



Biodiesel Production from Tung Seed Oil using Strong Base Supported on Activated Carbon from Longan as Catalyst by Microwave Technique

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Abstract

This research project studied biodiesel production from tung seed oil via transesterification reaction using catalysts supported activated carbon from low grade longan, sodium hydroxide associated with activated carbon (NaOH/AC). The reaction conditions were varied as follow; molar ratios of oil to methanol 1 : 8 – 1 : 16, amount of catalysts 1 – 5 wt%, reaction temperature of 65 °C and reaction time for microwave of 5 minutes. It was found that the highest yield of biodiesel was 84.41% when using the ratio of oil to methanol 1:8 with 1 wt% catalyst, reaction temperature 65 °C and reaction time 5 minutes. Physical and chemical properties of biodiesel were studied. Purity of biodiesel was determined by gas chromatography mass spectrometry (GC-MS) technique. The result showed that the biodiesel purity was 99.96%.

Keywords: activated carbon; biodiesel production; longan, microwave; tung seed oil

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1. Introduction

In recent years, the demand for energy has increased rapidly with the growing world population. The reserves of fossil fuels are being depleted, thus renewable energies are being urgently developed [1, 2]. Among the applicable renewable energies, biodiesel has attracted much attention [3]. Biodiesel could be a sustainable substitute for petroleum diesel. Biodiesel is non toxic, biodegradable and has lower exhaust emissions than petro diesel. Biodiesel can be synthesised by transesterification of vegetable oil or animal fats with alcohols in the presence of a catalyst. It is used to define a mixture of fatty acid alkyl esters. Transesterification can be catalyzed by alkalis, acids, or enzymes [4 – 6], and can be either homogeneous or heterogeneous. The commonly used homogeneous base catalysts in transesterification of vegetable oil are NaOH, KOH and their alkoxides because they are more active

Homogeneous alkali-catalyzed transesterification is much faster than acid-catalyzed transesterification [7]. However, the conventional method of producing biodiesel utilizes homogeneous catalysts which require the use of water to wash away the catalysts at the end of the reaction, leading to the generation of wastewater. Therefore, it is considerably more costly to separate the catalyst from the product solution. Way to reduce the amount of wastewater that is generated by the use of heterogeneous catalysts rather than homogeneous catalysts.

Heterogeneous base catalysts have many advantages such as non-corrosive, environmentally benign and present fewer disposal problems. Furthermore, they are much more easily separated from the liquid products and can be designed to give higher activity, selectivity and longer catalyst lifetimes.

Nowadays, many types of heterogeneous catalysts have been explored for transesterification of vegetable oils to biodiesel, such as alkaline earth metal oxides and various alkali metal compounds supported on alumina or zeolite [8 – 12]. The use of heterogeneous catalysts also using a support, that can arise to ensure good mixing and possibility of molecules being trapped in the pores of the support. Sodium or potassium hydroxide are homogeneous catalysts, but when supported on activated carbon becomes a heterogeneous catalyst that can be easily separated after the reaction has completion.

Microwave irradiation has been an alternative heating system in transesterification over the past few years. As a result, a drastic reduction in the quantity of by-products and a short separation time have been obtained. Today, microwave irradiation is widely used in many areas including assisting transesterification of vegetable oils to produce biodiesel.

The main objective of this study was to investigate the biodiesel transesterification reaction using activated carbon supported catalyst by microwave technique to obtain the optimal procedure for achieving the highest possible percent yield of biodiesel. The optimal reaction conditions of amount of catalyst used, reaction temperature, reaction time and oil/methanol ratio were also investigated.

2. Materials and Methods

Materials

Low grade longan obtained from a longan orchard in Chiang Mai. Tung seed oil was purchased from Gemon China. Methanol and sodium hydroxide were purchased from Merck KGaA Co.Ltd., Germany. Phosphoric acid was purchased from Italmar (Thailand) Co., Ltd.

Preparation of Activated Carbons

The activated carbon that was used was produced from low grade longan and chemical activated. The longan was ground and dried by sunlight for 2 – 3 days, then heating in an oven at 103 °C for 72 hours, chemically activation by 85% H₃PO₄ for 24 hours was employed.

Preparation of Catalyst

The catalyst was prepared through impregnation by soaking. Activated carbon was placed in solution of sodium hydroxide and agitated for 24 hours. The impregnated activated carbon was dried at 120 °C for 24 hours to remove the water

Biodiesel Production

In transesterification reaction, triglycerides were converted into esters (biodiesel) with methanol using a sodium hydroxide-activated carbon (NaOH-Ac) catalyst. The reaction was carried out in a conical flask with tung seed oil, methanol and the activated carbon supported sodium hydroxide as the catalyst. The transesterification reaction was assisted by microwave irradiation for 5 min. The reaction temperature was set in this step. The molar ratios of oil to methanol were varied between 1:8, 1:10, 1:12, 1:14 and 1:16 while the catalyst loadings were varied in the range of 1 – 5 wt %. At the end of the reaction, the mixture was filtered to remove the catalyst.

