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Original Research Article

Bioinspired Synthesis of Novel Different Nanoparticles and its Utility in Biodiesel and Animals Applications

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Abstract

Because of its ability to speed up the reaction, the catalyst is critical to its success. Most catalysts are either homogeneous or heterogeneous. It has been shown that utilizing a heterogeneous catalyst, which is easier to remove from the product after the reaction has been finished. Because of the large surface area of the Nano-catalyst results in high catalytic efficiency. To enhance the performance of catalysts a range of various types of support materials have been used. SO_4^{2-}-ZnO and So_4^{2-}/TiO active acid catalyst was prepared and characterized. ZnO nanoparticles catalyst synthesized by precipitation of zinc nitrate for comparison with supported catalyst. Sulphated zinc oxide (SO_4^{2-}-ZnO) and sulphated titania (SO_4^{2-}/TiO) catalysts were synthesized using impregnation methods, to test their efficacy in biodiesel production. Various waste oils from different wastes such as mutton or beef tallow, chicken fat, and methanol are preferred to use during the esterification of waste animal fat oils using solid acid catalysts to produce biodiesel. Biodiesel synthesis generates a substantial amount of glycerol as a byproduct. Effect of optimum parameters such as temperature 60 degree centigrade (°C) shown 90% yield, time 1 hour resulted in 85% yield, catalyst dose 2wt% resulted in 80% yield, stirring speed 250rpm resulted in 80% yield, methanol to oil ratio12:1 resulted as 85.5% yield for transesterification of waste fat oil. It is valuable that the supported acid catalysts showed more yield than simply synthesized ZnO nanocatalyst similarly sulphated zinc oxide showed more FAME yield than sulphated titania.

Keywords: Waste, animal fat, oil, heterogeneous catalyst, biodiesel, thermodynamic analysis.

1. INTRODUCTION

Animal waste oils are gaining popularity as a potential feedstock due to their low cost. Due to its low cost, eco-friendly use, and lack of competition with the food sector, this feedstock is an appealing choice for the generation of biodiesel, avoiding societal concerns [1, 2]. Moreover, it frequently contains a high quantity of FFA, needing a pre-treatment before it could be processed using the traditional homogeneous alkali method. When combusted in diesel engines, biodiesel is a reproducible transporting fuel that emits fewer atmospheric gases. At the research, trial, and industrial levels, significant attention has been paid to producing commercially feasible biodiesel from a range of low-cost feedstock. The use of heterogeneous catalysts in biofuel synthesis from low-price feedstock could be a game-changer [3-5]. Due to the obvious, characteristics of metal oxides, such as feasible accessibility, enough basic power, economic efficiency, and enhanced catalytic efficiency, metal oxide-based multiphase nanocatalysts including alkaline earth oxides have shown merits compared to normal acid and base catalysts [6].

Due to the highest catalytic activity, selection range, a large number of free fatty acids and water relations the heterogeneous catalysts are considered superior in activity. These are all properties controlled by the presence of active sites at the catalyst surface. Depending upon the solubility properties of catalysts there are two types of catalysts used in the biodiesel process homogeneous and heterogeneous catalysts [7, 8]. From different biodiesel manufacturing methods transesterification method is the best route for converting triglycerides into glycerol and fatty acids in the presence of catalysts or without catalysts. For the study of mass transfer of oils during biofuel manufacturing different techniques were studied like, microwave irradiation, ultrasonication, and the co-solvent method. The use of Nanocatalysts for the production of biofuels is very important based on the metal oxides and a lot of different types of magnetic nanoparticles used for it. The most important catalyst used for the transesterification of biofuel is the solid acid catalyst impregnated with metal oxides. A lot of solid acid catalysts are used such as Zr, Zn, TiO, Fe, tungsten and magnetic materials at different reacting factors, like catalytic dose, a mass ratio of oil and alcohol, temperature as well as time [9, 10].

