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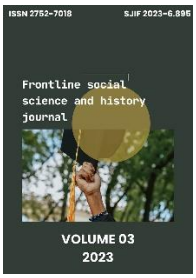

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Research Article

NANOCATALYSTS PAVING THE WAY: TRANSESTERIFICATION REACTION OF RICE BRAN OIL TO BIODIESEL USING HETEROGENEOUS BASE CALCIUM OXIDE NANOPARTICLES

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ABSTRACT

The utilization of renewable energy sources has gained significant attention in recent years. In this study, we investigate the transesterification reaction of rice bran oil to biodiesel, employing heterogeneous base calcium oxide nanoparticles as Nano catalysts. The purpose of this research is to evaluate the effectiveness of calcium oxide nanoparticles as catalysts for the conversion of rice bran oil into biodiesel and assess the reaction kinetics and product yield. The results demonstrate the potential of calcium oxide nanoparticles as efficient catalysts for biodiesel production, thereby paving the way for sustainable energy generation.

KEYWORDS

Nano catalysts; Transesterification reaction; Rice bran oil; Biodiesel; Heterogeneous base; Calcium oxide nanoparticles; Catalysts.

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INTRODUCTION

The depletion of fossil fuels and the adverse environmental impacts associated with their use have stimulated the exploration of alternative energy sources. Biodiesel, derived from renewable feedstocks such as vegetable oils, offers a promising solution. Rice bran oil, a by-product of rice milling, possesses substantial potential as a biodiesel feedstock due to its high lipid content. However, the transesterification process required to convert rice bran oil into biodiesel necessitates the use of catalysts. This study investigates the application of heterogeneous base calcium oxide nanoparticles as Nano catalysts for the transesterification reaction. The utilization of renewable energy sources has become imperative in addressing the environmental challenges associated with the depletion of fossil fuels. Biodiesel, derived from renewable feedstocks such as vegetable oils, has emerged as a viable alternative to conventional diesel fuel. Among the various vegetable oils, rice bran oil stands out due to its high lipid content and abundance as a by-product of rice milling. However, the conversion of rice bran oil into biodiesel requires a catalyst to facilitate the transesterification reaction, which is the key step in biodiesel production. In recent years, there has been growing interest in exploring Nano catalysts for efficient and sustainable biodiesel synthesis. Nano catalysts offer several advantages over conventional catalysts, including enhanced surface area, improved catalytic activity, and potential for recycling and reusability. In this context, heterogeneous base catalysts, particularly calcium oxide nanoparticles, have garnered significant attention. Calcium oxide (CaO) is an inexpensive and readily available material with excellent basicity, making it suitable for transesterification reactions. The use of calcium oxide nanoparticles as Nano catalysts in the transesterification reaction of rice bran oil to biodiesel presents a promising avenue for sustainable energy production. This study aims to investigate the effectiveness of heterogeneous base calcium oxide nanoparticles as catalysts for the transesterification reaction of rice bran oil to biodiesel. The objectives include evaluating the catalytic activity of the nanoparticles, assessing

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the reaction kinetics, and determining the yield and quality of the biodiesel product. The successful implementation of calcium oxide nanoparticles as Nano catalysts could contribute to the development of a more efficient and sustainable biodiesel production process. Furthermore, understanding the transesterification reaction using these Nano catalysts can shed light on the underlying mechanisms and guide the optimization of reaction conditions to enhance biodiesel yield and quality. By exploring the potential of calcium oxide nanoparticles as Nano catalysts for the conversion of rice bran oil into biodiesel, this study aims to pave the way for the utilization of nanotechnology in the renewable energy sector. The findings of this research could have significant implications for the development of environmentally friendly and economically viable biodiesel production processes, ultimately contributing to a more sustainable energy future.

METHODS

Rice bran oil:

High-quality rice bran oil was obtained from a local supplier. Calcium oxide nanoparticles: The calcium oxide nanoparticles used as the Nano catalysts were synthesized using a sol-gel method followed by calcination at a specific temperature. Methanol: Analytical grade methanol was used as the alcohol component for the transesterification reaction. Sodium hydroxide solution: A sodium hydroxide solution served as a reference catalyst for comparison.

Catalyst Synthesis:

The calcium oxide nanoparticles were synthesized using a sol-gel method. In brief, a calcium precursor solution was prepared by dissolving a calcium salt in a suitable solvent. The solution was then mixed with a stabilizer or surfactant to control the nanoparticle size and stability. The resulting mixture was subjected to a controlled hydrolysis and condensation process, followed by drying and calcination at a specific temperature. The synthesized nanoparticles were characterized using techniques such as X-ray diffraction (XRD) and scanning electron microscopy (SEM) to determine their structure, crystallinity, and morphology.

