"NANOPARTICLE CATALYSIS: EXPLORING THE EFFECIENCY OF ZINC OXIDE AND CALCIUM OXIDE NANOPARTICLES IN BIODIESEL SYNTHESIS "

A DISSERTATION

Submitted in partial fulfilment of the requirements
for the degree of

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in
BIOTECHNOLOGY

Submitted by

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CANDIDATE'S DECLARATION

I **Riya Rai,** Roll No. 2K22/MSCBIO/41 hereby certify that the work which is being presented in the thesis entitled **"nanoparticle catalysis: exploring the efficiency of zinc oxide and calcium oxide nanoparticles in biodiesel synthesis"** is in partial fulfilment of the requirement for the award of the Degree of Master of Science, submitted by me to the Department of Biotechnology, Delhi Technological University, Delhi is an authentic record of my own work carried out during the period from January 2024 to May 2024 under the supervision of Prof. Jai Gopal Sharma.

The matter presented in the thesis has not been submitted by me for the award of any degree of this or any other Institute.

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CERTIFICATE

Certified that **Riya Rai (2K22/MSCBIO/41)** has carried out their search work presented in this thesis entitled **"** Nanoparticle catalysis: Exploring the efficiency of ZnO and CaO in Biodiesel Synthesis "for the award of Degree of Masters of Science in Biotechnology and submitted to the Department of Biotechnology, Delhi Technological University, Delhi under my supervision. The thesis embodies results of original work, and studies are carried out by the student herself and the contents of the thesis do not form the basis for the award of any other degree to the candidate or to anybody else from this or any other University/Institution.

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Nanoparticle catalysis: exploring the efficiency of zinc oxide and calcium oxide nanoparticles in biodiesel synthesis

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ABSTRACT

Biodiesel has gained interest recently due to its environmental benefits and its production from renewable sources, offering a sustainable alternative to traditional fossil fuels. Used cooking oil, sunflower oil, coconut oil, and other types of oils serve as raw materials for biodiesel production. The main techniques for making biodiesel are pyrolysis, mixing, microemulsions, and transesterification—which is the technique that is most frequently used.

High-quality biodiesel is recovered through the transesterification of oils, with glycerol remaining as a byproduct. The reaction is mostly influenced by the molar ratio of glycerides to alcohol .In addition to this catalyst, other factors that influence the reaction include water content, free fatty acids, temperature, and duration. Various investigations have been conducted with varying catalysts and raw materials. Homogenous catalysts such as sodium and potassium hydroxide and heterogenous catalysts such as lipases are two types of catalysts that are utilized for biodiesel production. Nanoparticles are also an interesting choice for biodiesel production due to the presence of high surface area and catalytic properties. In this study, we have utilized Zinc and Calcium nanoparticles in the transesterification process. Characterization of nanoparticles are performed by FTIR. The yield results of solid acid catalyst blends of trans-esterified biodiesel is compared with that of biodiesel produced without using any catalyst.

LIST OF PUBLICATIONS

1. The manuscript entitled "Unveiling Future Advancements in Azo Dye Degradation and Enhanced Bioelectricity Production using Microbial Fuel Cells" has been accepted in the Research Journal of Biotechnology

2. A paper entitled "Docking Study of Environmental Dyes: Insights into Affinity and Bioremediation Potential of Laccase Enzyme" was presented at the 14th International Conference on Science and Innovative Engineering -2024 (ICSIE-2024) held on April 27th -28th 2024

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LIST OF SYMBOLS, ABBREVIATIONS

℃ - Degree Celsius

Zn – Zinc

NP – Nanoparticles

Ca – Calcium

FTIR – Fourier Transform Infrared Spectroscopy

CHAPTER 1

INTRODUCTION

With the upscaling prices and limited resources of petrol and diesel, alternative fuels such as biodiesel have gained immense interest. It is environmentally beneficial as it is non-toxic and biodegradable with low emission profiles. It lessens the quantity of toxins and cancer-causing substances emitted into the atmosphere. Monoalkyl esters of vegetable or animal fats make up biodiesel. It is created by the reaction of vegetable oil or fat with alcohol via the method of transesterification, which involves the action of a catalyst to form monoalkyl esters known as biodiesel (Knothe, 2006) Fats and oils are water-insoluble, hydrophobic substances consisting of 1 mole glycerol and 3 moles of fatty acids (Marchetti et al., 2007) . There is a considerable amount of research going on the potential and use of oils and animal fats as sources of Biodiesel. Palm oil, sunflower oil, rapeseed and coconut oil are the main oils for study (Ma & Hanna, 1999) . According to studies by Pahl et.al, out of global raw material used for biodiesel 59% of sources are rapeseed oil, 25% as soyabean, 5% as sunflower oil and 1% from other sources. The main advantages of Biodiesel as a fuel is its renewability, availability, portability, biodegradability, and higher combustion efficiency with low sulphur and aromatic content. Major constraints include low energy content, high pour points, engine compatibility, NO emissions, and reduced engine speed and power. Due to these limitations, there is an intensive need for research on this fuel to make it compatible for everyday use in the transportation sector.

Cetane number is used as a reliable indicator of fuel ignition quality. Biodiesel exhibits a higher cetane number, approximately 50, compared to conventional diesel fuels. The ignition quality of Biodiesel is determined by the fatty acid methyl esters, which refers to the fuel's capacity to auto-ignite upon engine injection weight. (Balat & Balat, 2010) Given that Biodiesel's viscosity influences the fuel's fluidity, research on this property is also quite crucial. Apart from this, biodiesel lacks aromatics, sulfur, and about 10–11% of oxygen by weight.