The role of several parameters on biodiesel production, consisting of methanol and oil mass range, temperature, catalytic dosage and reacting period estimated. Optimal conditions for manufacturing biodiesel were 65°C, alcohol and oil mass range to 13:2, a catalytic dosage of 2weight per cent, at 2 hrs reacting period, which resulted in a biodiesel yield of 92.72 per cent. Furthermore, the catalyst's reusability was tested and the results revealed that the catalyst may be reused two times with a product yield greater than 85% [11-15]. The most frequent approach for the analysis of crystalline materials is X-ray diffraction (XRD), which gives a sense of chemical composition and crystalline structure. The electron microscope is utilized for studying the morphology of manufactured nanocatalysts and their predecessors. The particle sizes and shape of nanocatalysts can be studied utilizing transmission electron microscopy (TEM). The Fourier transform infrared (FTIR) spectroscopy, which is more sensitive to phase assimilation, is another approach for assessing nanocatalysts [16-20].

2. MATERIALS AND METHODS

Initially, the Waste animal fat oil was boiled and stained to prevent all the undissolved particulates and then heated at 100ºC to remove moisture. All the chemicals and reagents used in the present study were of analytical grade and mainly purchased from Sigma-Aldrich Chemical Co.(USA) and Merck (Germany) unless otherwise stated.

2.1. Collection and Pretreatment of Waste Animal Fat Oil

The feedstock for biodiesel manufacture is chicken fat oil. On a plate, waste chicken fat was combined with warm water, brought to a boil, and then cooked for 5–6 hours. The produced liquid was cooled to a point where solid and liquid phases separated. After that, the solid fraction (oil) was separated from the liquid fraction. Because of the highest FAME content from chicken fat oil, it is processed using the water washing method.

2.2. Synthesis of ZnO nanoparticles

Zinc oxide nanoparticles synthesized from $ZnSO_4.7H_2O$ by calcining in a muffle furnace at 500-degree Celcius temperature for 4h. The obtained zinc oxide powder was mixed into a 1M solution of sulfuric acid maintaining a temperature of 50 degrees Celcius for 4h with continuous stirring. The resulting solid was dried in an oven at 100 degrees Celcius for 24h. After drying to get the final product the obtained solid again calcined at 400 degrees Celcius for 2h in a muffle furnace. This catalyst is ground and then sieved to get the zinc oxide nanoparticles [21, 22].

2.3. SO_4^{2-}/ZnO Nanocatalyst Preparation

A 1M solution of $Zn(NO_3)_2$ was produced by mixing $Zn(NO_3)_2.6H_2O$ in distilled water for the production of SO_4^{2-}/ZnO. Ammonium hydroxide was used dropwise to the zinc nitrate solution after it was prepared. For 25 minutes at room temperature, the resulting mixture was constantly agitated in a magnetic stirrer until complete precipitation. The precipitates were cleaned with pure deionized water before being dried the whole night at 110-degree centigrade. To obtain homogeneous-sized particles, the dry precipitate was crushed, ground, and sieved. After sifting, the dried precipitate ($Zn(OH)_2$) was soaked in 40ml of 1N H_2SO_4 solution for 2 hours while being agitated. The blended material was then dried overnight in a 100°C oven. In the muffle furnace, the resulting solid was calcined at 400ºC for 3 h. To obtain homogeneous-sized particles, the calcined catalyst was smashed, ground, and sieved.

2.4. SO_4^{2-}/TiO Nanocatalyst Preparation

The sulfated group from sulfuric acid was impregnated on TiO to make So_4^{2-}/TiO. In a typical procedure, 9g of titanium oxide was mixed with 150ml of 1M H2SO4 in a 200ml beaker. For 6 hours, the liquid was magnetically stirred. The product was filtered and rinsed with 10ml of distilled water after filtering. It was dried at 90 degrees Celcius for 6 hours. Then the resultant white product was calcined for 2 hours at 600°C. The calcined product is crushed and sieved to provide a uniformly sized sulfated titania nanocatalyst for biodiesel generation [23].

2.5. Esterification of Waste Chicken Fat Oil

The use of methanol to esterify animal waste fat oil to biodiesel was investigated utilising sulphated zinc oxide and sulphated titania nanocatalyst. A 150 mL mixed solution of methanol and animal fat oil following an 8:1 mass rate of methanol and fat oil with 3 weight% acidic catalysts was supplied through a 200 ml three neck round bottom flask connected with a condenser, thermometer for temperature control and magnetic stirrer. All that reacting species agitated by fixing 250 roots per minute speed while temperature maintained to 60 degrees Celsius. The heater was turned off after the transesterification process had proceeded for the required amount of time and then it was allowed to cool [24].

