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Design and Fabrication of a Model Reactor for Biodiesel Production from Waste Cooking Oil

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***Abstract*—. Nowadays, the production of biodiesel plays an important role due to the pollution caused by other fuels. Transesterification reaction for the production of biodiesel can be carried out either in the presence of an alkali catalyst or a biological catalyst. In this study, by using mollusk shells as a green catalyst the transesterification reaction was carried out. Waste fried cooking oil was used for the production since it was necessary to analyze how far biodiesel is feasible. Physiochemical properties such as density, acid value, and free fatty acid content of waste oil were checked to know whether the raw material is suitable for biodiesel production. Distinct types of reactor plans have been used for efficient, biodiesel production and biomass utilization including oil expellers as reactors, transesterification, and biomass conversion reactors. In this work, a model reactor was designed for the production of biodiesel in which the temperature and stirring option all can be controlled using necessary instruments. Different transesterification reactions were done based on the methanol to oil ratio (6;1, 7:1, 8:1, 9:1) and catalyst loading (0.75%, 0.85%, 1%, 1.5%, 1.75%, 2%,3%,3.5%) and finally, it was optimized based on density at 7:1 molar ratio and 3.5% catalyst concentration. In the optimized study, the biodiesel yield obtained was 70.71% also the biodiesel produced from the reactor met the requisite quality standards of ASTM.**

Key Words: Biodiesel, transesterification, mollusk shell, catalyst, model reactor.

I. INTRODUCTION

While energy consumption is increasing day by day, the usage of non-renewable fossil fuels is also showing steeper growth. Studies show that the combustion of fossil fuels contributes more than half of Co_2 emissions compared to that of human activities. Under such situations, it is important to find out other energy sources in order to overcome the harmful effects caused by greenhouse gases. In the background of environmental concerns and other harmful effects, the global communities have started searching for alternative renewable fuels. On this basis, Biodiesel from alternative sources such as microalgae is considered to be a potential solution. Microalgae-based biodiesel is sustainable and more eco-friendly and is also rich in qualities like photosynthetic capacity, and faster growth rate.

Currently, the usage of fossil fuels raised steadily compared to that of past years. Over usage of fossil fuels leads to many environmental issues like global warming. The hazardous effects of global warming include a shooting up of temperature and, major changes in climatic conditions which even leads to many health issues for the living beings. In order to avoid the disastrous consequences caused by fossil fuel energy, the production of energy from non-fossil and eco-friendly energy resources became crucial. In the coming future, renewable energy resources like biofuels, hydroelectric power, solar, wind, geothermal, etc. going to play an inevitable role.

Nowadays, the search for alternative fuels has been raised due to environmental concerns. On this basis, biodiesel is an emerging alternative fuel to diesel that can be extracted locally and is also eco-friendly in nature. Using homogeneous catalysts such as NaOH, KOH or other methoxides in transesterification can give rise to the production of biodiesel. Mostly the production of biodiesel is from vegetable oils which are from edible plants, such as rapeseed, palm, soybean, sunflower, etc. Alcohol is also used as raw material for the production of biodiesel. Moreover, methanol is also used for the production of biodiesel because of its low cost and its physical and chemical properties. Catalyst is one of the other main materials used for the production of biodiesel. Catalyst is of different types like enzyme catalysts, homogeneous catalysts, and heterogeneous catalysts.

II. METHODOLOGY

In this research, biodiesel is been produced from waste cooking oil in the presence of mollusk shells as a catalyst. The transesterification reaction was carried out in a model reactor which was designed using the necessary instruments.

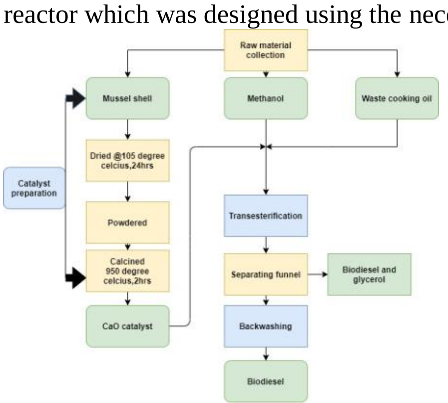

Fig 1 Methodology flow chart

A. Materials

Mollusk shells were collected from different sea shore regions in Alappuzha, Kerala, India. Waste fried cooking oil was collected from the bakeries in Alappuzha. Methanol was taken from the laboratory. The magnetic stirrer, heating plate, thermometer, and beaker which are all required for the reactor design were purchased from the shops in Kollam.

B. Filtration of Oil

The collected waste fried cooking oil was filtered using a filter paper in order to remove all the impurities present in the oil. The contaminants present in the oil may lead to a decrease in the yield.

C. Catalyst Preparation

CaO catalysts were prepared by the calcination treatment of mollusk shells. The mollusk shells were washed properly to remove all the contaminants present on the shell, after tap washing it was washed in distilled water. Later the washed shells were kept for 24 hours in an open region in order for drying. After that, the shells which were crushed into pieces using a hammer were kept in a muffle furnace for 2 hours at 880^0C for the formation of CaO particles.

