4th International Conference Eco-Innovation in Science, Engineering, and Technology
Volume 2023
http://dx.doi.org/10.11594/nstp.2023.3611

Conference Paper

The Efficiency of Producing Biodiesel from Used Cooking Oil by Precipitating Blood Cockles Shell Waste with a CaO Catalyst

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ABSTRACT

Bio-based waste materials perform an essential duty as valuable sources of components that can be effectively utilized as active phases in the synthesis of CaO catalysts for the generation of biodiesel. The abundance of shell Blood cockles is considerable. Additionally, Indonesia has a stockpile of used cooking oil. The utilized cooking oil has a notable concentration of fatty acids, presenting the potential for conversion into biodiesel. The technology of converting leftover cooking oil into biodiesel through transesterification has undergone significant advancements. An accelerator is necessary to boost the biodiesel yield to attain a sufficiently high yield. The CaO catalyst was selected due to its ability to expedite and boost biodiesel output. This study evaluated the blood clam shell's potential as a transesterification catalyst for used cooking oil. This study used temperature and concentration change variables for transesterification, with a settle variable of 60 minutes. The concentrations of the variables are 3 N, 4 N, 5 N, 6 N, and 7 N, whereas the temperatures are 45 ^{0}C, 50 ^{0}C, 55 ^{0}C, 60 ^{0}C, and 65 ^{0}C. With varying transesterification times of 60 minutes, transesterification temperatures of 60°C and 65°C, and catalyst concentrations of 6N and 7N, the research findings indicate that utilizing this catalyst can boost biodiesel yield with conversion yields of 85%, 88%, and 95%. This demonstrates that temperature can also promote improving biodiesel production and that using catalysts can boost the conversion of biodiesel to over 90% or more.

Keywords: Biodiesel, catalyst, blood cockles shell, used cooking oil

Introduction

The need for alternative energy is growing yearly due to the depletion of fossil fuel supplies. Searches for sustainable and environmentally benign alternative energy sources have become more widespread in the scientific community due to the rapid depletion of fossil fuel reserves, rising oil prices, and growing worries about greenhouse gas emissions in the atmosphere. Alternative energy derived from vegetable raw materials, such as coconut oil, soybeans, corn, castor oil, and so forth, is biodiesel (Suherman et al., 2022).

Used cooking oil is waste oil derived from vegetable oil. This oil is commonly utilized for domestic purposes. Elevated quantities of free fatty acids are observed in used frying oil. Cooking oil becomes damaged after being used frequently. Peroxide compounds are formed from the oxidation of unsaturated lipids. Using used cooking oil has the potential to undergo processing procedures that transform it into alternative fuels, specifically biodiesel. In addition, frequent disposal of spent kitchen garbage into the environment pollutes the environment (Inayati & Kurnia, 2021).

Biodiesel fuel is produced by the process of transesterification, which involves the conversion of alcohol derived from triglycerides found in vegetable oils or animal fats. Fatty acid methyl esters

How to cite:
Rahmandika, A. J. P. (2023). The efficiency of producing biodiesel from used cooking oil by precipitating blood cockles shell waste with a CaO catalyst. *4th International Conference Eco-Innovation in Science, Engineering, and Technology*. NST Proceedings. pages 68-72. doi: 10.11594/ nstp.2023.3611

derived from vegetable oil, commonly called biodiesel, have demonstrated efficacy in initiating combustion in diesel engines when utilized at specific mixture ratios. Biodiesel comprises monoalkyl esters and is created through the intermediate reactions of triglycerides and monohydric alcohols. Alkaline catalysts are generally more numerous and are typically chosen over acid or enzyme catalysts. The potential of this fuel lies in its ability to meet the SNI guidelines for renewable fuel sources, which include specific criteria such as density within the range of 850-890, viscosity between 2.3-6.0, FFA levels below 0.3, acid number below 0.5, water content below 0.05, and a flash point over 100 (Setyawardhani et al., 2021).

Catalysts derived from renewable sources, specifically calcium oxide, exhibit significant promise for their utilization as catalysts in the commercial synthesis of biodiesel. Calcium oxide (CaO) is a potent basic oxide that exhibits notable catalytic properties, rendering it suitable for application as a catalyst in biodiesel production. Additional benefits encompass the utilization of reaction conditions characterized by low energy input levels, the catalyst's extended lifespan, and the economic advantage of employing a catalyst with minimal associated costs. The potential utilization of blood cockle shells arises from their high mineral content, specifically calcium carbonate ($CaCO_3$). This characteristic renders them a promising candidate for developing a heterogeneous catalyst in synthesizing biodiesel. According to Putra et al. (2021), the process of calcination is employed to convert cockle blood into calcium oxide (CaO), resulting in a purity level of 99.14%.