Overnight, the mixture settled into two distinct phases. The mixture of methanol, water, and sulfuric acid was in the top phase and undissolved fat oil with esterified FA occupied to lower zone. A separating funnel is used to separate the upper and lower phases. To extract the catalyst, the lower zone was cleaned two times using distilled water keeping 60-65 degrees celsius temperature after separation.

2.5.1 Transesterification of Esterified Fat Oil

For the next condition, alcohols like methanol and sulphated zinc oxide as well sulphated titania are used. For the transesterification reaction, the mass rate between alcohol and esterified fat oil was kept at 12:1. Then catalyst concentration was set at 2% of the oil weight. The technique and laboratory equipment used in the second step trials were identical to those used in the first. First treated fat (50 g) was placed in a reacting flask with a magnetic stirrer and thermometer and then heated [25].

The methanol–sulphated zinc oxide solution was added to the fat when the temperature reached 60 °C. At 60°C, the finished mixture was agitated for 1 hour. The glycerin byproduct is removed in a funnel after the transesterification reaction. At a temperature of 65 degrees Celcius, the ME rinsed many times utilizing deionized water. The methyl ester was then heated to 100 degrees Celsius to eliminate remaining useless alcohol as well as water. Three times that process have been carried out. Finally, the average biodiesel yield was determined as wt per cent (87%) based on the data.

3. RESULTS AND DISCUSSIONS

3.1 Effect of methanol and oil ratio

The results of our study shown in Fig 1-8. The most critical parameter which affects acid value is the alcohol to broiler fat oil ratio. It speeds up the transesterification reaction. The higher mass ratios are needed to enhance solubility and then improve associations between methanol and glycerol[26]. The mass range should be larger than to stoichiometric range for moving the rate towards product formation. Performing several experiments with a series of methanol to oil ratios like 2:1, 4:1, 6:1, 8:1, and 12:1 using different nanocatalysts it was observed that the increase in methanol and oil ratio by keeping all other parameters kept constant the biodiesel yield decreased. Optimum biodiesel yields 90% investigated at suitable methanol to oil rate of 4:1 using sulphated zinc oxide nanocatalyst higher as compared to the synthesized zinc oxide and sulphated titania.