Due to the need for environment-friendly fuels biodiesel production has gained interest. There are several methods of production of biodiesel using different kinds of raw materials namely refined oils, frying oils or animal fats with the use of a variety of catalysts namely basic catalysts such as NaOH or KOH or acidic ones such as sulfuric acid or ion exchange resins. Tradition methods include acid-catalysed methods due to low maintenance .Other than this nanoparticles have also been studied as catalysts of the transesterification process.(Marchetti et al., 2007) These heterogeneous catalysts have high recyclability and efficiency. It also increases the yield of Biodiesel. Zinc Oxide nanoparticles have serious applications in biodiesel production due to their high surface region and high catalytic effectiveness (Dasta et al., 2022). It also reduces the reaction time. Other than this ZnO nanoparticles can be synthesised using several methods such as pyrolysis, precipitation, thin film deposition, and solvothermal method (Cao et al., 2010) .Biodiesel and zinc oxide nanoparticles were synthesized simultaneously using supercritical methanol. Zinc nitrate was used as the source of zinc for the formation of the zinc oxide nanoparticles, which acted as a catalyst during the transesterification of rapeseed oil. In addition, the in situ formed zinc oxide nanoparticles led to a reduction in the reaction temperature and time. The fatty acid methyl ester (FAME) yields in the various biodiesels synthesized were determined using Fourier transform infrared (FT-IR) spectroscopy. The results of this analyses confirmed the formation of surface-modified zinc oxide nanoparticles of sizes smaller than those obtained using conventional techniques. This newly developed method provides an economical advantage since it results in the lowering of the operational temperature and the production of zinc oxide as an additional byproduct. (Kim et al., 2013) Calcium nanoparticles are also used as catalysts for the transesterification process with advantages such as being cheap, higher basicity and environment friendly as it can be produced using egg shells also. The two-step Decomposition of calcium carbonate in the egg shells leads to the formation of Calcium oxide nanoparticles (Bet-Moushoul et al., 2016) Nanoparticles have garnered attention for their potential to significantly boost biodiesel yield, promising a more efficient pathway for renewable energy production.

CHAPTER 2

LITERATURE REVIEW

2.1 Biodiesel and its properties

Biodiesel is a sustainable fuel composed of fatty acid methyl esters (FAME) that is created by the process of transesterification, which involves converting vegetable oils and animal fats.

Biodiesel ranges from golden to dark brown. Colour and Properties of biodiesel varies according to the feedstock used. It is slightly miscible in water with low vapour pressure and high boiling point. It has a considerable amount of oxygen (11%) and low hydrogen and carbon contents due to which it has a 10% low mass-energy content (Hoekman et al., 2012) . Biodiesel has high fuel density which makes its volumetric content only 5-6% less than petrol diesel. (Mishra & Goswami, 2018) Other than this biodiesel fuels have high cetane numbers due to the presence of straight chain esters and higher viscosity than petrol diesel. The flash point of biodiesel can be a minimum of 130°C which is higher than petrol diesel. The density of biodiesel is around 37.27MJ/kg. There are also no sulfur contents in biodiesel. (Sorate & Bhale, 2015)

2.2 Biodiesel Sources

A wide variety of feedstock can be used for biodiesel production. At present soyabean oil is used in US dominantly while rapeseed oil in Europe and palm oil in southeast Asia. Used cooking oil, animal fats and other vegetable oils such as canola, coconut and sunflower oils are also used (Knothe, 2016) . Biodiesel is an eco-friendly, alternative diesel fuel prepared from domestic renewable resources i.e. vegetable oils (edible or non-edible oil) and animal fats, that runs in diesel engines-cars, buses, trucks, construction equipment, boats, generators, and oil home heating units. Biodiesel has been gaining worldwide popularity as an alternative energy source because it is non toxic, biodegradable & non flammable. Various edible and non edible oils, like rice bran oil, coconut oil, Jatropha curcas, castor oil, cottonseed oil, mahua, karanja which are either surplus and are nonedible type can be used for preparation of biodiesel (S. P. Singh & Singh, 2010) . Biodiesel can be used either in the pure form or as blends on conventional petrol diesel in automobiles without any major modifications. Its biodegradability makes it eco-friendly. It may lead to a revolutionary transformation of the current economic & energy scenario with an era of economic bloom & prosperity for our society. This work describes the production, its properties, composition and future potential of biodiesel (Bajpai & Tyagi, 2006) .The allure of algal lipids as biodiesel sources is fuelled by their remarkable capacity to sequester significant amounts of CO_2 while delivering higher yields. Additionally, their potential to produce substantial annual volumes of biodiesel per acre adds to their appeal as a sustainable energy solution.