D. Design of a Model Reactor

The reactor was designed as shown in figure 2. In this model reactor, a 1000 ml glass beaker was used, in the upper portion of the beaker, two holes were provided for the thermometer and cooling condenser of diameters of 10mm and 20mm respectively. The thermometer was used for temperature detection of the solution and a cooling condenser was used for the cooling action to take place. For heating, the solution to a particular temperature heating plate was used and in the heating plate, the required temperature was set. In order for stirring up magnetic stirrer was placed inside the solution and using it the solution got stirred up.

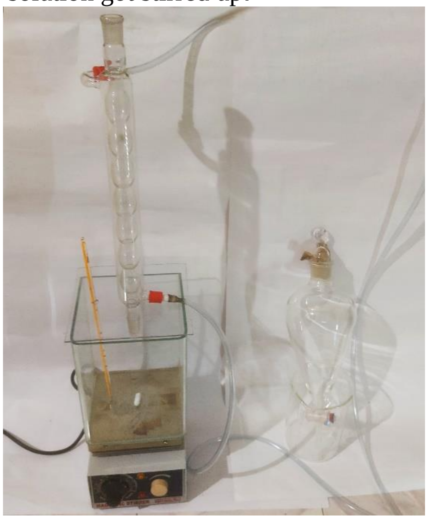

Fig 2 Model Reactor

E. Working of a Model Reactor

Transesterification was carried out in the reactor, as shown in Fig 3 the 1000 ml beaker was kept on the heating plate, and in the holes provided in the beaker, the thermometer and water-cooling condenser were inserted. To the beaker methanol as per the ratio was charged into the reactor and then the catalyst was provided to this particular mixture waste cooking oil was poured and then the temperature was set up to 60^0 c the temperature was given based on the boiling point of the methanol. Along with setting up the temperature, the magnetic stirrer functioned to mix up the solution. The reaction took place for 1 hour at 60^0 c. After the reaction, it was transferred to the separating funnel as shown in figure 4.

Fig 3 – Reaction in Reactor

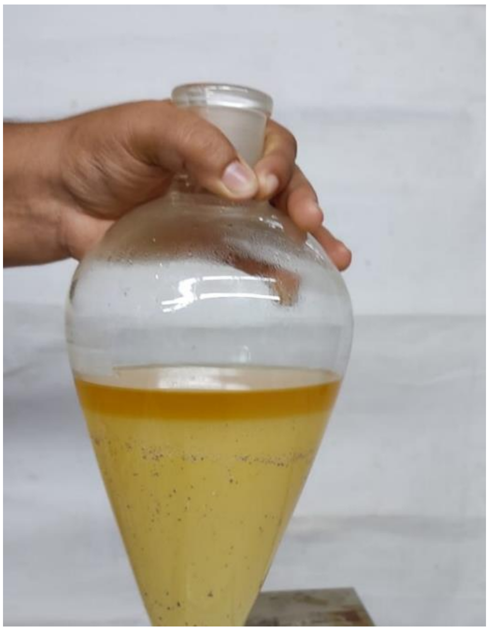

Fig 4 Product in separating funnel

F. TESTS ON SYNTHESIZED BIODIESEL

In order for knowing the properties of biodiesel certain tests were conducted. Firstly, after the production of biodiesel, the density of the biodiesel was analyzed. Secondly, the Kinematic viscosity test and Flashpoint and Fire point test were conducted to know whether the properties of synthesized biodiesel come under standard values of biodiesel.

III. RESULT AND DISCUSSION

A. Properties of waste cooking oil

The main properties of the waste cooking oil were determined and are shown in table 1. From many studies, it is clear that the free fatty acid content should be less than 3 in order for the biodiesel production, or else soap formation will be there if the FFA value is more than 3, in this case from the table it is clear that the FFA value is less than 3 and it's suitable for biodiesel production.

Properties	Values
Density (g/cm^3)	0.848
pH	5
Acid Value (mg of KOH/gm of oil)	4.488
Free fatty acid (mg of KOH/gm of oil)	2.244

Table 1 Properties of waste cooking oil

B. OPTIMIZATION RESULT FOR MODEL REACTOR

After optimization, it was found that the density was within the standard limit at the methanol to oil ratio of 7:1 and at catalyst loading of 3.5% at a temperature of 60^{0}c.

C. TESTS VALUES ON SYNTHESIZED BIODIESEL

The main properties of the synthesized biodiesel were analyzed and tested to know whether it comes under the standard limit. Table 2 shows the obtained values and standard values of the biodiesel.

Properties	Test value	Standard value as per ASTM
Density (kg/m^3)	890	850-900
Kinematic Viscosity(mm^2/s)	3.3	1.9-6
Flash point (^{0}c)	125	100-170
Fire point (^{0}c)	138	10^{0}c higher than fire point

Table 2 TEST VALUES ON SYNTHESIZED BIODIESEL

IV. CONCLUSION

In this study, waste fried cooking oil was used as the raw material and mollusk shell after calcination was used as a catalyst for the biodiesel production. Transesterification reaction was carried out in the model reactor at 7:1 methanol to oil ratio and 3.5% catalyst concentration and required density within the standard limit was obtained.

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