Biodiesel production from waste oil using mussel shell as catalyst

Sona Gloriya Antony, Nithya Kurup

Abstract*: Waste utilization is an essential component of sustainable development and waste shells are rarely used to generate practical products and processes. Most waste shells are CaCO3 rich, once calcined at 950 °C for 2 hour and can be employed as inexpensive and green catalysts for the synthesis of biodiesel. Herein, utilization of mussel shell as green catalysts for the transesterification of substrate as feedstock into biodiesel. Waste cooking oil is used in the study which is easily available and sustainable, thus reduces the price of biodiesel to make it competitive with petroleum diesel. Transesterification was done in the presence of waste cooking oil, methanol and the prepared mussel shell catalyst depending on different parameter. The catalysts from waste shells were characterized by Scanning electron microscope (SEM), X-ray diffraction (XRD) and Fourier transformed infrared (FTIR) spectroscopy. The SEM image of catalyst showed the "rod like particle" structures. Different transesterification reaction are done based on the effects of methanol to oil ratio (1:5, 1:10, 1:15), reaction time (1h, 2h) and reaction temperature (55 °C, 60 °C, 65 °C) and catalyst loading (0.1%, 0.2%, 0.3%, 0.4%, 0.5%, 0.6%) and finally being optimized based on density. And then analyzing for Kinematic visocity, Flash point and Fire point

***Index Terms*: Biodiesel; mussel shell; tranesterification; petroleum diesel**

I. INTRODUCTION

The search for alternative energy resources to supplement or replace fossil fuels has been intensifying in the recent years because of the increase in environmental concern, energy security and fast depletion of fossil fuel resources. In this respect, biodiesel is an emerging alternative to diesel fuel derived from renewable and locally available resources which is biodegradable, nontoxic and environmentally friendly.[1]Biodiesel production is carried out through the process of transesterification reaction. The reaction is carried out with a suitable catalyst either homogeneous or heterogeneous. The selection of an appropriate catalyst depends on the amount of free fatty acids in the oil. Recently, homogeneous catalysts are widely chosen for biodiesel production in large scale operation. However, they are toxic, highly flammable and corrosive in nature. Furthermore, the use of homogeneous catalyst produced soaps as by-product and large amount of wastewater that required additional processing technologies and therefore increases the cost for proper disposal. On the other hand, heterogeneous catalysts are capable to overcome the problems faced by the former ones. [2]. Transesterification is the process of converting the vegetable oil or animal fats to biodiesel. Reaction are often carried through an acid or base catalyst.Transesterification of triglyceride using homogeneous and heterogeneous catalyst produces biodiesel[4,5]

The primary aim of the study is to produce biodiesel from raw materials such as waste cooking oil and mussel shell. So as to produce less environment polluting biodiesel as compared to petroleum diesel.

II. EXPERIMENTAL DETAILS

A. Stage *Materials*

Mussel shells were collected from a nearby fishmarket in kollamkerala, India. Waste frying oil was collected from bakeries and restaurants in kollam, India. The collected waste oil from different bakery was filtered using a filter paper to remove the comtamination from it. Anhydrous methanol of analytical grade are taken from the laboratory of BIOVENT-Solution for Research, were used in the transesterification reaction.

B. Catalyst Preparation

Mussel shell was initially rinsed with distilled water to remove any unwanted materials on its surface. The washed mussel shells were then dried in hot air oven at 105 °C for 24 h. The dried mussel shells were calcined in a muffle furnace under static air conditions at 950 °C for 2 h to transform the calcium species in the shell into CaO particle.

C. Catalyst Characterisation

Scanning Electron Microscopy (SEM) analysis was performed to confirm the morphology of the catalyst using a High Resolution Scanning Electron Microscope.

Fourier Transformed Infrared (FTIR) spectroscopy was used to study the functional groups attached to the catalysts with Nicolet is50FT-IR at wave number 5000-400 cm-1

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D. Optimisation for Biodiesel Production

Biodiesel has been produced by the transesteriication of different ratios of waste cooking oil, methanol and catalyst such as 1:5, 1:10, 1:15 methanol to oil ratio and for different catalyst loading rates such as 0.1%, 0.2%, 0.3%, 0.4%, 0.5%, 0.6%. Varying reaction time as 1h, 2h, and reaction temperature as 55 °C, 60 °C, 65 °C was also optimized according to the need.