2.3 Biodiesel Production by Transesterification

Three methods are mainly utilized for the production of biodiesel. These include pyrolysis which consists of chemical change in the presence of nitrogen or oxygen (Leung et al., 2010) . Micro-emulsion method that involves the use of micro-emulsion molecules known as co surfactants along with solvents such as methanol or ethanol (Meher et al., 2006) . The third process is transesterification which is mainly utilized (Fukuda et al., 2001). Triglycerides must first be converted to di-glycerides, which must next be converted to mono-glycerides and finally to glycerol. Every stage yields one methyl ester. Esters of saturated and unsaturated fatty acids with trihydric alcohol glyceride are found in vegetable oils and animal fats. In the presence of a catalyst, these triglycerides react with alcohol (methanol/ethanol). Because it's less expensive, methanol is the chosen alcohol.(Leung et al., 2010)

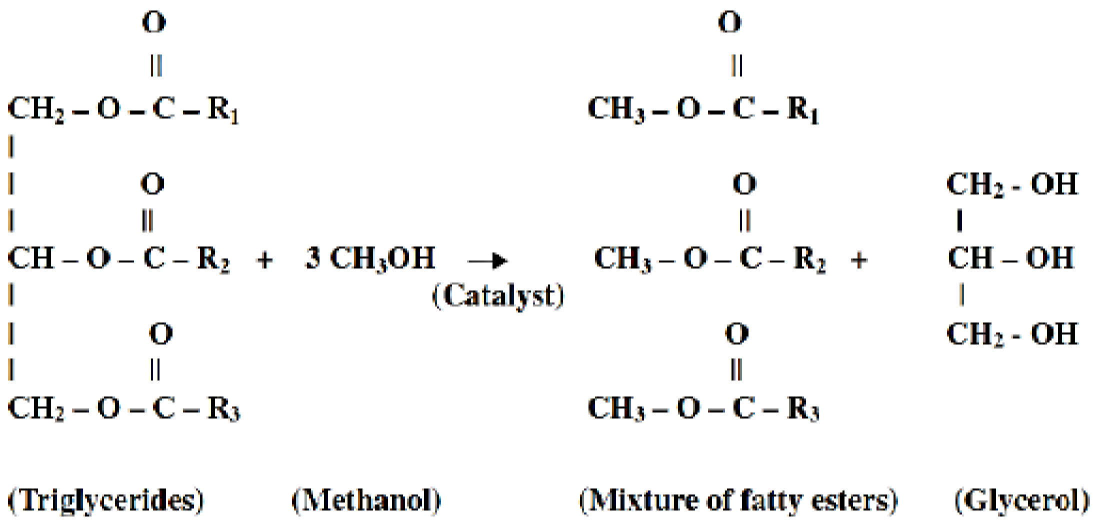

Figure 2.1 Illustrates the process of transesterification, which involves the reaction between a triglyceride and an alcohol.

The equation that applies in general; three successive reactions that can occur in both directions. R,, R,, R3, and R' denote alkyl groups.

2.4 Role of catalyst in biodiesel production

Enzyme catalysts are preferred in biodiesel production for their effectiveness in preventing soap formation, yet they typically demand longer reaction times and entail higher costs compared to acid or alkali catalysts .Alkali and acid catalysts can be heterogeneous or homogenous catalysts. KOH and NaOH are the most common types of alkali homogenous catalysts. Also, these have high catalytic activity (Atadashi et al., 2013). While alkali heterogeneous catalysts are environmentally friendly, non-corrosive, highly selective and have longer lifetimes .and some examples are CaO, , KOH/Al2O3 CaO–CeO2, CaMnO3, KOH/NaY, Al2O3/KI . The reusability of mussel shell catalyst was studied for five times and the result showed that the catalyst re-calcination in reusability step has negative effects on the yield of biodiesel production (Rezaei et al., 2013). For acid-homogenous catalysis concentrated sulphuric acid is used in which both esterification and transesterification is catalyzed simultaneously. Heterogenous catalysts such as ZnO/I2, carbohydrate-derived catalyst, and TiO2=SO2 4 also have the same advantages as homogenous catalysts (Bet-Moushoul et al., 2016)

2.5 Use of nanoparticles as catalyst

Nanotechnology has been recently studied for the second generation of biofuel. This focuses on the shift towards low-cost production and sustainability. In addition, the use of Nanoparticles has been studied to reduce the impacts of diluents used to produce biodiesel. NPs also ease the process of lipid extraction which contributes majorly to the cost of microalgae biodiesel production (Qamar et al., 2023) . Use of nanoparticle metals such as Fe , Mg , Zn ,Al , Au , Si or metallic oxides Al_2O_3 ,TiO_2 ,ZnO , CuO are used to enhance physical , and chemical properties and performance efficiency. Nps with magnetic properties are also used widely due to their reusability after getting detached from process media. Also, adsorption methods and nanoencapsulation are used for immobilization using NPS which reduces the cost of the process. As per experiments done by (Sarma et al., 2014) silica and methyl-functionalized silica is used for high lipid extraction with 1.49 g/L dry mass and acquired higher outcomes than controlled experiments which shows the efficiency of nanoparticles (Bidir et al., 2021)

2.6 Use Zinc and calcium nanoparticles as catalysts in transesterification

Zinc nanoparticles exhibit good catalytic activity with pseudo-first-order kinetic reactions. Zinc sulphate can be used as a precursor and Zinc oxide nanoparticle powder can be produced. Co-precipitation , sol-gel method and impregnation methods are various processes through which efficient ZnO nanoparticles can be produced (Wang et al., 2021).Zinc oxide nanoparticles have high surface area, suitable pore size and enhanced catalytic activity. Studies have shown that ZnO/SiO_2 nanoparticles have the potential to serve as a catalyst in the transesterification process of fatty acids found in jatropha oil, which is employed in the biodiesel production (Salim et al., 2022)

CaO nanoparticles are also used as efficient catalysts in biodiesel production because of properties such as low toxicity, low cost, and high basicity. One major problem is the leakage of calcium ions from CaO nanoparticles in the transesterification process as CaO is soluble in methanol. To solve this decalcifying agents are used to increase the purity of the product. Sol-gel method can be used to produce CaO NPs from egg shells. In the transesterification process, CaO and methanol react which creates a nucleophile that attacks carbonyl carbon present in glycerides Cao can show reusability up to 14 cycles as per studies shown by (Ozor et al., 2023)