Chemical characterization

In this research project, the functional groups of biodiesel products were investigated by Fourier Transform Infrared Spectrometer (Perkin Elmer model Spectrum RX I, Perkin Elmer, England). The spectra were recorded in the range 400 – 4,000 cm⁻¹. Using gas chromatography-mass spectrometry to separate and identify the methyl esters.

3. Results and Discussion

Effects of Mass Ratio of Catalyst to oil on Biodiesel Yield

The effects of the mass ratio of NaOH-Ac to oil for percent yield of tung seed oil to biodiesel were studied under the reaction conditions of: oil/methanol molar ratio, 1:10; reaction temperature, 65 °C and microwave irradiation 5 min. Percent yield was calculated using equation (1).

$$\%Yield = \frac{\text{Actual Mass Product}}{\text{Theoretical Mass of Product}} \quad (1)$$

The results shown in Fig. 1 that as the weight% of NaOH-Ac to oil is increased from 1 – 5 wt %, the amount of biodiesel yield decreased continuously. The reason may be offered to explain why 2 – 5 wt % of catalyst used resulted in lower percent yield. More catalyst used might initiate the saponification reaction. This might explain why 2 – 5 wt % of catalyst used resulted in lower percent yield than 1 wt %.

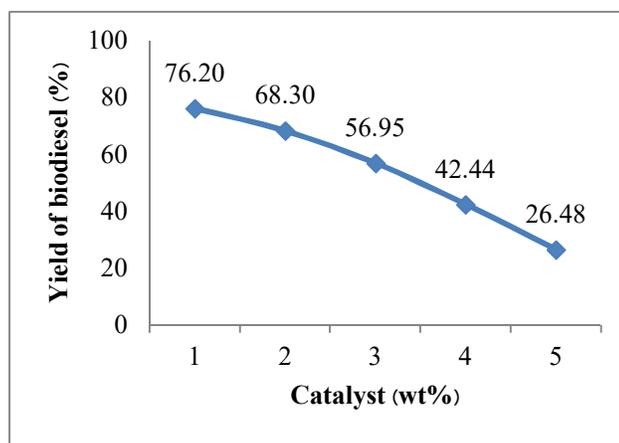


Fig. 1 Effects of mass ratio of catalyst to oil on biodiesel yield. Reaction conditions: oil/methanol molar ratio 1:10; reaction temperature 65 °C and microwave irradiation 5 min.

Effects of Molar Ratio of Oil to Methanol on Biodiesel Yield

The effects of the molar ratio of oil to methanol on the production of biodiesel were studied under the reaction conditions of NaOH-Ac 1 wt %; reaction temperature 65 °C and microwave irradiation 5 min. The results shown in Fig. 2 that, the percent yield at these oil/methanol molar ratios were 84.41%, 79.63%, 80.12%, 78.71% and 79.80%, respectively. The percent yield decreased when increased the oil/methanol molar ratio. The reason may be offered to explain why increased oil/methanol molar ratio resulted in lower percent yield. Excess methanol will increase the solubility of by-product (glycerol), which might initiate the reverse reaction to reduce the percent yield

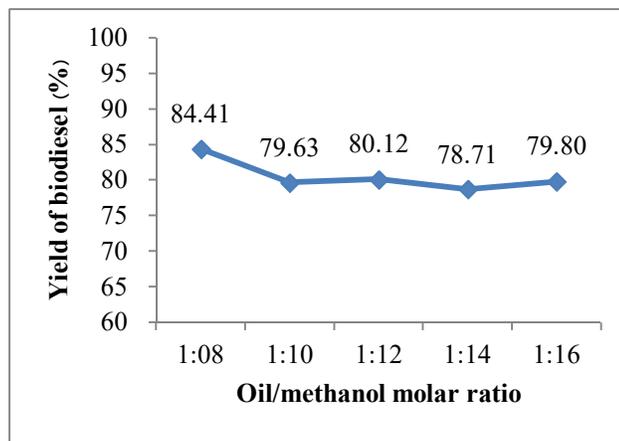


Fig. 2 Effects of molar ratio of oil to methanol on biodiesel yield. Reaction conditions: Catalyst amount 1 wt%; reaction temperature 65 °C and microwave irradiation 5 min.