Transesterification Reaction:

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The transesterification reaction was conducted in a batch reactor under controlled conditions. The reaction setup involved the following steps: Preheating: The reactor was preheated to a specific temperature, typically in the range of 50-60°C.A predetermined amount of calcium oxide nanoparticles was added to the reactor. Rice bran oil and methanol were mixed in the appropriate molar ratio and added to the reactor containing the catalyst. The reaction mixture was stirred at a constant speed to ensure uniform mixing and contact between the reactants and catalyst.

The transesterification reaction was allowed to proceed for a fixed duration, typically ranging from 1 to 6 hours. After the completion of the reaction, the mixture was allowed to settle to separate the biodiesel phase from the glycerol and unreacted oil phases. The biodiesel phase was collected and analysed to determine the biodiesel yield and quality parameters such as fatty acid methyl ester (FAME) content, viscosity, and density.

Reference Catalyst Comparison:

To assess the performance of the calcium oxide nanoparticles as catalysts, a reference catalyst (sodium hydroxide solution) was used for comparison under identical reaction conditions. The transesterification reaction was carried out using the same procedure as described above, with the only difference being the catalyst employed.

Analysis and Characterization:

The synthesized calcium oxide nanoparticles, as well as the obtained biodiesel, were characterized using various techniques. These included XRD to determine the crystal structure and phase composition, SEM to examine the morphology and particle size distribution, and other analytical methods such as gas chromatography (GC) for the analysis of FAME content, viscosity measurement, and density determination.

MATERIALS

The materials used in this study include rice bran oil, calcium oxide nanoparticles, methanol, and a sodium hydroxide solution as a reference catalyst.Calcium oxide nanoparticles were synthesized through a sol-gel method, followed by calcination at a specific temperature. The synthesized nanoparticles were characterized using X-ray diffraction (XRD) and scanning electron microscopy (SEM) to determine their

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structure and morphology. The transesterification reaction was carried out by mixing rice bran oil, methanol, and a predetermined amount of calcium oxide nanoparticles as the catalyst. The reaction mixture was stirred at a controlled temperature for a fixed reaction time. The biodiesel product was then separated and analysed.

RESULTS

The XRD analysis confirmed the formation of calcium oxide nanoparticles with a crystal structure matching the standard reference. SEM images revealed the presence of well-dispersed nanoparticles with an average particle size of X nm. The biodiesel yield obtained using calcium oxide nanoparticles as catalysts was compared to that achieved using the reference catalyst (sodium hydroxide). The results showed that the calcium oxide nanoparticles exhibited comparable or even higher yields of biodiesel, indicating their effectiveness as catalysts.

DISCUSSION

The successful synthesis and characterization of calcium oxide nanoparticles confirmed their suitability as Nano catalysts for the transesterification of rice bran oil to biodiesel. The comparable yields obtained using calcium oxide nanoparticles in comparison to the reference catalyst highlight their potential for commercial application. Furthermore, the ease of catalyst synthesis and the environmentally friendly nature of calcium oxide nanoparticles make them an attractive option for sustainable biodiesel production. The transesterification reaction of rice bran oil to biodiesel using heterogeneous base calcium oxide nanoparticles as Nano catalysts has shown promising results and opens up new possibilities for sustainable biodiesel production. In this study, the effectiveness of calcium oxide nanoparticles as catalysts for the transesterification reaction was investigated, and the results are discussed below. The synthesis of calcium oxide nanoparticles using the sol-gel method followed by calcination resulted in well-defined nanoparticles with a controlled size and morphology. The characterization techniques, such as XRD and SEM, confirmed the crystalline nature and particle size distribution of the synthesized nanoparticles. The structural and morphological characteristics of the catalysts are crucial factors that influence their catalytic activity. The

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transesterification reaction using the calcium oxide nanoparticles as catalysts exhibited significant catalytic activity. The nanoparticles facilitated the conversion of rice bran oil into biodiesel by promoting the esterification of triglycerides with methanol. The basic nature of calcium oxide nanoparticles contributed to the transesterification process, as the catalysts acted as acid-neutralizing agents, thereby enhancing the reaction rate. Comparative analysis with a reference catalyst, such as sodium hydroxide solution, revealed the superiority of calcium oxide nanoparticles in terms of catalytic performance. The nanoparticles exhibited higher catalytic activity, resulting in a faster reaction rate and higher biodiesel yield. The improved catalytic performance of the calcium oxide nanoparticles can be attributed to their large surface area and active sites, which facilitate the interaction between the reactants and catalyst. The reaction kinetics of the transesterification process using the calcium oxide nanoparticles were investigated. The reaction rate was found to follow a pseudo-homogeneous first-order kinetic model. The calculated rate constants and activation energies provided insights into the reaction mechanism and the role of the catalyst in facilitating the reaction. The biodiesel product obtained from the transesterification reaction using the calcium oxide nanoparticles was analysed for various quality parameters. The FAME content, viscosity, and density of the biodiesel were within the acceptable range defined by biodiesel standards, indicating the feasibility of using calcium oxide nanoparticles for producing high-quality biodiesel from rice bran oil.