2.7 Yield and comparison

The presence of catalyst and its quantity highly affects the yield of biodiesel

Calculation for biodiesel yield%

$$yield\ \% = weight\ of\ methyl\ ester\ (gms)/\ weight\ of\ oil\ (gms) * 100$$

The oil/methanol ratio affects the biodiesel yield. Beyond the optimum point if there is an increase in the oil/methanol ratio it negatively affects the yield . Temperature also affects the yield. Many studies conclude the optimum temperature for biodiesel production is 60’C which is the boiling point for methanol. Above this point, there is high energy input and reduced mass transfer resistance which increases the reaction rate and decreases the yield (Sinha & Madavi, 2021)

CHAPTER 3

MATERIALS REQUIRED AND METHODOLOGY

The nanoparticles utilized in this study are Zinc and Calcium nanoparticles. For production of nanoparticles, ZnSO4.7H2O chemical is sourced from the Environmental and Industrial Biotechnology Laboratory at Delhi Technological University. For the purpose of Biodiesel production methanol and other equipment are also sourced from the same. For Calcium nanoparticles eggshells are utilized from kitchen waste which is also the source of waste cooking oil for biodiesel production.

3.1 FTIR

Fourier Transform Infrared spectroscopy is an analytical method employed to identify organic, polymeric, and inorganic substances. The samples are scanned using infrared light with a wavelength range of 10,000 to 100 cm-1. A portion of the radiation is absorbed while the remaining portion passes through. The incident radiation is transformed into rotational or vibrational energy by the sample, resulting in the generation of a spectrum that describes the molecular characteristics of the substance. sample (Tiernan et al., 2020).Microplastics (MPs) have become the talk of the century globally and hence taken the centre stage of major research works especially in the environmental sector. (Andoh et al., 2024) .FTIR is widely used for characterization of nanoparticles .It helps in determining the chemical composition and reactive sites with surface activity can be identified (Mudunkotuwa et al., 2014)

3.2 Experimental procedure

3.2.1 Formation of Zn nanoparticles

Wet precipitation method is used for the production of Zn nanoparticles. The first step of the procedure is a precipitation reaction taking 250 ml of 1M ZnSO4.7H20 and 250 ml of 2M NaOH solution. For making 1M ZnSO4.7H20 solution 72g of the chemical is required while for making 250 ml of 2M NaOH 20g NaOH is required.

1M $ZnSO_4$ solution was placed on a hot plate and continuously stirred. After some time 2M NaOH is added dropwise for maintenance of pH As the reaction takes place the colour of the $ZnSO_4$ solution starts to turn white due to the formation of gels. The solution is then kept overnight with continuous stirring. Then washing is performed . 4 ml solution is taken and centrifuged for 10 mins at 5000 rpm. The supernatant is then removed and 3 ml distilled water is added and mixed using pipetting. The mixture is again centrifuged for 10 mins at 5000 rpm. This step is repeated 3 times. The precipitate obtained is taken on a glass plate and is allowed to dry in an oven at 80°C for 3 hours then 30°Covernight and after the drying process, the material was converted into a fine powder representing nanoparticles.

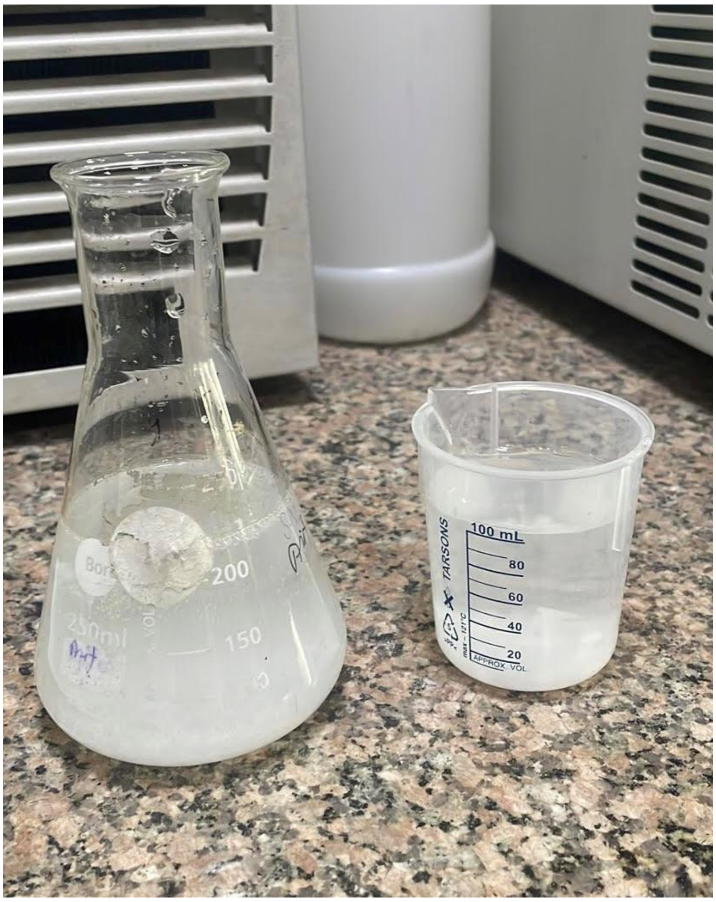

Figure 3.1 . $ZnSO_4$ solution on the left side and NaOH solution on the right side.