Several factors exert influence on the formation of calcium oxide (CaO). The production of CaO in the precipitation process is influenced by many factors:

1. The stirring speed.
   The duration of churning directly correlates with the frequency of collision events. As the length of the particles increases, there is a corresponding rise in CaO production. The concept of matter is a fundamental aspect of scientific inquiry and is central. there is a correlation between the duration of stirring and the level of purity observed in the production of CaO (Hanin & Sande, 2021).
2. Measurement of Acidity Level (pH)
   There is a positive correlation between the pH level and the yield obtained, whereby an increase in pH leads to an increase in yield. In the present scenario, the substance under consideration is calcium oxide (Pangestu et al., 2021).
3. The calcination temperature
   This refers to the temperature at which a material undergoes the process of calcination. An increase in calcination temperature results in a better degree of purity in the produced CaO concentration (Islamillennio, 2023).

Several factors play a significant role in influencing the formation of biodiesel (Sutanto & Samik, 2021):

1. The impact of the molar ratio
   A positive correlation exists between the number of molar ratios between oil and alcohol utilized and the resulting percentage output of biodiesel.
2. The Concept of Reaction Time
   An ongoing escalation in reaction time will lead to a decrease in the percentage yield of biodiesel generated.
3. Reaction temperature
   The rise in reaction temperature leads to an increase in the velocity of reactant molecules, hence enhancing the likelihood of collisions. Consequently, this results in an increase in the percentage yield of biodiesel produced.
4. The concentration of a catalyst
   Catalysts exert an impact on the rate of a reaction by facilitating a reaction mechanism, either by lowering the activation energy for positive catalysts or by increasing it for negative catalysts.

Material and Methods

The primary materials utilized in this study consist of waste frying oil, waste blood cockle shells, methanol, sodium hydroxide, distilled water, acid chloride, activated carbon, and potassium hydroxide. The primary equipment utilized in this study encompasses a collection of biodiesel instruments. The biodiesel tools encompass a three-neck flask, a stirrer, a stirrer motor, a condenser, a thermometer, and a stand with clamps. The equipment employed for CaO precipitation includes a glass beaker, magnetic stirrer, filter paper, burette, stative, and clamp. The present study was carried out in the Biomass and Energy Laboratory of UPN "Veteran" Jawa Timur, specifically within the Faculty of Engineering. The research spanned a duration of four months, commencing in March and concluding in August of the year 2023.

Production stage of CaO catalyst by precipitation method

The procedure commences with the extraction of blood cockle shells by the utilization of hydrochloric acid (HCl) dissolution. Subsequently, the resulting filtrate is subjected to a reaction with a solution of sodium hydroxide (NaOH) with a concentration of 3 N. The resultant solid product obtained from the chemical reaction is subsequently subjected to a drying process utilizing a furnace operating at a temperature of 700 ^{0}C for a duration of 3 hours.

Production stage of biodiesel

The esterification process involves the reaction of spent frying oil with methanol and hydrochloric acid under specific conditions, namely at a temperature of 65^{0}C for a duration of 1 hour. Subsequently, the transesterification reaction is conducted by combining calcium oxide (CaO), methanol, and esterified oil. Next, the methyl ester can be isolated as crude biodiesel together with glycerol by the utilization of a separating funnel. Subsequently, the specimen should be rinsed using warm distilled water and subsequently subjected to separation using a separating funnel. Subsequently, the substance was subjected to a heating process until it achieved a state of clarity.

Analyze yield of biodiesel

Interpretation of biodiesel yield analysis is by making a graph of the relationship between variations in catalyst concentration and temperature variations.

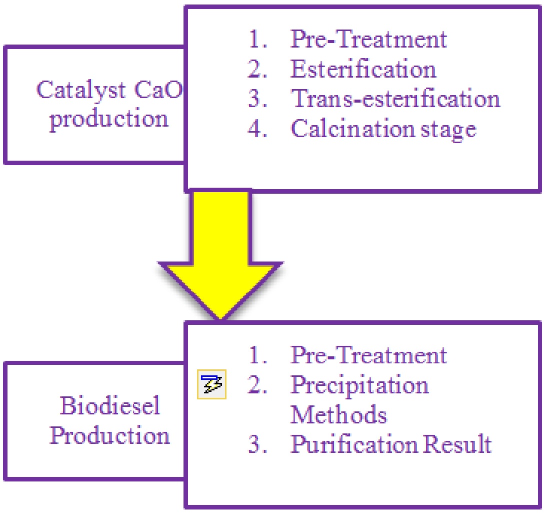

Figure 1. Production of biodiesel

Results and Discussion

The conversion of biodiesel yield

This study employs non-instrumental analytic techniques to ascertain the outcomes of the transformation process of used cooking oil into biodiesel. The yield is determined by dividing the final weight (weight generated) by the initial weight (weight of biomass utilized), and then multiplying the result by 100%. The graph presented illustrates the relationship between catalyst concentration and transesterification temperature with respect to biodiesel yield as shown as Figure 2.