Characterization of Biodiesel from Tung Seed Oil by FT-IR

The FT-IR spectrum of the biodiesel from tung seed oil are shown in Fig. 3 and the most prominent peaks assigned in Table 1.

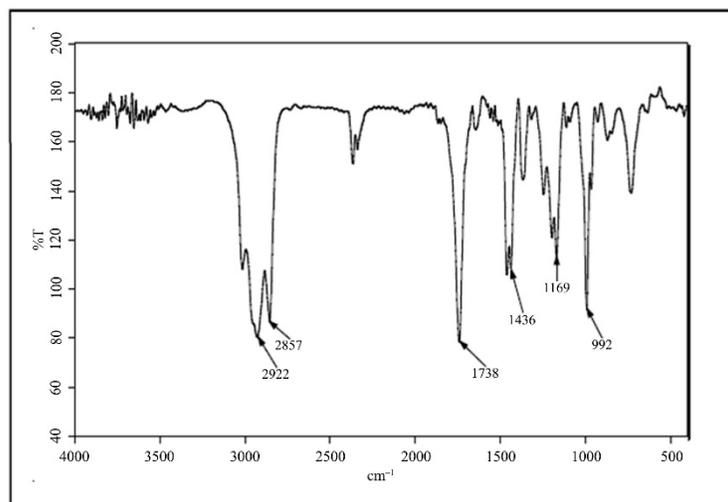


Fig. 3 FT-IR spectrum of biodiesel produced from tung seed oil.

Table 1 Analysis of the functional groups of biodiesel in the FT-IR spectrum.

| Wave number (cm ⁻¹) | Functional groups |
|---------------------------------|--|
| 2,857 – 2,922 | CH ₂ , CH ₃ stretching |
| 1,738 | C=O stretching |
| 1,436 | C-H bending |
| 1,169 | C-O stretching |

Chemical Composition of Biodiesel by GC-MS

The chemical composition of the biodiesel from tung seed oil from GC-MS is shown in Fig. 4. It was found that the retention times of the methyl esters of fatty acids were in the range of 25.570 – 31.459 min with a purity of 99.96 %.

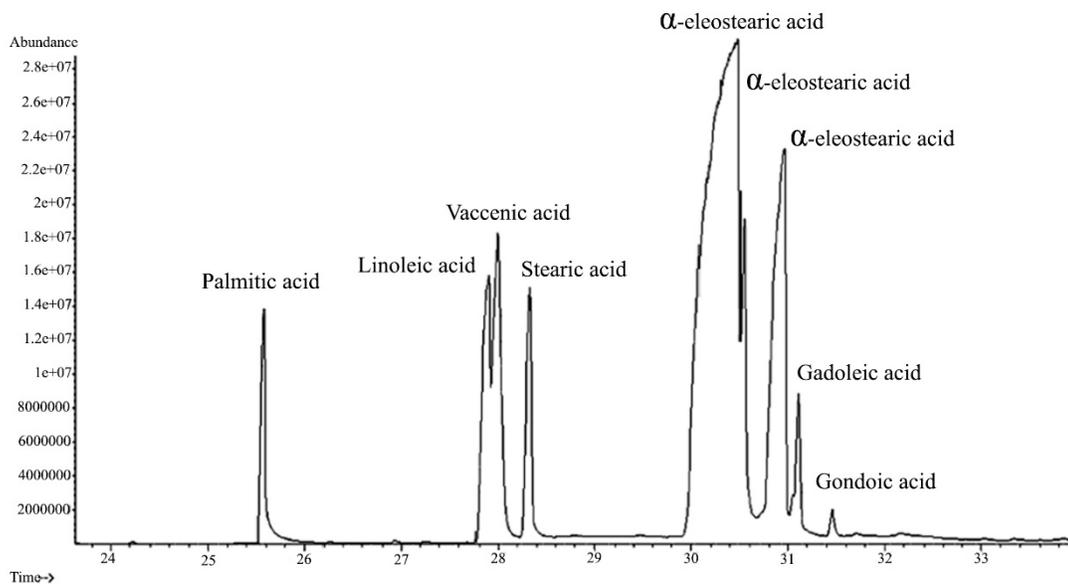


Fig. 4 GC-MS chromatogram of biodiesel from tung seed oil

4. Conclusion

In conclusion, biodiesel production from tung seed oil using strong base supported on activated carbon from Longan as catalyst by microwave technique is a new technique. Results showed that under 5 min microwave irradiation the optimal reaction conditions of catalyst amount, 1 wt%; reaction temperature, 65 °C; and oil/methanol molar ratio 1 : 8, the percent yield of biodiesel achieved was 84.41%. Microwave technique can reduce reaction time in biodiesel production.

5. Acknowledgements

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