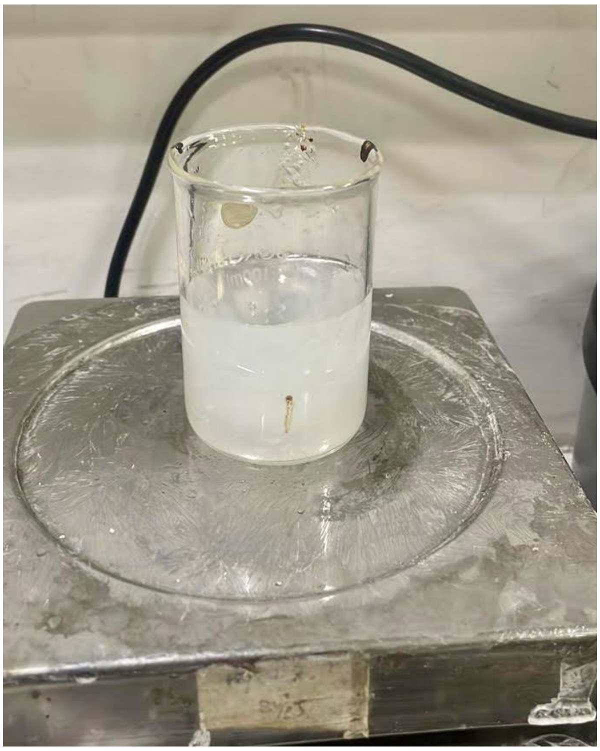

Figure 3.2 . Heating of ZnSO4 solution

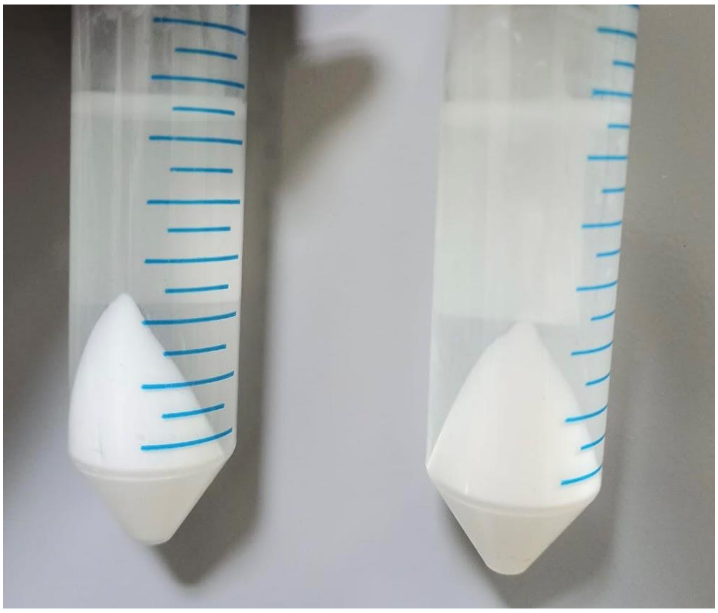

Figure 3.3 Pellet containing Zinc Nanoparticles

3.2.2 Formation of Ca Nanoparticles.

Egg shells were sourced from kitchen waste . Distilled water is used to clean the egg shells and is dried overnight at 65℃ The dried egg shells were crushed using mortar and pestle and needle into a fine powder of nanoparticles (Mensah et al., 2022)

3.2.3 Biodiesel production

Transesterification is carried out for the process of biodiesel production.1:6 methanol: oil ratio is used with a 4wt% catalyst. After calculations 3 ml of oil was taken and 18 ml of oil with 0.84g of nanoparticles. The reaction was carried out for 15 mins at 60 ℃ with continuous stirring. Two experiments were conducted one with nanoparticles and the other without nanoparticles. The same method is repeated while using calcium nanoparticles. After the reaction biodiesel was transferred to a separating funnel for 24 hrs for separation of glycerol, methanol and the catalyst. The yield of biodiesel from both experiments is compared .(Sinha & Madavi, 2021)