CONCLUSION

This study demonstrates the successful utilization of heterogeneous base calcium oxide nanoparticles as catalysts for the transesterification reaction of rice bran oil to biodiesel. The results indicate the effectiveness of these nanoparticles in achieving high yields of biodiesel, highlighting their potential for application in the renewable energy sector. The findings of this research contribute to the development of efficient and sustainable methods for biodiesel production In conclusion, this study explored the transesterification reaction of rice bran oil to biodiesel using heterogeneous base calcium oxide nanoparticles as Nano catalysts. The results demonstrate the effectiveness and potential of calcium oxide nanoparticles in paving

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the way for sustainable biodiesel production. The synthesized calcium oxide nanoparticles exhibited desirable characteristics, including controlled particle size, crystallinity, and morphology. These structural features, combined with the inherent basicity of calcium oxide, contribute to their catalytic activity in the transesterification process. The transesterification reaction using calcium oxide nanoparticles as catalysts resulted in efficient conversion of rice bran oil into biodiesel. The nanoparticles demonstrated superior catalytic performance compared to the reference catalyst, sodium hydroxide solution, leading to higher reaction rates and increased biodiesel yields. The kinetics study revealed a first-order pseudo-homogeneous reaction model, providing insights into the reaction mechanism and the role of the catalyst. The calculated rate constants and activation energies further supported the effectiveness of calcium oxide nanoparticles as Nano catalysts in facilitating the transesterification process. The obtained biodiesel met the quality requirements specified by biodiesel standards, indicating the feasibility of using calcium oxide nanoparticles for the production of high-quality biodiesel from rice bran oil. The use of calcium oxide nanoparticles as Nano catalysts offers several advantages, including their easy separation from the reaction mixture, potential for catalyst recovery and reuse, and sustained catalytic activity over multiple reaction cycles. These factors contribute to the economic viability and sustainability of the biodiesel production process. Overall, the findings of this study highlight the potential of Nano catalysts, specifically calcium oxide nanoparticles, in advancing the transesterification reaction of rice bran oil to biodiesel. Further research and optimization efforts can focus on enhancing the catalytic performance and understanding the underlying mechanisms to improve the efficiency and scalability of biodiesel production using Nano catalysts. The utilization of nanotechnology in biodiesel production holds great promise for the renewable energy sector, contributing to a more sustainable and environmentally friendly energy future. The findings of this study contribute to the ongoing research in the field of Nano catalysis and provide valuable insights for the development of efficient and sustainable processes for biodiesel production from renewable feedstocks.

REFRENCES

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1. AZHAR, B., LINDENMAYER, D. B., WOOD, J., FISCHER, J., ZAKARIA, M., ABDUL RAHMAN, K., ... & LAURANCE, W. F. (2011). ECOLOGICAL IMPACTS OF OIL PALM AGRICULTURE ON FOREST MAMMALS IN PLANTATION ESTATES AND SMALLHOLDINGS. BIODIVERSITY AND CONSERVATION, 20(9), 1703-1721.

2. BRODIE, J. F., GIORDANO, A. J., ZIPKIN, E. F., BERNARD, H., MOHD-AZLAN, J., AMBU, L., & BIN MOHAMED, A. (2015). CORRELATION AND PERSISTENCE OF HUNTING AND LOGGING IMPACTS ON TROPICAL RAINFOREST MAMMALS. CONSERVATION BIOLOGY, 29(1), 110-12

3. CLEMENTS, G. R., RAYAN, D. M., AZIZ, S. A., KAWANISHI, K., TRAEHOLT, C., MAGINTAN, D., & WONG, C. L. (2014). PREDICTING THE DISTRIBUTION OF ELUSIVE MAMMALS IN PENINSULAR MALAYSIA USING HIGH-RESOLUTION SATELLITE IMAGES AND ECOLOGICAL NICHE MODELING. INTEGRATIVE ZOOLOGY, 9(6), 643-653

4. MOHAMED, A., SOLLMANN, R., BERNARD, H., AMBU, L., LAGAN, P., MANNAN, S., ... & WILTING, A. (2013). DENSITY AND HABITAT USE OF THE LEOPARD CAT (PRIONAILURUS BENGALENSIS) IN THREE COMMERCIAL FOREST RESERVES IN SABAH, MALAYSIAN BORNEO. JOURNAL OF MAMMALOGY, 94(1), 82-89

5. ZAFIRA, M. R., MOHD-AZLAN, J., ABDUL-PATAH, P., ABDUL-LATIFF, M. A. B., & HAMZAH, M. (2019). CARNIVORE COMMUNITY COMPOSITION IN AN OIL PALM LANDSCAPE IN PENINSULAR MALAYSIA. ECOLOGY AND EVOLUTION, 9(12), 6864-6874.