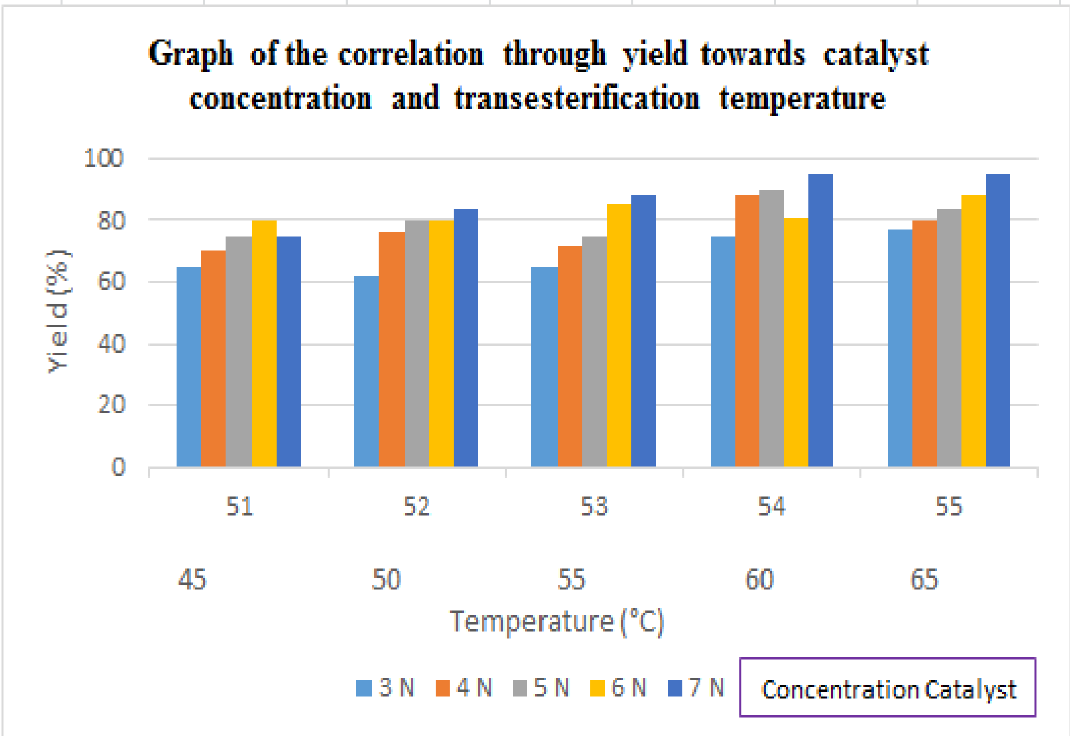

Figure 2. Graph of the correlation through yield towards catalyst concentration and transesterification temperature

The graph illustrates a positive correlation between the catalyst concentration and the conversion yield of biodiesel derived from spent cooking oil. This phenomenon occurs due to the catalyst's capacity to enhance its interaction with spent cooking oil, thus leading to an augmentation in the conversion of biodiesel. The observed outcomes primarily occurred at concentrations of 6 and 7N, as well as temperatures of 60 ^{0}C and 65 ^{0}C. The obtained biodiesel yield ranged from around 90% to above 90%. The aforementioned findings are consistent with those reported by other researchers, indicating that the catalyst under investigation has the potential to enhance the production of biodiesel. This improvement is observed across different transesterification durations (50 and 70 minutes), temperatures (50 ^{0}C and 70 ^{0}C), and catalyst concentrations (2% and 4%) (Azzahro & Broto, 2021).

Catalyst analysis test results

The catalyst analysis entails the utilization of scanning electron microscopy (SEM) and Brunauer-Emmett-Teller (BET) devices. This device has the capability to visually represent the morphology and quantify the surface area of the catalyst employed in our research pertaining to the conversion of spent cooking oil into biodiesel. The presented data in the table pertains to the examination of catalysts as shown as Table 1.