CHAPTER 4

Results and Discussion

4.1 Fourier transform Infrared spectroscopy (FTIR)

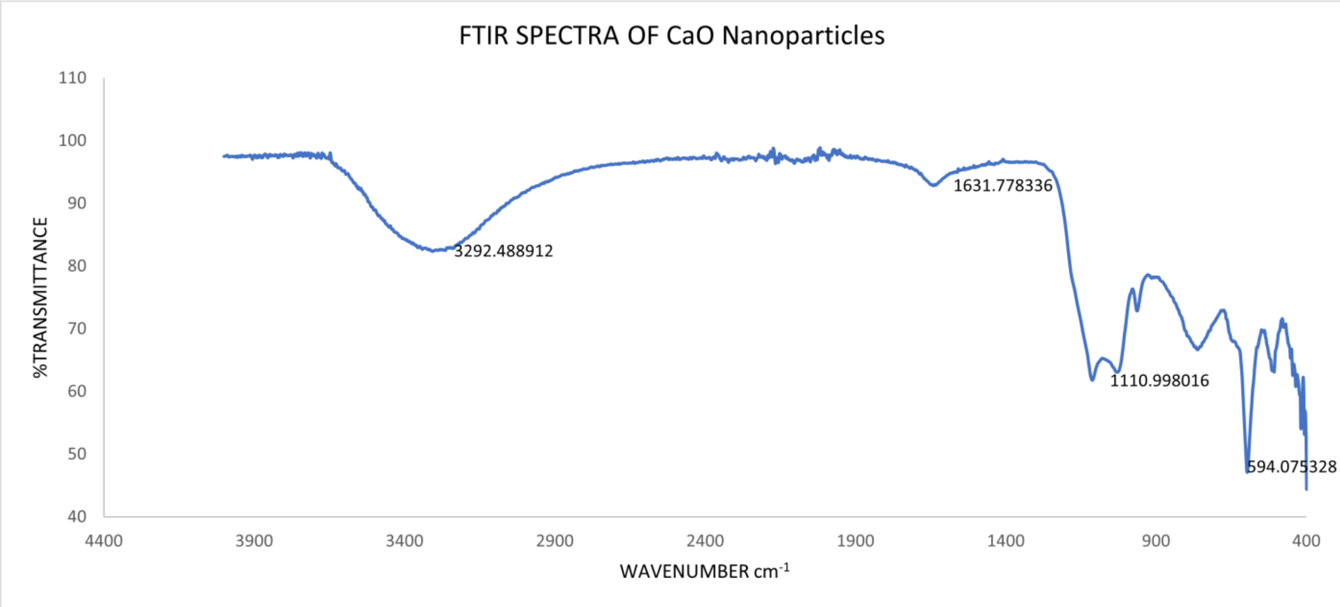

Figure 4.1 . FTIR Spectra of ZnO nanoparticle

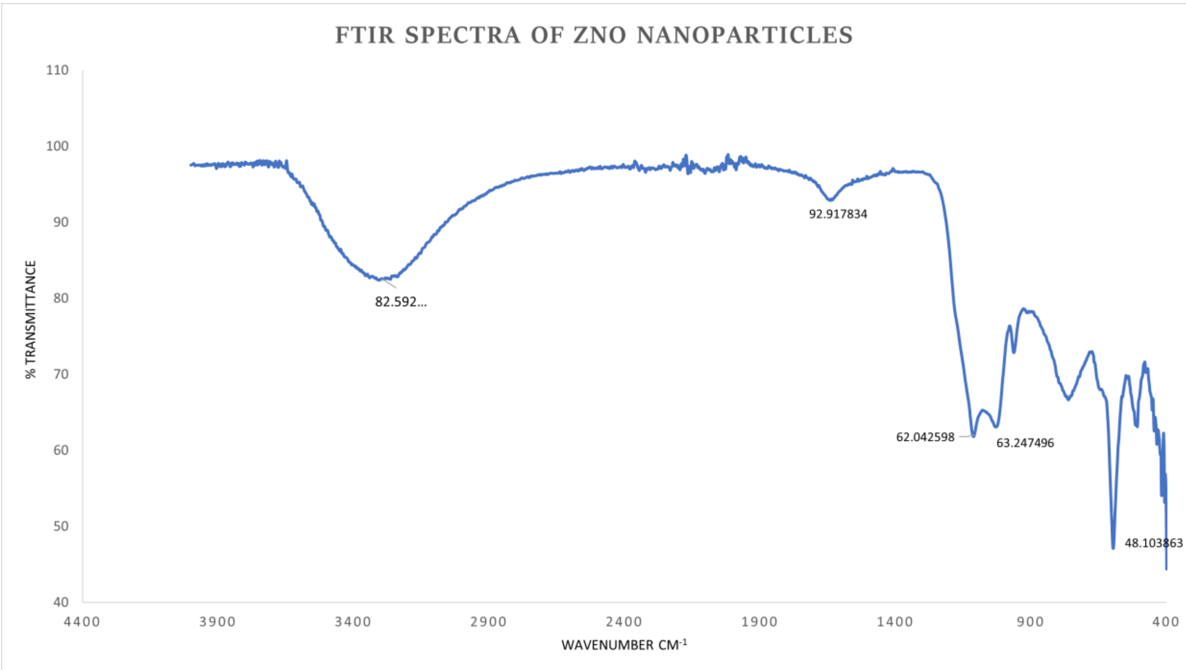

Figure 4.2 FTIR Spectra of CaO nanoparticles

The FTIR spectrum is usually understood in two regions 1400 cm^{-1} to 400 cm^{-1} as the fingerprint region and 4400 cm^{-1} to 1400 cm^{-1} as the functional group region . According to Fig (4.1) A broad absorption peak is observed in the range of 3000-3500 cm^{-1} which accounts for the characteristic absorption of hydroxyl groups (o-H). The absorption peak at 1109 cm-1 attributed to ammonium ion angular deformation. The bending of water molecules causes absorption peaks at 1633 cm^{-1}. Peaks in the range 400-450 cm^{-1} is because of presence of Zn-O bond and unresolved peaks is due to impurities (Salim et al., 2022)

FTIR spectra of CaO nanoparticles is shown in Fig (4.2) O-H free hydroxyl bond from residual hydroxide in the sample indicates Strong peak obtained at 3292 cm-1.This also indicates pure phase particles formation . Peak at 1631 cm-1 also supports residual hydroxyl groups .The peak observed at 594 cm-1 is the characteristic peak of CaO. (Kumar et al., 2021).

4.2 Biodiesel Yield

Yield of biodiesel (%) =mass of biodiesel obtained / mass of oil used.

Control

3 ml methanol and 18 ml oil are used. After the experiment 14 ml of biodiesel was produced.

