therefore, distinguishing these different alkyl groups, we have a more accurate depiction of the reaction as follows.



Where R_1, R_2, R_3 are alkyl groups in the above shown schema.

2.5 Procedure

Used ricebran oil of 150ml is measured in a measuring jar and is taken into a batch reactor. Then the heater is switched on and the oil is heated to desired temperature and maintained at that temperature using a temperature controller. Meanwhile, alcohol is taken into a 100ml round bottomed flask and desired weight of catalyst (1.25gms) is taken and added into that flask and it is to shake gently until the catalyst is dissolved. When the desired temperature is reached the methoxide solution is carefully added into the reactor and the stirring is to be started.

The reaction mixture is maintained up to the desired time. Then after completion of maintenance the mixture is taken into a separating funnel and is allowed to settle for a period of 12-24 hours. After settling down we can see two layers of liquids in separating funnel where the bottom layer will be glycerine due to its high density, which is thick brown in colour and the top layer will be FAME(biodiesel), which is pale yellow in colour are separated into two different flasks and their respective weights are noted down.

Above procedure is repeated with used ricebran oil of 200ml, 250ml and 300ml by keeping the methanol quantity constant at 50ml.

3. Results and Discussions

3.1 Effect of reaction time

Variation of percentage yield (% Yield) of FAME with time at 60^{o}C temperature with KOH as catalyst is studied. Keeping temperature constant, reaction time is varied from 30 to 210 minutes. Percentage yield of FAME increases as time increases, reached a peak level after 180 minutes for 3:1 and 4:1 mole ratios & after 150 minutes for 5:1 and 6:1 mole ratios, thereafter in both the cases the yield showed a descending trend. This fall in yield may possibly be because of the initiation of other reactions, leading to the degradation of the formed fatty acid methyl ester (FAME) layer. Further, higher oil to methanol ratios (> 6:1) tend to faster reactions and hence the peak formation is observed at a lower reaction time of 150 minutes. The results are tabulated and plotted as shown in table 1 and figure 1.

Table 1

S. No.	Time (Min)	% Yield			
		Mole ratio 3:1	Mole ratio 4:1	Mole ratio 5:1	Mole ratio 6:1
1	30	67.56	68.63	72.41	75.12
2	60	69.3	71.88	75.72	77.49
3	90	72.84	73.9	79.68	82.62
4	120	73.92	74.13	81.52	85.35
5	150	74.1	78.66	84.85	88.84
6	180	80.03	81.92	83.16	86.03
7	210	79.01	80.58	80.24	85.37

Tab.1: Effect of reaction time at a temperature of 60^{o}C with KOH as a catalyst.

Figure 1

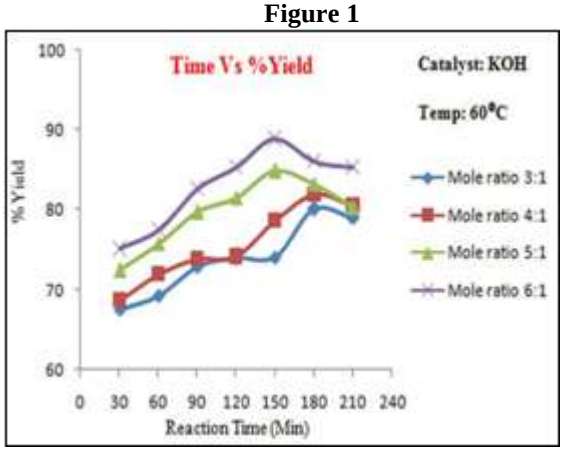


Figure 1: Time course of Biodiesel formation with KOH as a catalyst.

A Similar trend is observed with the other catalyst, NaOH also. The results are tabulated and plotted as shown in table 2 and figure 2.

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Table 2

S. No.	Time (Min)	% Yield			
		Mole ratio 3:1	Mole ratio 4:1	Mole ratio 5:1	Mole ratio 6:1
1	30	56.35	62.87	67.59	70.34
2	60	58.42	66.52	70.5	72.88
3	90	61.08	68.43	71.98	76.1
4	120	62.96	69.75	75.47	77.11
5	150	67.71	71.96	77.64	78.52
6	180	71.52	73.1	75.21	76.97
7	210	68.13	72.26	73.35	74.01

Tab. 2: Effect of reaction time at a temperature of 60^{o}C with KOH as a catalyst.

Figure 2

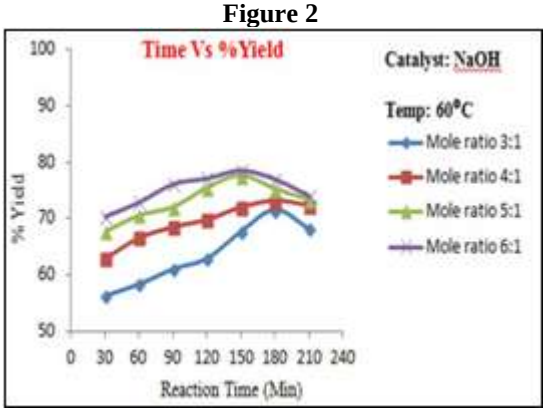


Figure 2: Time course of Biodiesel formation with NaOH as a catalyst

3.2 Effect of catalyst

Comparison of % yield of FAME (NaOH) with FAME (KOH) shows that % yield of FAME (KOH) is more than that of FAME (NaOH) at all the four mole ratios studied and represented in figure 3.

Figure 3

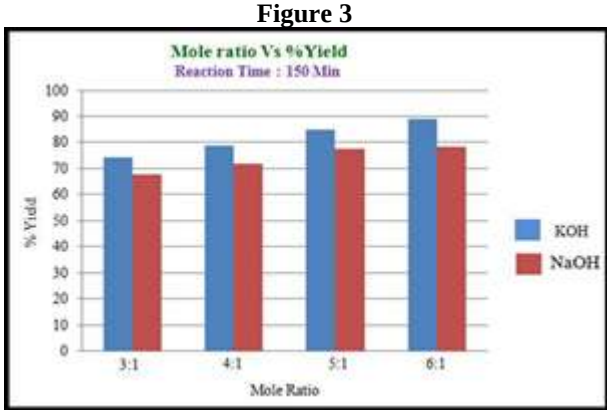


Figure 3: Effect of catalyst on %Yield at various conditions of reaction time and mole ratios

4. Conclusions

From the study, the following conclusions may be drawn

1) A reaction time of 150 minutes, provided the highest yield of 88.84%, when the transesterification reaction is conducted with used ricebran oil and methanol, catalysed by KOH.
2) With NaOH catalyst, the peak yield is realized at 60^{o}C & 6:1 oil to methanol ratio and is equal to 78.52%.
3) A 10.32% higher yield is achieved with KOH, as compared to NaOH catalyst.
4) Time for transesterification reaction decreased with increasing oil to methanol ratio.
5) Undesirable reactions are initiated at high concentrations of esters, causing degradation of esters.

Figure 4

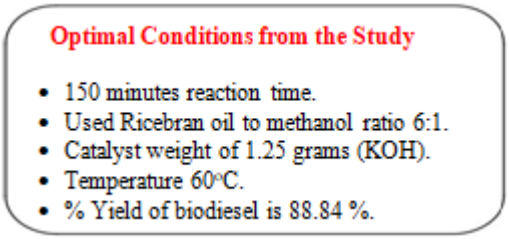


Figure 4: Optimal Conditions

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