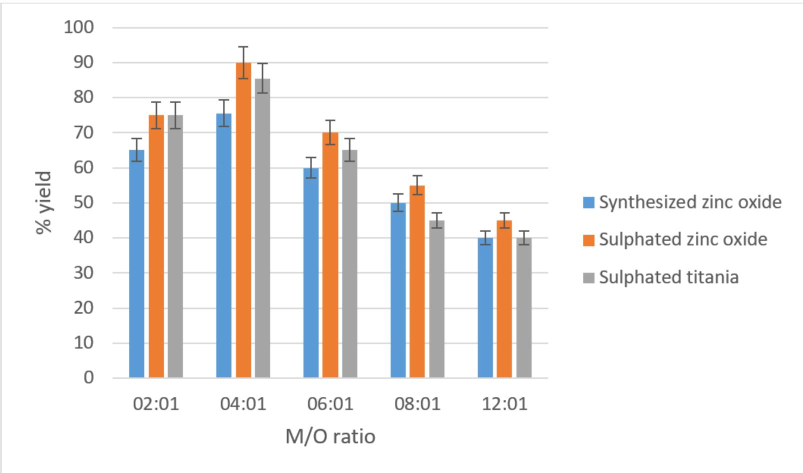

Fig. 1: Effect of M/O ratio on yield of biodiesel

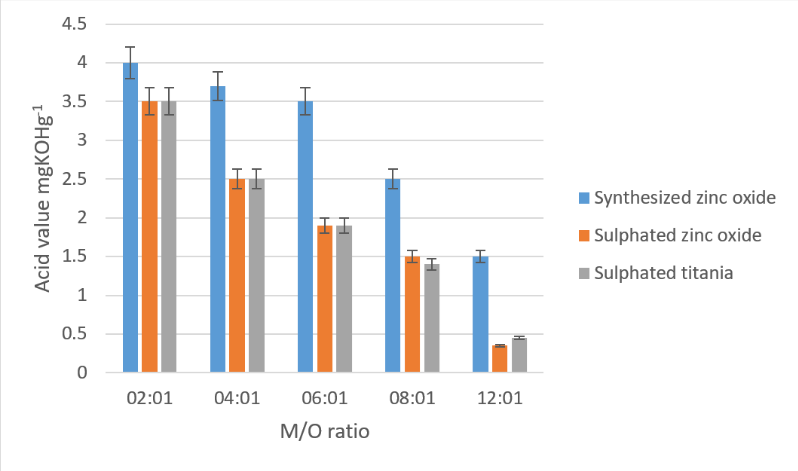

Fig 2: Effect of M/O on acid value

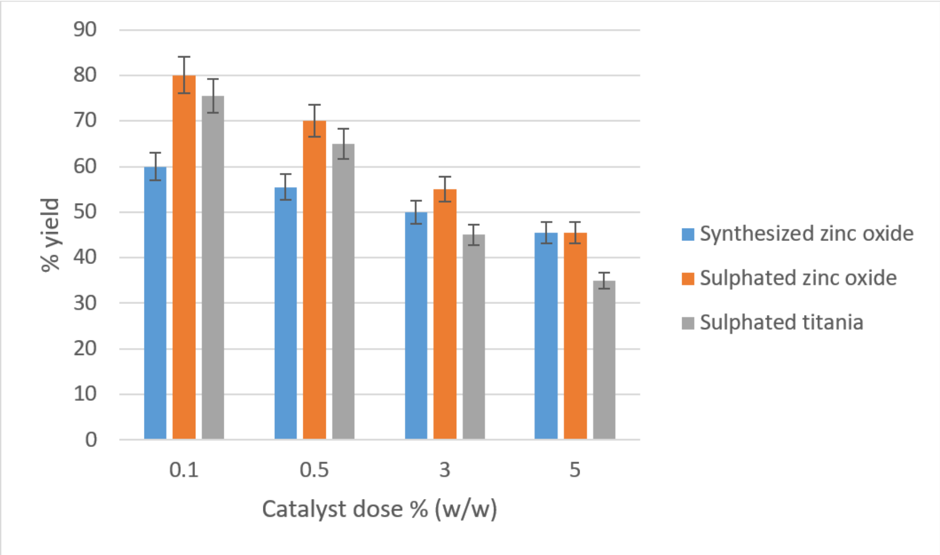

Fig 3: Effect of catalyst dose on yield

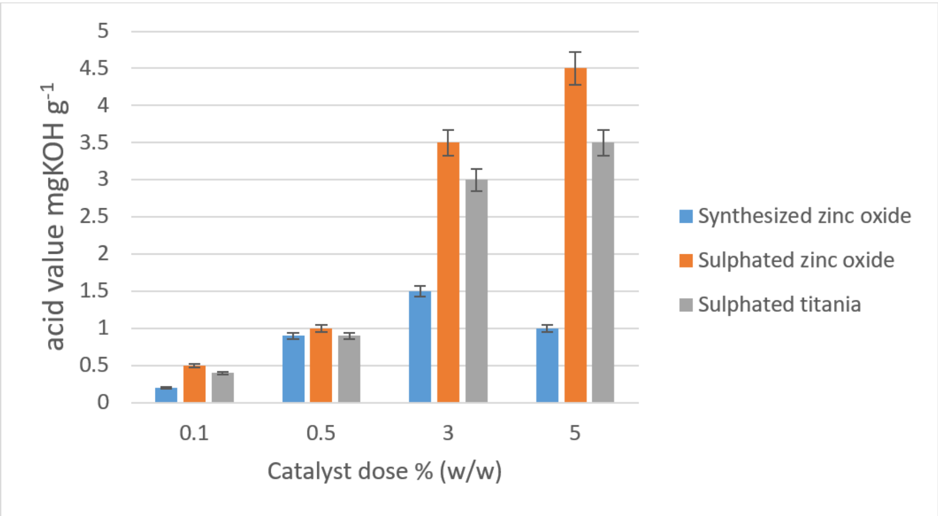

Fig 4: Effect of catalyst dose on acid value

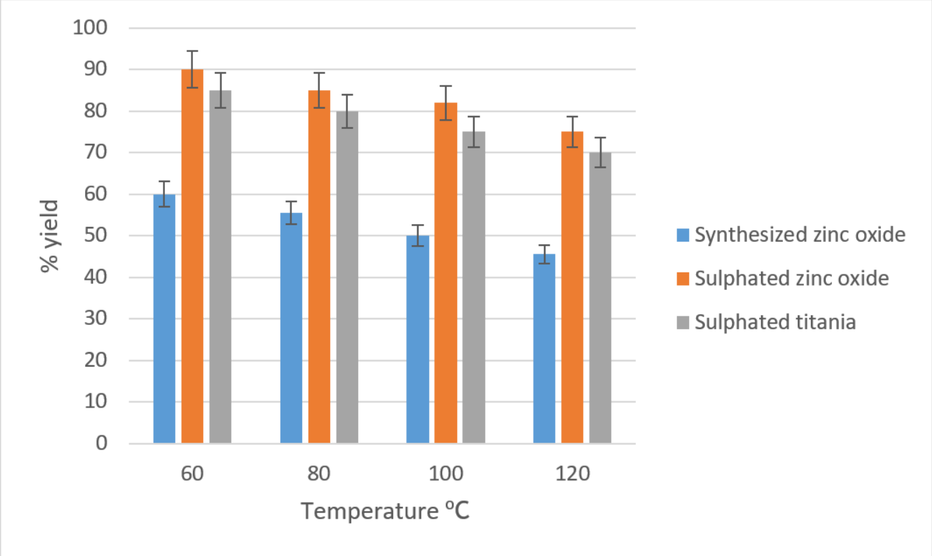

Fig 5: Effect of temperature on yield

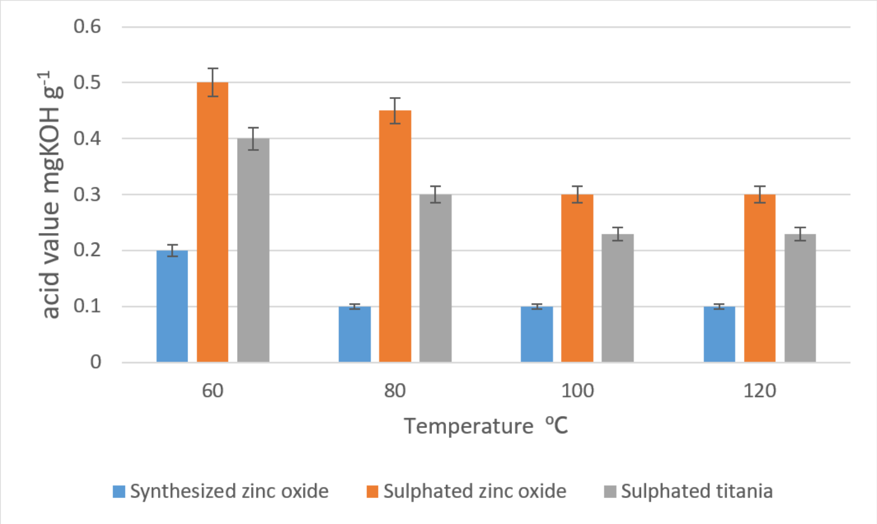

Fig 6: Effect of temperature on acid values

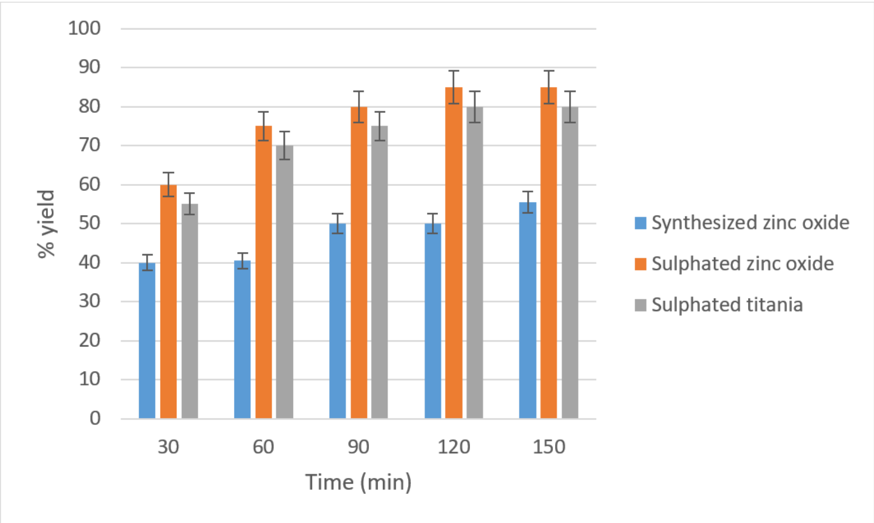

Fig 7: Effect of time on yield

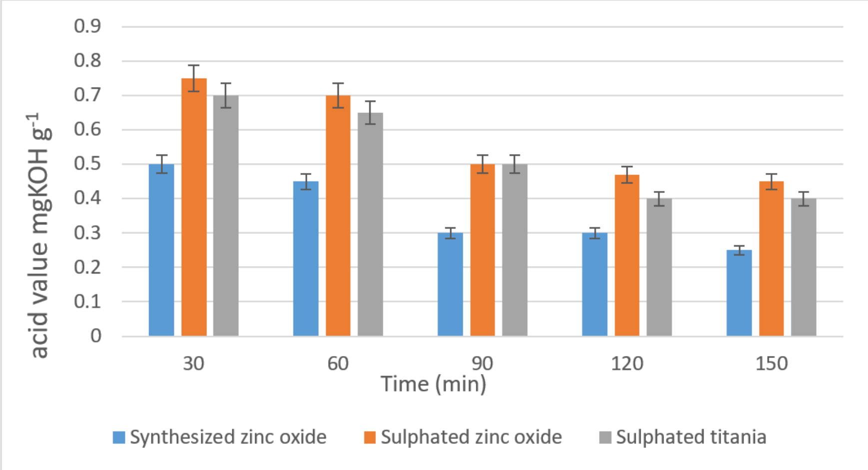

Fig 8: Effect of time on acid value

3.2 Effect of Catalyst Dose

As the quantity of catalysts in fat oil increases, the transformation of triglycerides to biodiesel increases as well[27]. The transesterification method is repeated many times by following multiple supported catalyst concentrations (0.1%, o.5%, 3%, and 5%), alcohol mass rate (6:1) depends on the FFA content of the waste fat oil maintaining 60 degrees celsius temperature during 2 h reaction time. During multiple tasks of biodiesel production by maintaining catalyst dose it was