Yield (%) = (14 ÷18) X 100 = 77.7%

Using Zinc Nanoparticles

3 ml methanol and 18 ml oil are used with 4wt% catalyst .17 ml Biodiesel is produced

Yield (%) = (17÷18) X 100 =94.4%

Using calcium Nanoparticles

10: 1 oil to methanol ratio is used. 0.825g of nanoparticles used 50 ml oil and 5 methanol oil is used. 52 ml biodiesel is used.

Yield (%) = (52 ÷55) X 100 = 94.5 %

The use of nanoparticles increased the yield of biodiesel up to 94.45 % using ZnO and 94.5 % using CaO nanoparticles as compared to the control experiment without using nanoparticles yielded 77.7% of biodiesel. This indicates the efficiency of nanoparticles as catalyst to increase the yield of biodiesel .

Figure 4.3 . Control experiment(without nanoparticles) representing 14 ml of Biodiesel

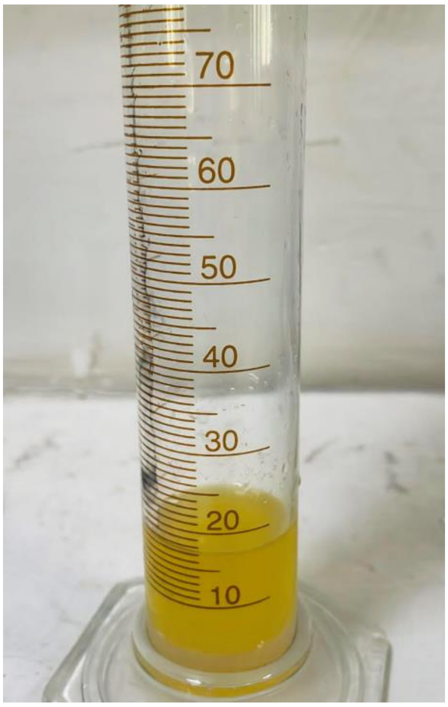

Figure 4.4 . 17 ml of Biodiesel produced using ZnO nanoparticles as catalyst

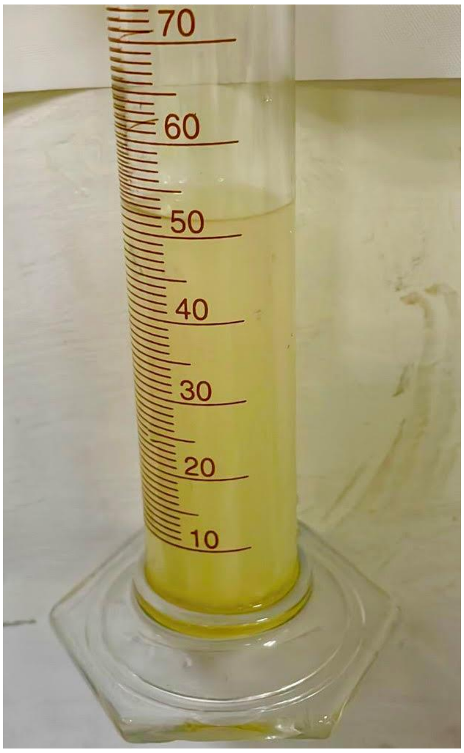

Fig 4.6 . 52 ml of Biodiesel produced using CaO as nanoparticles

CHAPTER 5

CONCLUSION AND FUTURE PROSPECTS

In this work, the effect of catalysts on biodiesel production was studied. Several types of catalysts heterogenous and homogenous can be used in the process of transesterification of biodiesel (Hoang, 2021) .In this study ZnO nanoparticles and CaO nanoparticles are first produced by precipitation and sol gel method respectively and then is utilized in the process of biodiesel production . FTIR studies were conducted to study the size and characteristics of the nanoparticles (Ağbulut et al., 2020).The yield of biodiesel produced using nanoparticles is compared with the biodiesel produced without using any catalyst. Waste cooking oil was the source and methanol was used for transesterification.

The use of nanoparticles in biodiesel production presents several promising future prospects. This innovative approach aims to address some of the limitations and inefficiencies in traditional biodiesel production methods. Here are the key future prospects for this technology:

1. Increased Reaction Efficiency

Nanoparticles, due to their high surface area to volume ratio, can significantly enhance the catalytic activity in biodiesel production. This can lead to faster reaction rates and higher conversion efficiencies, making the production process more efficient and cost-effective.(N. Singh et al., 2024)

2. Reduction in Production Costs

The enhanced catalytic properties of nanoparticles can lower the amount of catalyst required for biodiesel production. Additionally, the possibility of reusing nanoparticles multiple times without significant loss of activity can further reduce production costs. (Gebremariam & Marchetti, 2018)

3. Improved Fuel Quality

Nanoparticles can help in producing biodiesel with better quality characteristics. For example, they can aid in achieving a more complete transesterification process, resulting in fuel with lower levels of impurities and better combustion properties.(Mathew et al., 2021)

4. Environmental Benefits

Using nanoparticles can reduce the environmental impact of biodiesel production. Efficient catalysts mean fewer by-products and waste, and the potential for lower energy consumption during production. Additionally, biodiesel itself is a more environmentally friendly alternative to fossil fuels.(Souza & Seabra, 2013).

5. Versatility with Feedstocks

Nanoparticle-based catalysts can be more versatile in handling various types of feedstocks, including low-quality or waste oils. This can expand the range of raw materials that can be used for biodiesel production, including non-edible oils and industrial waste oils, which are more sustainable options.

