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Magnetized-Nano Catalyst KF/CaO-$Fe_3O_4$for Biodiesel Production from Beef Tallow

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ABSTRACT

The nano-magnetic catalysts KF/CaO-Fe_3O_4 were prepared and used for the transesterification of beef tallow to produce biodiesel. The raw materials were brought as a waste material from the slaughter house. The made up catalyst was characterized with X-Ray Diffraction spectroscopy (XRD) and Thermal Gravimetric Analysis (TGA). For the investigation of the transesterification reaction various process parameters such as methanol to oil molar ratio, reaction temperature, catalyst loading and reaction time were conducted. After the process was completed, the results show that 10:1 molar ratio of methanol to oil, 5 g of catalyst, 55 °C reaction temperature and 1 h reaction time was the optimum condition to achieve a yield of 94 wt%. The catalyst used for the production of biodiesel from beef tallow shows an effective result.

KEY WORDS: Nano catalyst, Beef Tallow, Biodiesel, Transesterification.

1. INTRODUCTION

Due to the demand of energy, rapid depletion, and to avoid the emission of carbon monoxide, particulate matter and sulphur oxide in the environment by using fossil fuels, the researchers are focusing in find an alternate fuel. Biodiesel which is the alternate fuel for fossil fuel produced by transesterification of vegetable oil and animal fat using a base or an acid or an enzyme catalyst. Tallow is an animal fat mostly used in the soap industries, the excess amount of tallow is considered as waste and pollutes environment. In order to transform the waste material into a useful material, biodiesel was produced via transesterification reaction using alkali catalyst, acid catalyst, enzyme catalyst or nano catalyst. This work is based on the use of waste tallow for the production of biodiesel using nano based catalyst. The selection of catalyst is mainly dependent on the availability of free fatty acid present in the beef tallow oil. The oil which possess lower amount of free fatty acid, base catalyst can be used and for oil possessing higher amount of free fatty acid, acid catalyst can be used (Surbhi Semwal, 2011). Nano-magnetic catalysts are used for the production of biodiesel for the oil containing higher amount of free fatty acid. While using homogeneous and heterogeneous catalyst for the production of biodiesel more amount of water has been utilized during the separation process. In order to reduce the separation costs, a nano-magnetic catalyst is used to reduce the loss of catalyst during separation. Fatty acid methyl ester produced is utilized by the automobiles after testing with the ASTM specification. Once the produced biodiesel meets the specification, it can be used directly in the engine without any modification or can be blended with petroleum diesel which has less sulphur content and high cetane value (Fengxian Qiu, 2011).

2. MATERIALS AND METHODS

Waste Tallow material is collected from the slaughter house and melted up to 60°C in order to remove the waxy material, suspended particles and residue. The melted tallow was then filtered, centrifuged and decanted to make the oil clean for the next step. All chemicals and glasswares for the experiment were brought from Merck, Mumbai.

Transesterification set up: The experiment was carried out in a 250 ml three-neck glass flask equipped with a reflux condenser (Libai Wen, 2010). The mixture was agitated by using a stainless steel stirrer. The whole set up was placed in a heating mantle. The mixture of methanol and catalyst was charged into the reactor containing tallow oil.

Optimization studies were performed for various parameters such as methanol to oil molar ratio, catalyst amount, reaction temperature and reaction time. After optimizing each parameter, it was kept constant for further optimization studies. Initially, methanol to oil molar ratio was varied from 3 to 12 molar ratios of alcohol. Then, catalyst amount was varied from 1 to 6 g, reaction temperature ranged from 40 to 65 °C and reaction time was from 20 to 70 min. After the reaction is completed, the sample was poured into a separating funnel for the separation process. Due to gravity separation, the upper layer contains fatty acid methyl ester and the lower layer contains glycerol, extra methanol and undesired products. Catalyst was separated easily by applying magnetic field.

3. RESULTS AND DISCUSSION

Characterization of KF/CaO-Fe_3O_4 catalyst: Five different peaks were obtained at 2θ values 20.1°, 28.3°, 34.8°, 40.6° and 79.5° which are associated to $KCaF_3$. The crystal size was calculated using Debye-Scherrer formula shows 149.5 nm. TGA curve of KF/CaO-Fe_3O_4displays two loss weight peaks, at 340 to 450 °C and 670 to 800 °C as shown in Fig. 1, corresponding to the crystal water loss (15%) and sintering of the preformed compound (4%) respectively. The results of the thermal analysis suggest that the best calcination temperature of nano-magnetic solid base catalyst between 670 to 800 °C (Shengyang, 2011).

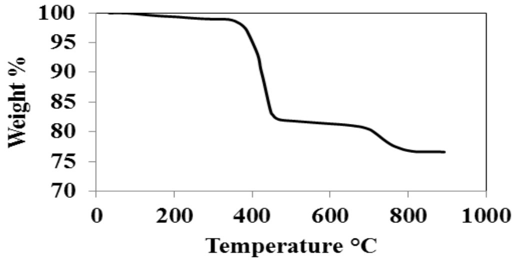

Figure 1. TGA plot of CaO-Fe_3O_4

Effect of ratio of methanol to Tallow oil: The effect of methanol to oil molar ratio is one of the most important parameter which will determine the yield of biodiesel. Excess amount of methanol was used in the transesterification process in order to shift the equilibrium and to increase the forward reaction for obtaining maximum yield (Anh, 2008). Fig.2 shows when methanol to oil ratio was 3:1 the conversion of biodiesel at a temperature of 55°C in the presence of 3 g of nano magenitized catalyst yielded 68%. By increasing the methanol to oil ratio further from 5:1 to 10:1 the conversion increased to a maximum of 89.8%. On further addition of methanol to oil ratio 12:1, yield remains constant.