observed that optimum biodiesel yield was 80% with 0.1wt% sulphated zinc oxide nanocatalyst. As we increased the catalyst dose of sulphated zinc oxide nanocatalyst, the acid value increased. By increasing the dose of acidic catalyst more and more acid sites are produced. The acid value was lowest at 0.5 milligrams KOH/gram at the 0.1 catalyst dose then goes to the maximum level of 4.5 by increasing 5% the catalyst dose in 60 minutes. Sulphated Titania nanocatalyst showed the same trend as sulphated zinc oxide, the acidic value increases.

3.3 Effect of Temperature

Reaction temperature also has an important impact on increasing yield[28-29]. As the temperature rises, the rate of the reaction and kinetics accelerate, and reduce the reaction time. Temperature effect was observed within the range of 60°C,80°C,100°C and 120°C by using nano-supported heterogeneous nanocatalysts. Experiments were performed in the presence of different nanocatalysts. An optimum biodiesel yield of 90% was observed at 60°C with SO_4^{2-}/ZnO and then reduce in biodiesel yield was observed till 120°C temperature.

3.4 Effect of time

Because the transformation of oil to methanol or alcohol is slow at first due to scattering and mixing, fatty acid conversion accelerates with time. Optimal ester conversion was reported to be obtained in 90 minutes; however, due to the multiple quality of the reaction, increasing the duration does not boost the yield, resulting in greater glycerol generation. An optimum biodiesel yield of 85% was observed at 150 minutes. After that, it remained constant with a further increase over time. The lowest acid value was investigated during the 90, 120, and 150-minute reacting period.

4. CONCLUSION

Sulphated zinc oxide and sulphated titania were utilised as nano-supported catalysts in this study. Waste animal fat oil, such as mutton fat oil and waste chicken fat oil, was used as the research feedstock. The impregnation process is the most popular method for producing catalysts. For comparison with sulphated zinc oxide and sulphated titania, a synthesised zinc oxide nanocatalyst was made from zinc nitrate solution. Temperature, catalyst dose, methanol to oil ratio, Time duration, and stirring speed were all optimised to produce a high production of biodiesel.

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