6. Development of Hybrid Catalysts

The future may see the development of hybrid catalysts combining nanoparticles with other catalytic materials to optimize performance. These hybrid catalysts could offer superior performance in terms of stability, reusability, and catalytic activity (Kesserwan et al., 2020) .

7. Scalability and Commercialization

Advancements in nanoparticle synthesis and application can lead to scalable and commercially viable biodiesel production processes. As the technology matures, it is likely to attract more investment and interest from the biofuel industry.

8. Research and Innovation

Continued research into the use of different types of nanoparticles (e.g., metal oxides, carbon-based nanoparticles) can lead to the discovery of new catalytic mechanisms and further improvements in the biodiesel production process. Ongoing innovation will likely result in more efficient and sustainable production methods.

9. Integration with Other Renewable Technologies

Nanoparticles can potentially be integrated with other renewable energy technologies, such as solar or wind power, to create more sustainable and energy-efficient biodiesel production systems. This integration can further enhance the environmental benefits of biodiesel.

10. Policy and Market Support

As governments and international bodies continue to push for greener energy solutions, there may be increasing policy support and market incentives for adopting advanced biodiesel production technologies. This can drive further research, development, and adoption of nanoparticle-based methods.

The future prospects of using nanoparticles in biodiesel production are promising, with potential benefits in terms of efficiency, cost, environmental impact, and versatility. Continued research and technological advancements will be crucial in realizing these prospects and transitioning from experimental to commercial-scale applications.

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LIST OF PUBLICATIONS WITH ACCEPTANCE LETTER

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Delhi Technological UNIVERSITY

Dr. Jai Gopal Sharma <sharmajaigopal@dce.ac.in>

Regarding Status of review papers

World Researchers Associations <info@worldresearchersassociations.com> Tue, May 7, 2024 at 12:52 AM
To: "Dr. Jai Gopal Sharma" <sharmajaigopal@dce.ac.in>

Dear Author,

It is a pleasure to accept your manuscript entitled "Unveiling Future Advancements in Azo Dye Degradation and Enhanced Bioelectricity Production using Microbial Fuel Cells" in its current form for publication in the Research Journal of Biotechnology.

Thank you for your fine contribution. On behalf of the editors, we appreciate your research work and its quality and we look forward to your continued contributions to the Journal.

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EDUCATION

Delhi Technological University, New Delhi *2022-2024*
Masters in Biotechnology ***8.64 /10***
Relevant Coursework: Human Physiology, Anatomy, Medical Diagnostics, Computational Biology, Research Methodology, Immunology

University of Delhi, New Delhi *2019-2022*
Bachelors in Zoology *8.378/10*
Relevant Coursework: Analytical Techniques, Nanobiotechnology, Biostatistics, Genetic Engineering, Computer Applications

SKILLS

Laboratory skills: PCR, Silver Staining, NGS, Basic microbiology Techniques, Non-LinearPhenomenon (Mathematical Biology)
Bioinformatics Tools: BLAST, FASTA, ClustalW, Omega, SOPMA, Chimera
Technical skills: Data Analysis using R (ggplot, t-test, ANOVA, scatter plot, Heat maps, Volcano Plot, t-SNE,), Office 365

EXPERIENCE

Vrushk Ecosystems *Mar 2023-May 2023*
Program Management Intern

- Supported the company's goals of promoting entrepreneurship and innovation by connecting startups, social impact change makers, and innovators
- Provided the platform for different organizations to showcase their innovation to a wider audience
- Worked closely with cross-functional funding strategy, marketing, and Innovation teams to support startups in securing funding that was twice the amount attained in the preceding year

Benchmark Learning *Apr 2022-Present*
Academic Specialist

- Utilized technology (Zoom, Teams, Google Jamboard, Moodle, and IXL) to create an engaging learning environment in online tutoring sessions
- Involved in taking sessions of students (age 13+) for Mathematics and Science
- Developed and crafted questionnaires, assessments, and designed K-12 curriculum

Chegg *Jan 2021-Oct 2022*
Biology Subject Matter Expert

- Provided comprehensive solutions to Biology, Physiology, and Anatomy questions
- Showcased advanced proficiency in the subject matter
- Played a key role in enhancing the learning experience and maintaining accuracy

BioSoc, Biotechnological Society New Delhi *Dec 2022-Present*
Management Core Team Member

- Collaborated with other teams (PR and innovation) during cultural fest and executed successful events.
- Managed events, guest lectures, and research competitions held at the University and promoted the growth of society.

Publications

Chugh A. Rai R, Sharma J.G. "Unveiling Future Advancements in Azo Dye Degradation and Enhanced Bioelectricity Production using Microbial Fuel Cells" - manuscript accepted in Research Journal of Biotechnology

Certifications & Trainings

- Techniques in Molecular Biology, *Delhi University* [illegible]
- Primer Designing and qPCR, *Benekind Diagnostics & Prep2Excel* [illegible]
- Genomic Data Science & Analysis, *CIIDRET & DSSEED* [illegible]
- Non-Linear Phenomena in Mathematical Biology, *ABV IITM- Gwalior* [illegible]
- Basic Techniques in Microbiology, *CIIDRET & DSSEED* [illegible]
- Data Analysis for Biologists, *NPTEL Government of India* [illegible]
- Foundations of Project Management, *Google* [illegible]
- Cancer Fundamentals, ongoing *NPTEL*
- Precision Medicine, ongoing *Coursera*

Accomplishments

- Awarded third prize for research paper presentation All New Smart Hindustan: A Sustainable Way to Treat Waste at Hindu College, Delhi University [illegible]