Effect of concentration of catalyst: As shown in Fig. 3 a yield of about 72% was obtained for the methanol to oil molar ratio of 10:1 and 1g of catalyst. Increasing the catalyst amount from 2 to 6g, the conversion increases from 85.5 to 88.7% through 90.6% yield. This indicates that the optimum catalyst amount was 5g for obtaining a yield of 90.6% at 60°C.

Effect of temperature: The effect of temperature towards the conversion of biodiesel has been indicated in the Fig.4.The reaction took place using methanol to oil molar ratio as 10:1, 5g of catalyst and temperature of 40°C which results in 49.3% biodiesel yield. Then on increasing the temperature from 45°C to 75°C, conversion initially increases from 62.8 to 93.2% at 55 °C, which in turn gradually reduces to 91.7%. The optimum temperature was determined as 55°C for a yield of 93.2%.

Effect of reaction time: The effect of reaction on various time intervals has been determined during the transesterification reaction (Haq Nawaz, 2008). As we increase the time from 20 to 70min and keeping the temperature as 55°C, amount of catalyst as 5g, conversion of biodiesel goes on increases as shown in Fig. 5. A maximum conversion of 94% was obtained in 60 min and there was no notable increase after the reported time.

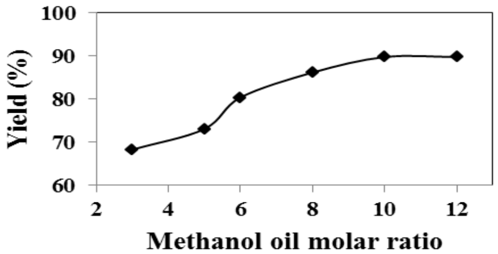

Figure 2.Effect of methanol to oil molar ratio on biodiesel yield

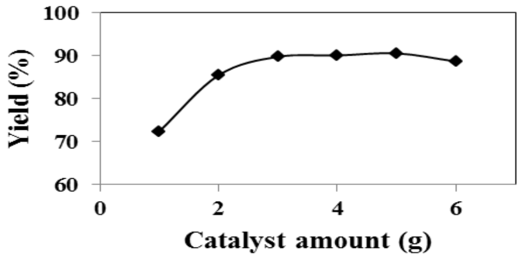

Figure 3. Effect of concentration of catalyst on yield

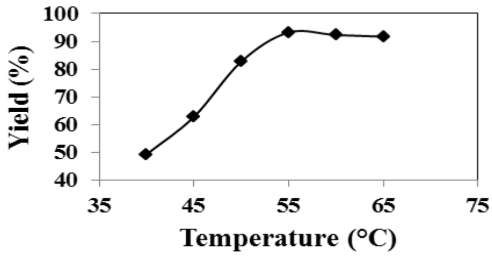

Figure 4.Effect of temperature on yield

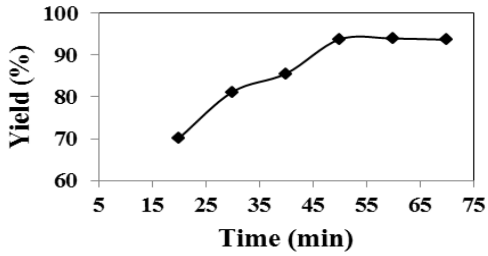

Figure 5.Effect of reaction time on yield

4. CONCLUSION

This work shows that KF/CaO-Fe_3O_4based catalyst is suitable for biodiesel production from beef tallow. The effect of methanol to oil molar ratio, concentration of the catalyst, reaction temperature and reaction were studied and the optimum value for the methanol to oil molar ratio was 10:1, catalyst was 5 g, temperature was 55°C and the reaction time was 60 min.

REFERENCES

Anh N Phan, Tan M Phan, Biodiesel production from waste cooking oils, Fuel, 87, 2008, 3490-3496.

Fengxian Qiu, Yihuai Li, Dongya Yang, Xiaohua Li, Ping Sun, Heterogeneous solid base nano catalyst: Preparation, characterization and application in biodiesel production, Bioresource Technology, 102, 2011, 4150-4156.

Haq Nawaz Bhatti, Muhammad Asif Hanif, Mohammad Qasim, Ata-ur-Rehman, Biodiesel production from waste tallow, Fuel, 87, 2008, 2961-2966.

Libai Wen, Yun Wang, Donglian Lu, Shengyang Hu, Heyou Han, Preparation of KF/CaO nano catalyst and its application in bio diesel production from Chinese tallow seed oil, Fuel, 89, 2010, 2267-2271.

Shengyang Hu, Yanping Guan, Yun Wang, Heyou Han, Nano-magnetic catalyst KF/CaO-Fe_3O_4 for biodiesel production, Applied Energy, 88, 2011, 2685-2690.

Surbhi Semwal, Ajay K Arora, Rajendra P Badoni, Deepak K Tuli, Biodiesel production using heterogeneous catalysts, Bioresource Technology, 102, 2011, 2151-2161.

Xuejun Liu, Huayang He, Yujun Wang, Shenlin Zhu, XianglanPiao, Transesterification of soybean oil to biodiesel using CaO as a solid base catalyst, Fuel, 87, 2008, 216-221.