Table 1. Comparison analyst of CaO catalyst

Reference	Catalyst CaO SEM	Catalyst CaO BET
This Research	Spherical	0.80381 - 1.26014
(Hussein et al., 2020)	Spherical	0,96
(Sibarani et al., 2020)	Spherical	1,974

Based on the findings from the analysis of the CaO catalyst, it can be inferred that the production of a CaO heterogeneous catalyst for the transesterification process of used cooking oil into biodiesel was effectively executed. This conclusion is supported by the observed morphology of the CaO, which exhibited a spherical shape, as well as the quantified CaO content determined through SEM and BET analysis. It is worth noting that a higher surface area corresponds to enhanced catalyst performance in terms of activity.

Conclusion

The utilization of CaO catalyst in the conversion of bio-based waste has been found to enhance the production of biodiesel. The enhanced transesterification of spent cooking oil to biodiesel can be attributed to the utilization of a CaO catalyst. The findings indicate a positive correlation between catalyst concentration and both conversion yield and transesterification. The findings acquired in this study exhibit a high degree of similarity when compared to the results reported by prior researchers.

Acknowledgment

This work was financially supported by the Student Creativity Program (PKM) research scheme in 2023. Therefore, we are grateful for this funding and support of this research.

References

Azzahro, U. L., & Broto, W. (2021). Pemanfaatan limbah cangkang kerang dara sebagai katalis CAO pada pembuatan biodiesel minyak goreng bekas. *Jurnal Sosial Teknologi*, *1*(6), 499–507. https://doi.org/10.59188/jurnalsostech.v1i6.110

Hanin, N., & Sande, N. A. (2021). Synthesis of hydroxyapatite with variations in stirring time from waste cuttlefish bone (*Sepia* sp.). *Seminar Nasional Teknik Kimia Soebardjo Brotohardjono XVII*, *17*(42), 55–59.

Hussein, A.I. *et al.* (2020) 'Synthesis and characterization of spherical calcium carbonate nanoparticles derived from cockle shells', *Applied Sciences (Switzerland)*, 10(20), pp. 1–14.

Islamillennio, A. (2023). Pengaruh suhu dan waktu kalsinasi terhadap kemurnian hidroksiapatit berbasis tulang ayam dengan metode presipitasi Mochamad Arif Irfa'i'. *Jurnal Teknik Mesin*, *11*(1), 19–24.

Inayati, N.I., dan Kurnia R. T. (2021). Pemanfaatan minyak jelantah sebagai bahan dasar pembuatan lilin aromaterapi sebagai alternatif tambahan penghasilan pada anggota Aisyiyah Desa Kebanggan Kec Sumbang. *Jurnal Budimas*, *03*(01), 160–166.

Pangestu, T.O., Damayanti, S. F., Santi, S. S., & Muljani, S. (2021). Sintesis dan karakterisasi kalsium fosfat dari cangkang bekicot dengan metode presipitasi. CHEESA: Chemical Engineering Research Articles, 4(2), 82-90. http://doi.org/10.25273/cheesa.v4i2.8931.82-90

Putra, W. A., Amalita, A. N. P., & Wahyudi, B. (2021). Biodiesel dari Crude Fish Oil (CFO) dengan Katalis Heterogen CaO dari Cangkang Kerang Darah. *ChemPro*, *2*(02), 18–23.

Setyawardhani, D.A., Widiasri, A.T.Y., & Rahman, M. (2021). Uji karakteristik pencampuran biodiesel minyak jelantah dan biodiesel minyak kesambi. *Jurnal Integrasi Proses*, *10*(2), 68. https://doi.org/10.36055/jip.v10i2.12213.

Sibarani, J., Zulfihardini, M., & Suarsa, I. W. (2020). Sintesis dan karakterisasi katalis CaO-Bentonit untuk reaksi transesterifikasi minyak jelantah menjadi biodiesel. *Cakra Kimia (Indonesian E-Journal of Applied Chemistry)*, *8*(1), 59–65.

Suherman, S., Abdullah, I., Sabri, M., Silitonga, A. S., & Suroso, B. (2022). Pengaruh perbedaan jumlah katalis terhadap angka yield pada proses pembuatan biodiesel dari minyak goreng sisa menggunakan pemanas double jacket. *Jurnal Rekayasa Mesin*, *17*(1), 113–120. http://dx.doi.org/10.32497/jrm.v17i1.3148

Sutanto, N., & Samik, S. (2021). Artikel Review : Pemanfaatan katalis CaO untuk pembuatan biodiesel menggunakan metode transesterifikasi dari non edible oil article review : Utilization of CaO Catalyst to produce biodiesel by Transesterification Method from Non-Edible Oil. *Prosiding Seminar Nasional Kimia (SNK)*, 46–55.