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| **Utilization and Optimization of Transesterification Process of Low-Grade *Ceiba Pentranda* Oil Using Low-cost Catalyst Based on Fly-Ash.** | | | | | |
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| **ARTICLE INFORMATION** | |  | **ABSTRAK** | | |
| Journal of Science and Technology – Volume xx  Number xx, May 2018  Page:  1 – 10  Date of issue :  May 20, 2018  DOI:  10.31284/j.iptek.2017.v21i2.91 | |  | Pengembangan biodiesel merupakan salah satu program prioritas dalam pengembangan energi baru terbarukan (EBT) dan menunjang pencapaian target *net zero emission* (ZNE) di tahun 2060. Kendala utama dalam pengembangan biodiesel di Indonesia berupa biaya produksi yang tinggi karena bahan bakunya berasal dari minyak pangan serta penggunaan katalis homogen. Untuk mengatasi permasalahan tersebut maka peneliti melakukan pengembangan biodiesel dari potensi *non edible oil* (NEO) maupun *low grade oil* (LGO) serta material maju berupa katalis komposit nano seng oksida (ZnO) dengan penyangga murah berbasis limbah *coal fly ash* (CNZO/CFA). Dimana tujuan jangka panjang dari penelitian ini yaitu mendapatkan teknologi proses yang tepat untuk produksi biodiesel dari NEO/LGO melalui reaksi transesterifikasi dengan katalis komposit CNZO/CFA. Sedangkan tujuan khusus dari penelitian ini berupa peningkatan aktivitas katalis melalui pengembangan rute sintesis katalis komposit nano CNZO/CFA untuk transesterifikasi minyak biji kapuk (MBK). MBK dipilih sebagai bahan baku pembuatan biodiesel karena LGO dengan kandungan *free fatty acid* (FFA) yang tinggi dan ketersediaannya melimpah dengan rendemen minyak yang tinggi. Untuk mengetahui aktivitas katalitik dari katalis CNZO/CFA maka dilakukan proses transesterifikasi dengan variabel suhu dan waktu transesterifikasi terhadap *yield* (%) biodiesel yang dihasilkan. Selanjutnya biodiesel akan dilakukan uji Gross Heating Value (GHV).  **Kata Kunci :** Biji kapuk; *coal fly ash*; katalis komposit; seng oksida; transesterifikasi | | |
| **E-MAIL** | |  | **ABSTRACT** | | |
| Author Email 1  Author Email 2 Author  Email … – font 9 | |  | Biodiesel development is one of the priority programs in the development of new renewable energy (NRE) and supports the achievement of the net zero emission (NZE) target in 2060. The main obstacle in developing biodiesel in Indonesia is high production costs because the raw material comes from food oil and the use of homogeneous catalyst. To overcome this problem, researchers are developing biodiesel from potential non-edible oil (NEO) and low grade oil (LGO) as well as advanced materials in the form of nano zinc oxide (ZnO) composite catalysts with cheap supports based on coal fly ash (CNZO/CFA) waste. The long-term goal of this research is to obtain the right process technology for biodiesel production from NEO/LGO through a transesterification reaction with a CNZO/CFA composite catalyst. Meanwhile, the specific aim of this research is to increase catalyst activity through the development of a CNZO/CFA nanocomposite catalyst synthesis route for the transesterification of kapok seed oil (MBK). MBK was chosen as the raw material for making biodiesel because LGO has a high free fatty acid (FFA) content and is abundant in availability with high oil yield. To determine the catalytic activity of the CNZO/CFA catalyst, a transesterification process was carried out with variable temperature and transesterification time on the yield (%) of the biodiesel produced. Next, the biodiesel will be tested for Gross Heating Value (GHV).  **Keywords:** Kapok seeds; coal fly ash; composite catalyst; zinc oxide; transesterification | | |
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| LPPM- Adhi Tama Institute of Technology Surabaya  Address:  Jl. Arief Rachman Hakim No. 100, Surabaya 60117, Tel/Fax: 031-5997244  *Jurnal IPTEK by LPPM-ITATS is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.* | |  |
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**INTRODUCTION**

Global energy dependence on fossil fuels causes petroleum reserves to deplete so that governments continue to develop renewable energy for sustainable energy systems in the future. The development of renewable energy in the future is considered the best solution because it is environmentally friendly. One of the efforts that continues to be made to reduce the level of dependence on the use of fossil energy is the use of biodiesel. Biodiesel was developed as an alternative fuel because it is environmentally friendly and has almost the same characteristics as diesel oil.

In Indonesia itself there are various biomass resources that can be developed as alternative fuels, one of which is Kapok Seed Oil (MBK). The use of MBK as raw material in making biodiesel is considered solutive because of its low price, not competing with the food industry to get raw materials so as to maintain national food security. So that the economic feasibility study of biodiesel will remain satisfactory.

**LITERATURE REVIEW**

**Transesterification Reaction**

Triglycerides are esterified into a glycerol structure during the transesterification event. Triglycerides' three fatty acid chains will be freed from the glycerol framework in the meantime, and when they interact with short-chain alcohols, they transform into biodiesel. Additionally, the transesterification event that takes place will result in the production of glycerol as a byproduct.

**Biodiesel**

A class of renewable fuels known as long-chain fatty acid acyl esters includes biodiesel. Biodiesel is currently being developed to solve a number of issues with fossil fuels, including their scarcity and potential for environmental pollution. While this is going on, biodiesel itself offers a number of benefits, including the fact that it is environmentally benign, and biodegradable.