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E. Transesterification process

In Fig. 1,Transesterification reaction was done using a reactor at . After reaction the product was transferred to a 1000ml separating funnel for an overnight to produce a clear separation between the layers. In the separating funnel, it appear in 2 layers where bottom layer is glycerol and the top layer is found to be biodiesel as shown in Fig. 2. After separation, biodiesel with density 0.87 is back washed with distilled water to remove any contamination, unreacted methanol content and glycerol. Fig. 3 shows while back washing with distilled water it appears in two layers where bottom layer is water and top layer being biodiesel. Back washing is done 2 to3 times

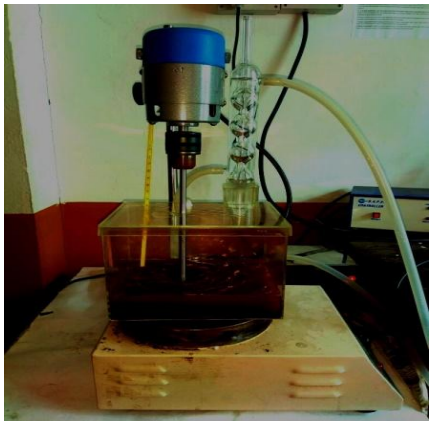

Fig. 1 Transesterification in reactor

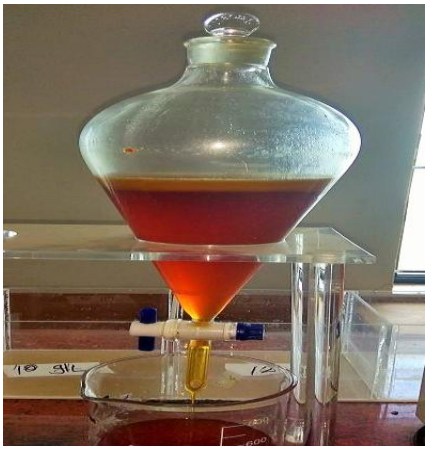

Fig. 2 Transesterified product in separating funnel

Fig. 3 Transesterified product backwashed with distilled water

III. Result and Discussion

A. Properties of Waste cooking oil

The physicochemical properties of waste cooking oil was analysed and shown isin the table 1. From the table it is clear that free fatty acid is the half of acid value. And the biodiesel yield is inversely proportional to the free fatty acid that is as free fatty acid value decreases, biodiesel yield increases.

Table 1. Physicochemical properties of waste frying oil used in the present study

Properties	
Density at 25 °C (kg/m^3)	912
Acid value (mg of KOH/gm. of oil)	4.488
Free fatty acid (mg of KOH/gm. of oil)	2.244

B. Characterization of catalyst using SEM

Fig. 4 shows the SEM image of the catalyst after calcination process for different magnification range. However the calcinated mussel shell shows a rod like particle was observed. It indicated a regular micro morphology of a rod like particle by Nijuet. al [8]

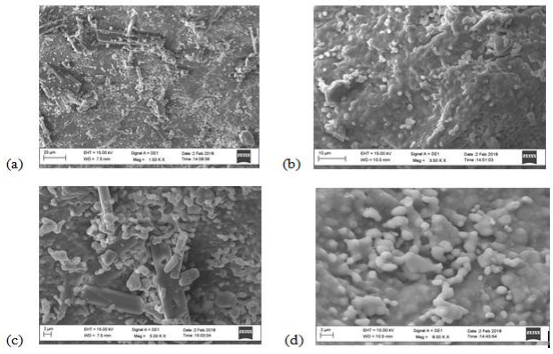

Fig. 4SEM image at magnification range (a) 1.50KX (b)3.50KX (c)5.00KX (d)8.00KX

C. Characterization of catalyst using FTIR

Figure 5 shows the FTIR spectroscopyof the prepared catalyst observed at a range of 500 – 4000cm^{-1}.FTIR analysis is carried out to identify the possible functional groups. And it shows that the peaks are in fingerprint portion. Peaks at 1390 cm^{-1} indicates CO bond. Wavenumbers of 873, 1450, 1640 cm-1 corresponds to CO_{2-3} andwavenumbers of 3570 an 3420 cm-1 are OH groups [1].

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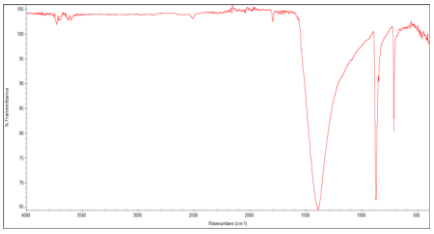

Figure 5:FTIR spectroscopy of prepared catalyst

D. Optimization Results

After optimization, it is seen that density was concurrently optimized at the methanol to oil ratio of 1:5. And from that ratio, the catalystloading was optimized at 0.5% at a temperature of 60 °C and a reaction time of 1 hour.

IV. CONCLUSIONS

In this study, waste cooking oil and mussel shell after calcination has been used as the raw material for the production of biodiesel. Thereby enhancing cost effective and green catalyst for the production process. Further characterisaton of catalyst such as SEM and FTIR was analysed. Transesterification reaction was carried out with waste oil, catalyst and methanol at 1:5 methanol to oil ratio, 0.5% catalyst loading at 1 hour and 60°C reaction temperature conditions and optimized based on density.

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