**Gross Heating Value**

Gross Heating Value (GHV) is the amount of energy released by fuel in the complete combustion process per unit of mass under standard conditions.

**METHOD**

**Tools and Materials**

The equipment needed in this practicum is a three-neck flask, reflux, stative, clamps, hotplate, thermometer, rubber plug, and magnetic stirrer for the transesterification process. At the same time, weighing bottles, beaker glass, porcelain dishes, erlenmeyer, burettes, split funnels, measuring cups, measuring flasks, volumetric pipettes, water hyacinths, pycnometers, *Oswald viscometer*, ovens, furnaces, analytical balances, and *bomb calorimeters* for the analysis process.

The materials used include MBK, FA, methanol, zinc chloride, and sodium hydroxide, for the transesterification process. While aquadest, alcohol, oxalic acid, potassium hydroxide, sodium carbonate, hydrochloric acid, phosphoric acid phenolphthalein indicator, and methyl red indicator for the analysis process.

**Work Procedure**

The research carried out includes the MBK pre-treatment process, FA activation, NZO / FA catalyst synthesis, and MBK transesterification using NZO / FA catalyst. For the MBK pre-treatment process, NZO / FA catalyst synthesis, and MBK transesterification using NZO / FA catalyst as has been done by Siswoyo and Asri (2023) equipped with the FA activation process. This is due to the *yield of* biodiesel produced from the MBK transesterification process using activated NZO/FA catalysts obtained a fairly high percentage, which is 95.93% at a variable time of 4.5 hours. The high *yield* produced is caused by the pores of FA that have begun to be active and open, so that ZnO can stick well to the surface of the catalyst.

Furthermore, the NZO / FA catalyst produced will be tested for catalyst activity through the MBK transesterification process with methanol using a laboratory-scale batch reactor with variable temperature and transesterification time. the temperature variables used are 60; 70; and 80°C. The time variables used are 3; 3,5; 4; 4,5; and 5 hours. To increase the *yield of* biodiesel produced, the dose of catalyst used is 5% with a molar ratio between MBK to methanol 1: 15. Later, the highest yield of each temperature and transesterification time will be tested externally using a bomb calorimeter to determine the amount of energy that can be produced from the combustion process. The *yield of* biodiesel is calculated based on equation 1 below.

................................................................................ (1)

Where *WBD* is the weight of biodiesel (g) obtained in experiments, while *Wo* is the weight of kapok seed oil (g) used in experiments.

**RESULTS AND DISCUSSION**

**MBK conversion**

NZO/FA catalysts that have previously been characterized in research conducted by Siswoyo and Asri in 2022 and 2023 were tested for catalyst activity through a transesterification process with variable effects of temperature and transesterification time on the yield produced. Theoretically, the higher more reaction time, the greater the yield of biodiesel produced. This is due to an increase in temperature in the duration of the reaction time that occurs during the transesterification process so that oil molecules that react with methanol to form methyl esters are increasingly supported by the presence of catalysts that help to increase the solubility of methanol so that the reaction rate increases. The following is the yield of biodiesel calculated from Equation 1:

From the picture above, it can be seen that biodiesel yield will increase with the addition of transesterification temperature and time because the higher the temperature and transesterification reaction time, the more methyl ester levels are produced. The low *yield* produced at the reaction temperature of 60C indicates that the temperature and time used by methanol in converting triglyceride to methyl ester is maximally still less. The decrease in *yield* at variable temperatures of 70C and 5 hours is caused by the transesterification reaction classified as a reversible reaction. So that when the equilibrium of the reaction has been reached, the transesterification process should be stopped so that the energy used in the conversion process is more efficient. In addition, the use of excessive temperature and time will increase the by-product of the reaction in the form of glycerin.

**GHV**

GHV relates to the amount of energy that can be produced from the process of burning fuel. GHV is related to several factors, including its chemical composition, fat content, and production process. The principle used in the combustion of fuel is the chemical reaction of the fuel to oxygen. While the elements contained in fuel are dominated by carbon, hydrogen, and sulfur. Where carbon and hydrogen compounds have an important contribution to the energy released.

In this study*,* the highest yield of each temperature variable on reaction time will be GHV tested to determine the combustion quality of the biodiesel products produced. The GHV test results produced are:

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| **Sample Code** | **GHV (MJ/kg)** |
| NZO/FA-60DC-5H | 37.61 |
| NZO/FA-70 DC-5H | 37,68 |
| NZO/FA-80DC-5H | 37,95 |

Based on the type, GHV is divided into two groups, namely Higher Heating Value (HHV) and Lower Heating Value (LHV). Biodiesel is classified as HHV if it has GHV between 39-43.33 MJ / kg. If biodiesel has a calorific value below 39 MJ / kg is included in the type of LHV.

From the table above, it can be seen that biodiesel produced from MBK conversion using NZO / FA catalysts is classified as LHV because it has a calorific value of around 37 MJ / kg. The calorific value is following the required quality specifications. Because based on ASTM D15, the calorific value in biodiesel samples ranges from 35-40 MJ / kg. Calorific values that meet quality standards indicate that the high content of volatile matter so that flammability and high carbon content will still result in a longer burn fuel time. In addition, the high calorific value also indicates the low value of ash content and moisture content of the material in the resulting biodiesel sample. Because the calorific value shows complete combustion results due to heat transfer that occurs very well. On the other hand, the low calorific value also indicates that the presence of H2O compounds in biodiesel is in the form of steam.

**CONCLUSION**

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